A SYSTEMIC EXAMINATION OF THE INTRODUCTION OF AN OUTDOOR LEARNING-BASED SCIENCE CURRICULUM TO STUDENTS, THEIR TEACHER, AND THE SCHOOL PRINCIPAL

by

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To Miriam
for encouraging me to solve problems
on Earth before solving problems in space…

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A Systemic Examination of the Introduction of an Outdoor Learning-Based Science Curriculum to Students, their Teacher, and the School Principal

by

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Chair: Joseph S. Krajcik

The outdoor environment has been under-utilized as a legitimate setting for learning within the formal school context, resulting in few examples of curriculum materials that integrate the indoors and outdoors. This systemic problem is explored holistically through investigation of key sets of players in the school system. The overarching research question is “What is the role and value of integrated outdoor learning experiences within the school system?” I developed an eight-week Earth systems science unit grounded in research-based design principles. One teacher enacted the unit with 111 sixth graders, whose learning gains and perspectives of the role and value of integrated outdoor learning experiences were explored using a mixed-methods approach in a pre-post study design, including individual interviews, and instruments regarding students’ perspectives of the outdoor component of the curricular enactment. I conducted six interviews with the participating teacher and one interview with the school principal, to explore their perspectives of the role of outdoor learning experiences, and their personal roles in the unit.

The main finding from this study was that the outdoor component of the curriculum enhanced coherence—connectedness across science concepts, activities, and learning environments. Higher ability students were more aware of connections than lower ability students. Field experiences were seen as a tool for learning, and all students achieved substantial learning gains. The teacher viewed the role of the outdoor experiences as a way to engage students, and promote connections across the unit through firsthand and relevant experiences. The school principal viewed his role as supporting teachers in their practice and encouraging risk-taking and creativity in instructional approaches. This study is a valuable contribution to the field as it 1) identifies outdoor learning experiences as one way to enhance intraunit coherence, and 2) highlights variations in students' awareness of coherence while examining the teacher's experience. I discuss potential revisions to improve the curriculum based on the findings from the students, teacher, principal, and external curriculum evaluation. These data indicate a need for greater support for teachers to help all students make coherent connections across the unit, and to take account of students' developing ideas.

CHAPTER I

Introduction

> **"There's big examples of rivers and lakes, but you can pretty much find them everywhere and they're the same examples. Cause we had that little creek just outside, and we got like 8 different examples of data just off of that! And then we went to a line of rocks and people can move rocks, so you can learn about something that came from a volcano in an area where there's no volcanoes around. We tested the rocks and we found that a lot of them were igneous rocks." (Interview, 5/28/09)**
>
> **--Isaac (age 12) on the potential of using the outdoors for learning**

Isaac's response comes after being asked what he has learned about his local setting at the conclusion of an Earth systems science unit. Instead of stating memorized facts, he provides insight into the potential value of learning outside of the traditional learning settings of the classroom and laboratory. He explains that there are opportunities to interact with phenomena anywhere outdoors as he describes two experiences over the course of a unit about the Earth system. Isaac expounds upon his realization that there are examples of natural phenomena all around that can be the concrete basis for science learning. This is a valuable insight for curriculum developers. Teachers need not visit the Grand Canyon in order to provide firsthand and vivid experiences with erosion. Indeed, such opportunities are available around schools and communities, and these resources should be used to promote coherence in science education.

There are some ways that science education could benefit from a greater focus on learning experiences that take place outside of the classroom and laboratory. In other words, visits to the outdoor environment can be a valuable educational activity when employed appropriately—as an integral part of the curriculum, with an ultimate goal of promoting coherence in science education (Kali, Linn, & Roseman, 2008b). There are many meanings of the word coherence. In this dissertation, the word coherence refers to connections between learning activities. The end result of a coherently designed curricular unit is one in which the connections between concepts learned through different activities are clear. Specifically, coherence also refers to connections between activities that take place in different learning environments, including the classroom, laboratory, and outdoor settings. In general, the research related to various aspects of field trips have often explored isolated experiences (Mason, 1980a) regarded as a “prize” for students at the end of the year (Orion, 1989), rather than those that contribute to salient educational goals.

The problem at the heart of this dissertation can be considered as a complex system with many components regarding the role of the outdoor setting in the formal school setting. The body of literature regarding the value and potential of outdoor learning experiences is relatively limited, and thus there is a general lack of depth of understanding regarding this learning environment (National Science Foundation, 1997). Perhaps due to the limited understanding and awareness of the outdoor setting as a valuable environment for educational activities (Sharp, 1988), such outdoor activities are not typically included as part of the school curriculum. There are a limited number of examples of curriculum materials that do include outdoor learning experiences in an integral way (Ben-zvi-Assaraf & Orion, 2005b, 2009; Orion & Kali, 2005). However in general, the development of curriculum materials has focused on the more traditional learning settings of the classroom and laboratory. In addition to these limiting factors, there is an added challenge to a wider use of the outdoors as a salient learning environment due to the limited numbers of teachers who have experience using such a setting, and who are comfortable teaching in the outdoors (Michie, 1998; Mirka, 1970).

There are many interactions amongst the separate but related issues that are part of this system of limitations. One end result is students who have not been exposed to the potentially valuable educational experiences fostered through outdoor learning activities. This leads to students who are less aware of their environment, and have limited awareness of the relevance of science to their lives. Orion (2007) suggests that there is a strong indication that the potential value of outdoor learning experiences as part of an Earth systems approach to science education can foster achievement of the overarching educational goal of a scientifically literate population put forth by Project 2061 (American Association for the Advancement of Science, 1989). In this dissertation, I extend upon Orion’s perspective to examine the role of outdoor learning experiences in promoting coherence, an understanding of the connections and interrelationships between scientific ideas, and the relevance of those ideas to the real world, which Kali, Linn, and Roseman (2008b) suggest is a new wave of science education reform. Shwartz, Weizman, Fortus, Krajcik, and Reiser (2008) describe several different aspects of coherence, including the aspect that is the focus of this study—"intraunit coherence between content learning goals, scientific practices, and curricular activities" (p. 199). Further, there is a need to achieve a more coherent science education in the United States through the incorporation of a logical sequence of topics, woven into a story that is interesting to students, and could help them develop into scientifically literate citizens (Schmidt, 2003; Schmidt, Wang, & McKnight, 2005).

Undoubtedly, this is a complicated system of problems with many facets. An alternative approach to the incorporation and integration of the outdoor learning environment into the formal educational system has been described by several researchers (Hofstein & Rosenfeld, 1996; Orion, 1989, 1993; Orion & Fortner, 2003), but remains largely unexplored in many respects compared to other more traditional learning settings. Specifically, the ways in which such learning experiences can be integrated into coherent curriculum materials, the potential role of such activities for student learning and engagement through coherence, and the perceptions of these experiences from the perspectives of teachers and school administrators who value coherence in the school setting, requires greater attention in the educational research literature, especially as we move into this fourth wave of reform (Kali et al., 2008b). As Hofstein and Rosenfeld put forth, "future research in science education should focus on how to effectively blend informal and formal learning experiences in order to significantly enhance the learning of science" (1996, p. 107). This dissertation moves the field of education forward to gain a deeper, and more holistic understanding of the inclusion of outdoor learning experiences in the school curriculum, and the important role that such a learning setting can play in promoting coherence. I explore the perspectives of key players in the educational system in the context of a developed curricular unit, including students, their teacher, and the school principal.

Due to teachers' expectations of the various demands of using the outdoor learning environment, and their perceived lack of knowledge with instruction outdoors, exploring new instructional techniques is not likely to occur. Without curriculum materials that can facilitate the teaching and learning in the outdoor setting, the pressure is placed upon the teacher, further reducing the chance of taking a risk. Finally, the literature regarding the value of learning outdoors is limited, thereby preventing widespread curriculum reform regarding the potential use of the outdoors as an integral part of the formal school curriculum. This, coupled with the variation among students in terms of engagement, ability, and interests, and the need to help all students learn can further the challenge of using the outdoors for teaching. The combination of these factors makes the use of the outdoors for teaching seem prohibitive, and further solidifies the status quo in the classroom and laboratory settings.

In an effort to attend to this system of related factors of teaching and learning in the school environment, I designed this study with three separate, but associated explorations of this problem. Each of these explorations is discussed in the following three chapters, followed by a chapter that discusses potential revisions to improve the curriculum materials.

First, I designed a curricular unit that includes outdoor learning experiences as an integral learning environment, and developed this unit with a number of research-based design principles (Chapter II). A single teacher with four sixth-grade class sections enacted this unit over an eight-week period in a middle school. Second, I used a mixed methods research approach to collect quantitative and qualitative data sources using survey instruments with all students, and in-depth interviews with a subset of twelve representative students across all four class sections (Chapter III). This chapter seeks to answer the following two research questions:

1) What are students' perspectives of the role and value of outdoor learning experiences in the context of the Earth systems science unit?
2) Did students demonstrate learning gains through the use of the Earth systems unit?

Next, I conducted a series of six interviews with the participating teacher over the course of the enactment, and a single interview with her school principal (Chapter IV). This chapter seeks to answer the following research questions:

1) What does the teacher see as the role of outdoor learning experiences in this curricular enactment?
2) What does the principal see as his role in the enactment of a novel curriculum by a teacher in his school?
3) What are the values and challenges that must be considered in the adoption of a curriculum that involves local and extended outdoor learning experiences?

In Chapter V, I report the findings from an external evaluation of the Earth systems science curriculum unit, and discuss the compiled findings from Chapters III and IV as they relate to revising the unit for a future iteration of this curriculum development project.

To summarize, we have a limited understanding of the particular ways in which outdoor learning experiences can be integrated into the more traditional learning settings of the classroom and laboratory. As a result, the value of using such a curriculum that includes learning in the outdoor setting, particularly for promoting coherence, needs exploration. A better understanding of the value and role of the outdoors for teaching and learning can provide insights into the development of educative curriculum materials, ways to improve professional development experiences for new and continuing teachers, and for improving pre-service teacher education to better prepare teachers to coherently incorporate the outdoors as a meaningful setting for teaching and learning.

A Systemic Approach

Chen and Stroup (1993) discuss the strengths of a general system theory as it relates specifically to the science education reform effort. However, the major strengths they highlight can be applied more generally as strengths of taking on a systemic approach to the study of innovation introduced to the educational system. For example, one strength they discuss is in the ability to integrate and structure understanding of different disciplines of science. Another strength is to engage students in complexity, while a third is to better understand the dynamics and importance of change over time in the natural world. While Chen and Stroup (1993) discuss these points as strengths of system theory as it might apply to science education, I expand on these notions to apply system theory as an approach to educational research. In other words, through such an approach, we can develop a more integrated understanding of the often separate "disciplines" related to the work of teachers, student learning, and policy decisions. This integrated understanding can help educators make sense of the complexity of educational reform, in order to understand the dynamic nature of the field of education. This application of system theory, not only to the integration of the science curriculum, but to the institution of education and schooling has been described by Senge and colleagues (2000) in a field book that deals with three nested systems: the classroom, the school, and the community. Senge et al. (2000) explain that “These systems…interact in ways that are sometimes hard to see but that shape the priorities and needs of people at all levels” (p. 11). Further, reform-based efforts must deal with changes and interactions taking place at all the level of all three systems.

As Geier et al. (2008) and Marx et al. (2004) highlight, new approaches to science education are associated with challenges to teachers and students. They describe many intertwined factors that impact the experiences of students and teachers related to educational reform and systemic initiatives, including professional development, collaboration between teachers and educational researchers, and administrative support. Due to the intertwined nature of components of the educational system, addressing a single component of the system tended to be ineffective due to the importance of interrelationships between the components. Therefore, Klein et al. (2000) describe the importance of systemic reform, a concept that attempts to align the various components of the educational system, including curriculum, instruction, and teacher preparation, among others. The purpose of this concept is ultimately to promote change in the classroom. Further, Blumenfeld et al. (2000) explain that within an educational system, successful implementation of instructional innovation can be challenging due to the environment that is highly connected to the work of teachers and students, in the areas of policy, management, and school culture.

In general, systems theory describes an approach that considers a system to be a set of interdependent and interacting parts. The components of a system interact, and these interacting are considered part of the system (Chen & Stroup, 1993; Lee, 2002). For example, organizational psychology recognizes the complexity of social systems, and the importance of examining multiple parts of a whole system. In the educational system, the component parts can be regarded as interdependent upon one another. As a simplified example of the educational system, a subset of the components includes people (teachers, students, principals, researchers, professional development leaders, parents, policy makers), and organizations (local, state, and national governments, schools, school districts, unions, universities, teacher education institutions, informal institutions). Within the school system, any number of relationships can be drawn between these numerous components. However, the examination of any single relationship, or a single component of this educational system in isolation, will not provide a complete picture. For example, Spillane (2005) describes the influence of subject matter on the work that teachers do, and the variation of this influence depending on subject areas. He states therefore, that the discipline in which a teacher is situated can provide a context for understanding leadership within a school. In the current study, I focus only on the science discipline within the school system, yet it is important to remember that because of the interrelationships within such a complex system, a large number of influences could be acting at all times. Spillane (2005) carefully notes that his study was problematic because it was confined to an examination of the school as a closed system. Researchers must acknowledge the limitations of examining a subset of a highly interconnected system, due to the importance of relationships between, for example, school districts, state and federal agencies, and textbook publishing companies. These influences impact decisions made by the school principal that affect teachers, and eventually students. In effect, a complete picture of the educational system can perhaps never be ascertained, without attention to a great number of interrelationships, interdependencies, and connections. We can, however, move closer to a deeper understanding of the educational system, particularly surrounding the introduction of innovative curricula to the educational system, by exploring such an innovation from multiple perspectives.

Thus, the goal of this dissertation is to explore the introduction of an Earth systems science unit that includes outdoor learning experiences to a single school, using a systemic approach. In this particular systemic approach, I explore the introduced unit from the perspectives of the curriculum reform, students, teacher, and school principal (Figure 1.1). While I believe that this study presents a more complete and holistic perspective of the introduction of this curriculum reform effort, it is certainly not

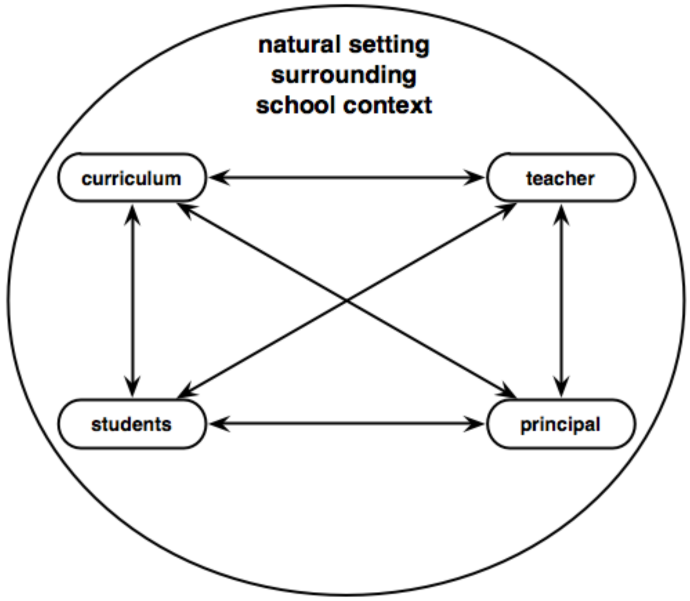

Figure 1.1. Systemic approach to exploring the introduction of a curriculum that includes outdoor learning experiences from various perspectives.

complete. Many components of this system have not been included, and the connections between the omitted components (people and organizations) undoubtedly play important roles in the educational system. In addition, the complexity is further complicated as it is acknowledged that systems are dynamic and constantly in flux, and that there is great variability between one educational system and another, due to the inherent differences in the individual components of different systems. These issues, and the implications for future research are discussed in Chapter VI.

CHAPTER II

The Design and Development of an Outdoor Learning-Based Science Curriculum

Abstract

Curriculum development has been recognized as one potential vehicle to educational reform. The specific topics to cover in curriculum materials, the instructional techniques, and the learning settings used can be carefully combined with what is known about science education. These key factors, along with research-based design principles can improve the educative nature of curriculum materials for both students and teachers. In this paper, the development of an Earth systems science curricular unit is discussed. This eight-week long middle school unit was designed to cover a range of learning goals related to the Earth's systems through instructional techniques that blend the classroom, laboratory, and outdoor learning settings. The inclusion of outdoor learning experiences that are integrated into the unit is a unique aspect of these curriculum materials and can promote curricular coherence. In addition, the unit was grounded in the local setting to increase the relevance of the unit to students' lives. In this unit, students and their teacher are guided through an exploration of the driving question, "Why does my city look the way it does?" which targets Earth systems science concepts related to interactions between components of the geosphere and hydrosphere, in the context of the complex nature of the Earth system. The design and development of this curricular unit provides an example of how materials can be adapted to a local setting and can integrate the outdoors to facilitate a teacher's enactment of an Earth systems unit that is relevant to students.

CHAPTER II

The Design and Development of an Outdoor Learning-Based Science Curriculum

Introduction

Curriculum materials are one vehicle for reforming the field of science education towards a goal of "science for all" (American Association for the Advancement of Science, 1989). Developers can examine the general needs of science education, and align materials to these needs using evidence-based principles of curriculum design (Powell & Anderson, 2002). One of the needs of science education in general, is to provide students with opportunities to learn in appropriate settings that are best aligned to the goals of society. In Earth science education specifically, the most appropriate setting for learning many concepts is the outdoors (Orion, 1993). Past research suggests that teachers have a desire to lead students in more learning activities that take place in the natural environment (Michie, 1998). However, one of the major barriers to this is the lack of curriculum materials that support teachers in leading outdoor learning experiences (Michie, 1998; Mirka, 1970). Teachers have also stated that they do not have the time necessary to develop materials for students (Mirka, 1970) indicating a need for curriculum developers to take on an active role in this regard. Nevertheless, although there is some evidence to suggest that students can benefit from outdoor learning experiences, "much more must be learned about how to structure such experiences and integrate them with other modes of instruction to take full advantage of these possibilities." (Disinger, 1987, p. 6).

This chapter focuses on the development of curriculum materials that can be used by teachers, and that can facilitate teachers' use of the outdoor setting as a learning environment, integrated with the more traditional classroom and laboratory settings. I intend for this type of curriculum to serve as a model of what teachers could develop for their own schools, as well as what curriculum developers could develop for schools in their local setting.

O'Neal's (2003) study of secondary science teachers who participated in a field-based research experience revealed that teachers who were instructed in the use of field activities as part of their teacher education curriculum had a much greater comfort level with learning in the outdoor setting. These teachers were also more capable of developing activities for their own students that make use of the field for teaching Earth science concepts. This suggests that preservice teacher programs should be modified to include a field studies component, as exposure to this type of learning and teaching technique can have a profound effect on teachers' practice. "For many teachers the main factor which affected their willingness to take field trips appeared to be their successful experiences, primarily as teachers but also as students, and learning the value of using other venues for their teaching" (Michie, 1998, p. 8). The importance of having well-developed curriculum materials was discussed in Michie's study, as this allows teachers to develop their expertise of teaching in the outdoor setting. "Teachers felt that there were many venues they could visit but they did not have the time to prepare teaching materials for them" (Michie, 1998, p. 9). This finding highlights the important role of curriculum designers as facilitators in the development of teachers' expertise in blending formal and informal learning environments (National Research Council, 2009). Thus curriculum developers play a key role in the development of well-designed, usable, and accessible curriculum materials that can act as a vehicle for science education reform (Powell & Anderson, 2002; Thier & Daviss, 2001) with a specific emphasis on promoting coherence (Kali et al., 2008b).

Within the systemic approach to this study, the current chapter focuses upon the curriculum. However, as with all systems, the components of the system are intertwined and interrelated in complex and dynamic ways (Figure 2.1). As discussed, curriculum materials merely serve as a vehicle for teaching and learning aligned to reform-based science education. The principal also plays a key role in the curriculum, typically as one who makes curricular decisions, and supports the teachers' use of a specific curriculum. This project as a whole explores the educational system through more focused investigations of the use of the curricular innovation discussed in this chapter from various perspectives. In this chapter, I describe the important role of curriculum materials, provide an overview of the designed unit, and then describe the principles of curriculum development that guided the design of the Earth systems science unit. Finally, I briefly describe the context of the study.

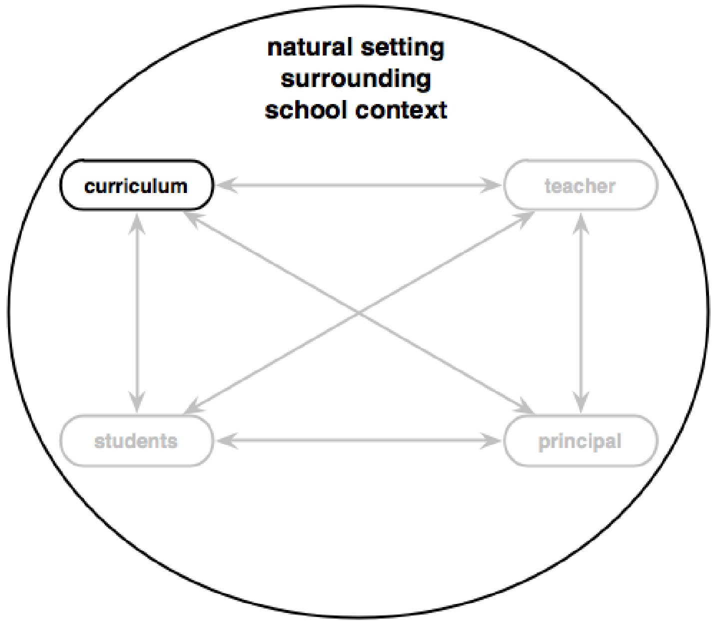

Figure 2.1. Focus on curriculum in the educational system.

Role of Curriculum Materials in Science Education

Curriculum materials play an important, multi-faceted role in science education reform. Teachers need practical tools they can rely upon to facilitate their practice (Powell & Anderson, 2002). By designing curriculum materials that take into account the aspects of science education reform that our country is working towards, we can move closer to impacting teachers and students. "But no matter how well conceived the materials are, their effectiveness depends on the human interactions between teacher and student as the two interpret together the materials' meaning and implications" (Thier & Daviss, 2001, p. 11). In other words, curriculum materials play an important role, but it is the interactions between the materials, the teacher, and students that should be examined to determine the potential value of the materials. This will be discussed further in Chapters III and IV.

The place of curriculum materials in an ever-changing system over the history of science education has had varying purposes and roles over the years, as our understanding about how students learn has changed (DeBoer, 1991; Thier & Daviss, 2001). For example, the curriculum reform movement began in the mid 1950s, and was a time of change in the way school science was approached. The science curriculum projects covered the various disciplines more thoroughly, and accurately than had previously been done, and began to deal with the work of scientists as investigators, and the nature of research. However, perhaps due to the limited inclusion of educators on the project teams, much of what was known about instruction and learning, was excluded from these curriculum projects. DeBoer cites some of the fundamental principles of curriculum and instruction that were ignored, mainly the importance of relating scientific content to the lives of students, student interest, and focusing on concrete experiences. In addition, efforts were not made to provide students with the “knowledge and skills that would help them live intelligent lives” (DeBoer, 1991, p. 172). Thus, a relationship between science and society became an important theme in the goals of science education, and was identified as scientific literacy (Hurd, 1958). The National Science Teachers Association stood strongly behind the educational goal of helping individuals become scientifically literate, through science programs that were student-centered and socially relevant (National Association of Science Teachers, 1971).

Scientific literacy remains as an educational goal at the forefront of science education. As a result, curriculum materials are recognized as a vehicle for helping students learn, and our understanding of the role of curriculum materials in teacher learning is growing. Both of these roles present worthwhile rationales for carefully developing educative curriculum materials, for both students and teachers.

What science educators know about how people learn (Bransford, Brown, & Cocking, 2000), provides a theoretical framework for guiding the development of educative curriculum materials, for both students and teachers. Project-based science (Krajcik & Blumenfeld, 2006) is a concept related to the work of Dewey (1900). Project-based science involves inquiry-based learning aligned to social constructivism (Singer, Marx, Krajcik, & Chambers, 2000). In a socially constructivist learning environment, students actively construct knowledge (Perkins, 1993) which can lead to the development of deeper understanding within a discipline. The engagement in a learning setting that characterizes active construction is a crucial component of the learning process, and can promote the building of new knowledge structures based on the foundation of students’ prior knowledge and experiences. The constructed knowledge becomes situated in a specific setting (Lave & Wenger, 1991). Situated cognition is also characterized by discourse in a collaborative community (Perkins, 1993). To summarize, social constructivism provides students opportunities to be actively engaged in the questioning, gathering of evidence, explanation of phenomena, and application of ideas. Ideally, these processes occur in authentic settings that allow students to make sense of their surroundings in a relevant context, and to share ideas with members of their community—typically other peers in their classroom.

More recently, the central role of instructional materials in the classroom, and the potential of those materials for teacher learning has been acknowledged (Ball & Cohen, 1996). Important interactions occur between printed materials, teachers, and students, and the sum of these interactions is the actual enacted curriculum. Therefore, to consider both students and teachers during the development of curriculum materials is to more fully tap the potential of those materials for their educative value. Davis and Krajcik (2005) took these ideas a step further and developed a set of design heuristics that are organized around the essential teacher knowledge base, including subject matter knowledge, disciplinary practices, and pedagogical content knowledge for particular topics. Attending to these design heuristics during the development of curriculum materials can improve the written curriculum.

Powell and Anderson (2002) explore the role of curriculum materials in the improvement of science teaching and learning from various perspectives, including teachers' knowledge and beliefs and the impact on classroom practice. Curriculum materials play an important role in reform efforts due to the concrete nature of these documents that are "tangible vehicles for embodying the essential ideas of a reform" (Powell & Anderson, 2002, p. 112). By explicating the design principles central to the development of this curricular unit, I can include the aspects of reform that will be attended to. Although, as Ball and Cohen (1996) suggest, the interaction between the materials, teacher, and students in the context of the classroom setting must also be explored. Such interactions, when aligned to the principles behind the development of the materials, "can result in a dynamic expression of reform in the classroom made most obvious by students who learn and enjoy science" (Powell & Anderson, 2002, p. 112).

Thus it becomes clear that the role of curriculum materials is multi-faceted. They can be regarded as a tool that can potentially be one vehicle for making science come alive from the perspectives of both teachers and students. Materials should embody those characteristics and principles of science education reform. When a teacher uses this tool to enact a curriculum that has the potential for improving students' scientific literacy, then materials can in part be regarded as moving us one step closer to achieving the goal of science for all. This includes the increased knowledge of both science and teaching that the teacher can develop through the use of educative curriculum materials.

Overview of Curriculum Development

The underlying scientific principle of conservation of matter was chosen as one focus of the unit. This principle, along with the decision to use an Earth systems science approach to developing this curriculum lead to a focus on cycling matter through the Earth system. In addition, an effort was made to help students develop a greater awareness of the interactions between Earth's subsystems, including their own presence on Earth as part of the biosphere, and the implications for environmental impact.

Several benchmarks (Appendix 2A) relate to these overarching learning goals from the most recent version of the Benchmarks On-Line database (American Association for the Advancement of Science, 1993, 2009). Again, the common threads woven throughout the unit summarize the related benchmarks, and focus on:

1) the exchange of matter through Earth's natural cycles
2) the interactions of Earth's four subsystems
3) human impact on Earth, and Earths' impact on humans

These benchmark concepts can be translated into learning goals for the unit by explaining what students are expected to be able to do by the end of the unit. For example:

1) students will describe and explain how matter on Earth cycles through Earth's systems
2) students will describe and explain the dynamic ways that Earths' systems interact and are interrelated
3) students will explain and predict how humans influence the Earth, as well as describe how humans use Earth's resources in daily life

These foci were chosen for several reasons. These learning goals are central to Earth systems literacy, and have the potential to move students towards a greater awareness of the environment. Richard Louv (2005) describes a phenomenon in which people do not care about what they do not understand; and they do not understand what they are not aware of. Therefore, this curriculum is meant to guide students to a greater awareness of the Earth and its subsystems, help them understand how they work and interact, and improve their scientific literacy regarding their world. In addition, these foci lend itself well to the curriculum materials design principles discussed in this chapter. Finally, Mrs. Hunter (all proper names are pseudonyms), the teacher for whom this unit was developed, was reasonably comfortable with these concepts. She stated that although she is not "an Earth science person," she has taught these Earth science concepts for the past eight years of her teaching career.

Overview of the Earth Systems Science Unit

This was an eight-week curriculum unit that explored concepts related to the geosphere and hydrosphere, and how these subsystems interact as part of the larger Earth system. The unit involved several outdoor learning experiences that took place in the school's local setting (i.e., around the school grounds), along with one more extensive, off-campus field trip to a local rock quarry.

Students began the unit by venturing outdoors to collect samples to determine what makes up the Earth, and to ask questions about the Earth, thus emphasizing the importance of inquiry. The next few lessons focused on a characterization and categorization of the samples, eventually reaching an understanding of the term "system" through direct experiences. The Earth system is one example, but there are several subsystems that are a part of the Earth system, including the atmosphere, geosphere, hydrosphere, and biosphere. Students explored relationships and interactions between components of these four systems, and how they themselves are part of the biosphere, and interact with other Earth systems. This encouraged the development of systems thinking skills in the context of the relevance of science to students' lives.

Students raised questions about the concepts they were learning, and then began focusing on gaining a better understanding of the geosphere. Students returned outdoors to collect samples of the geosphere for later study, and began considering where the geosphere materials, including soil, boulders, and sand found on the ground originated.

Students studied samples of the geosphere and characterized them based on their properties, and worked to come to a conclusion about why the various materials have different characteristics and properties. Students also compared and contrasted rock samples to learn about their differing structures, and eventually that the reason behind their structure was related to the process and location that each one formed on or in the Earth. Through these experiences, students were developing important scientific skills, including comparing and contrasting situations, and using observations as evidence in support of explanations. Once students knew how different types of rocks formed, they investigated different types of igneous rocks that were found in the local setting. They considered how an igneous rock could be found at the school when there were no volcanoes nearby. Eventually, students became aware of the way that rocks can be transformed from one type to another given changing conditions of temperature and pressure. Personal relevance was fostered as students searched for manmade objects in their local setting to explore why it is important to study rocks.

Students made a connection between the geosphere and hydrosphere systems when they considered how rock material found around the school arrived there. Students learned that moving water and wind are capable of transporting, shaping, and breaking apart solid rock to form sediment. This furthered the development of systems thinking skills as students encountered examples of how components of different systems interact in the environment. Additional interactions between rock and water were discussed, and the process of infiltration of water into rock material was introduced. Wells provide evidence that water is stored in the ground, and students discussed their personal experiences with wells.

At this point, students were prepared to make sense of the upcoming visit to the rock quarry, answer some large-scale questions, make connections among the topics they had been studying, and raise new questions to answer in the following weeks. The quarry visit included thirty-minute visits to each of four stations. As the buses arrived at the quarry, students investigated and hypothesized about a large hill with vents—a landfill that would be important to the coherence of the unit upon returning to the classroom. At one station, students investigated the lakes found within the rock quarry and made observations about whether the lake was natural or manmade, and why water collected there. A water sample from the lake was collected for testing back in the classroom. At the second station, students examined a rock outcrop that showed a graded bed of sediments that were deposited over several cycles of deposition in a body of water, providing another opportunity to study the interaction between rock and water. Students also collected and tested rock samples to determine what types of rocks were present in the quarry. At the third station, students photographed examples of components of the four Earth systems interacting to explore in the classroom. At the fourth station, students considered the machines present in the quarry, and the role they play in sorting the geosphere materials by size. Students modeled the sorting process using a set of nested sieves and mixed-sized sediment. Students measured the sizes of each group of sorted sediment, and hypothesized about what useful products might be produced from each type of material. This activity provided students practice with collecting quantitative data, and related this practice to an authentic need for sorting materials based on size to meet demands of society for raw materials. Upon returning to the classroom, students summarized the field trip to the rock quarry and made sense of the collected data, observations, and photographs.

Students returned to interactions between the geosphere and hydrosphere through an exploration of the characteristics of the stream on their school grounds. They collected data to hypothesize about how a large boulder, such as those observed in the stream, could have been transported naturally by such a small stream. This encouraged students to consider the characteristics of the stream in the past, and to conclude that rivers are dynamic and changing systems on Earth. Such practices of observing, predicting and hypothesizing, and gathering evidence are important for developing scientific ideas. The study of the stream continued in the classroom as students considered how water can weather and transport geosphere materials from one place to another, thereby carving the river deeper. The deposition of sediment from rivers into lakes is studied as a natural connection back to the field trip to the rock quarry, and students' personal experiences with rivers and lakes. In addition, cycles of deposition as explored at the quarry were revisited, as students worked in the laboratory setting to simulate depositional cycles and the formation of graded beds that they observed firsthand.

The unit continued to explore interactions between the geosphere and hydrosphere as lakes were studied in more detail. Students reconsidered the evidence that they observed while visiting the rock quarry, and discussed whether they believed the lakes at the quarry were natural or manmade. Students conducted a laboratory investigation about porosity and permeability to help them make sense of the different types of sediment and how water moves through each type. Using this knowledge, students worked collaboratively to build a model of a lake in a small tub. Students shared their models with the class, and then synthesized what they had learned by drawing a diagram of the lake they observed at the rock quarry using the knowledge gained from the laboratory activities.

The concept of groundwater was introduced through the lake model and a simulation of the different zones of saturation and the water table in a small groundwater, lake, and well model that the teacher uses for a demonstration. Groundwater was further discussed in the context of pollution of drinking water due to surface contamination. The idea that groundwater flows beneath the Earth's surface was discovered through this demonstration, and was acknowledged as an important process due to the possible contamination of widespread regions of the Earth, and the wells that were positioned there. This idea required students to return to what they observed at the quarry and to discuss the implications of the landfill that was adjacent to the quarry and lakes. Students tested the water quality of a sample collected from the quarry lake using a commercial testing kit to determine if any contaminants were present, perhaps as a result of the proximity to the landfill.

Students began several days of summarizing and synthesizing what they had learned in the unit by constructing a poster to represent the relationships between concepts regarding water and rock on Earth and the interactions between these systems. Students used their poster board to explain how an igneous pebble could have been transported through the Earth system to arrive where it is today, requiring students to use their knowledge of how igneous rocks form, as well as their understanding of weathering, rounding, erosion through rivers, and deposition in rivers and lakes. Finally, students determined how streams affect the landscape, and how the landscape can affect streams. Students explored photographs from landscapes around the world, and compared how those landscapes may have formed in similar or different ways compared to their local landscape.

To wrap up the unit, students worked in small groups to complete a mini-project. Students were encouraged to focus on a topic that had personal meaning or interest. The topics students chose related to concepts encountered throughout the unit. For example, several groups chose to explore the origin and formation of Petoskey stones, a phenomenon specific to the state of Michigan, for which many students had likely seen during family trips. Another common topic for the mini-project was an exploration of the sand dunes that are prevalent on Michigan's west coast. Students developed working models, posters, and brought in samples from home to provide their classmates with additional experiences. Each group researched their chosen topic, and presented their project to their classmates during a final presentation day.

Design Principles and Features of the Earth Systems Science Unit

This unit was designed based upon several principles of curriculum design (American Association for the Advancement of Science, 2002; National Research Council, 1996a; National Science Foundation, 1997; Orion, 1989, 1993; Orion & Hofstein, 1994; Piaget, 1955; Powell & Anderson, 2002; Rivet & Krajcik, 2004; Singer et al., 2000; Vygotsky, 1978). The design principles that guided the development of this unit are included in Table 2.1, along with examples of design principles that have guided other curriculum development projects, including the Scaffolded Knowledge Integration framework used by the Web-based Inquiry Science Environment (WISE) (Williams & Linn, 2002). The Center for Highly Interactive Classrooms, Curricula, and Computing in Education (hi-ce) developed the Learning Technologies in Urban Schools (LeTUS) and Investigating and Questioning our World through Science and Technology (IQWST) projects (Krajcik, Slotta, McNeill, & Reiser, 2008; Marx et al., 2004; Singer et al., 2000). The Delineating and Evaluating Coherent Instructional Designs for Education (DECIDE) project represents knowledge about design based upon curriculum development centers, including CCMS, and Technology Enhanced Learning in Science (TELS) groups (Kali, 2004; Kali, Fortus, & Ronen-Fuhrmann, 2008a).

There are many overlapping principles that have been used by these groups to guide curriculum design. I have arranged the principles from different groups into categories (rows), as they are often phrased in different ways, but have the same foundational meaning. For example, all of the projects include an aspect related to making connections to students' lives through relevant scientific ideas, although different groups reference this concept in different ways. There are several design principles that were included in the current study that were unique to the provided examples, but are included by other curriculum designers. For example, the Earth systems unit was designed using an Earth systems science approach (Birnbaum, 2004; Mayer, 1995; Orion, 2007; Orion & Fortner, 2003) in order to integrate and promote curricular coherence within learning materials, whereas other projects, such as those developed by hi-ce tend to be aligned to a single discipline. However, it is important to note that hi-ce promotes curricular coherence across disciplines through units that connect to one another (Shwartz et al., 2008). Another notable difference from Table 2.1 is that the other projects involve learning technologies and web-based learning environments, whereas the Earth systems science unit did not include this feature. Instead, different learning settings were blended and integrated, including the classroom, laboratory, and outdoor environment.

Each principle that guided the development of the Earth systems science unit, the focus of this project, is described and discussed in detail, followed by an example of how that principle or feature was integrated into the Earth systems science curriculum unit and the importance of that feature in the unit. While each design principle can be connected, and is interrelated to others, I have isolated each feature, to describe how it has the potential to add value to the developed curriculum materials.

Earth Systems Science Approach

"Science for all" is an educational goal put forth by Project 2061, whose goal is to provide opportunities for all young people to engage in, and learn major science concepts and principles important to being a citizen of the United States (American Association for the Advancement of Science, 1989). Since this goal was announced, there has been a focus in science education on ways to meet this goal. Reforms have been proposed and discussed; yet there is no single solution.

Table 2.1 *Design Principles of Earth Systems Science Unit Influenced by Other Sets of Design Principles*

Earth Systems Science Unit (current study)	**Scaffolded Knowledge Integration (Linn, 1995)**	**LeTUS and IQWST (Krajcik et al., 2008; Marx et al., 2004; Singer et al., 2000)**	**TELS + CCMS: DECIDE project (Kali et al., 2008a)**
Earth systems science approach			
Learning goals based on benchmarks		Identifying learning outcomes based on national standards	
Contextualization, personal relevance, and the local setting	Making science accessible for students through personally relevant problems	Contextualizing inquiry through driving questions	Connect to personally relevant contexts
Blending formal and informal learning contexts through integrated classroom, laboratory, and outdoor tasks		Integrates classroom, laboratory, and outdoor activities	
Direct experiences with phenomena and progression from concrete to abstract concepts		Inquiry-based activities in which students investigate phenomena	
Learning cycles and coherence		Structuring activities and benchmark lessons to prepare students for investigations	Engage learners in complex science problems
Curriculum artifacts, assessments, and projects		Creating artifacts that demonstrate student understanding, and serve as the basis for discussion, feedback, and revisions	Embed assessment-for-learning within instruction
Embedded educative teacher supports		Embedded educative teacher supports	Provide teachers with supports for adaptation
	Social supports in the science classroom to promote knowledge integration through the use of web-based learning environment	Using learning technologies to scaffold student learning	Scaffold the process of generating explanations and enable just-in-time guidance

One possible reform to achieve the goal of science for all, is to use an Earth systems approach (Ben-zvi-Assaraf & Orion, 2005b; Birnbaum, 2004; Gosselin & Macklem-Hurst, 2002; Gudovich, 1997; Mayer, 1995; Orion, 2007; Orion & Fortner, 2003). This approach is characterized by regarding components of the Earth system as interconnected and interrelated. Thus a study of one part or sphere of the Earth must be connected to other parts and spheres. The four major spheres that make up the Earth system typically include the geosphere, hydrosphere, atmosphere, and biosphere (Press, Siever, Grotzinger, & Jordan, 2004). By engaging students in a study of the interconnectedness of the Earth system, students may gain a deeper understanding of the Earth, as such an approach has been shown to help students develop general scientific literacy and scientific thinking skills (Orion, 2007). In addition, people must come to realize that humans are also part of the Earth system. Humans impact the Earth, just as the Earth impacts humans, and young people must gain awareness as to how and why this occurs. The most apparent example, and one popular today, is that of the greenhouse effect, in which humans and society have had a tremendous impact on the Earth (Mayer, 1995).

Orion (2007) compared the traditional disciplinary science programs and an Earth systems-based program, and found that the students who engaged with the Earth systems program outscored their peers in the traditional program in the areas of scientific knowledge and skills. Regardless, a move towards an Earth systems science education approach is not without difficulty, as science teachers are typically comfortable teaching a single scientific discipline. There would be a demand on teachers to gain expertise in a variety of disciplines, to develop knowledge of instructional representations relevant to Earth systems science, and to be able to transfer information across disciplines. In all, these demands could be described as relating to flexibility in the understanding of subject matter. This flexibility has been described by McDiarmid, Ball, and Anderson (1989) as an aspect that pre-service teacher education instructors try to promote in order for teachers to be able to develop awareness of interconnections between the parts of the Earth system as it relates to different disciplines. Orion (2007) concludes that an Earth systems science program is more holistic in its approach compared to the compartmentalized disciplinary approach, and is therefore better suited to achieving a scientific literacy for all paradigm.

Regarding the efficiency of this approach, some argue that systems thinking relies on higher order thinking rather than content-based knowledge (Ben-zvi-Assaraf & Orion, 2005b; Raia, 2005). These researchers further point out that students tend to have a lack of exposure to cyclic phenomena. These cycles are central to an understanding of both Earth science and Earth systems science. The rock cycle and water cycle are crucial to an understanding of rock and landform formation on Earth and other planetary bodies. However, students are not provided with sufficient opportunities to directly experience these processes and phenomena. Ben-zvi-Assaraf and Orion (2005) found that students tend to ignore processes that they cannot directly experience or see, such as the flow or existence of groundwater, which results in difficulty understanding that in a cyclic process such as the water cycle, the amount of matter is conserved.

This curricular unit was designed using an Earth systems approach, with a focus on interactions between the geosphere and hydrosphere in students' local school setting. For example, from the onset of the unit, students were introduced to the terms used to describe the Earth's subsystems, which were then used throughout the entire unit. Students collected samples of materials that make up the Earth, and then categorized them into each subsystem. Next, students viewed a photograph of a familiar landscape and described how objects in the subsystems interact (e.g., organisms depend on water and air for survival, which is an interaction between the biosphere, hydrosphere, and atmosphere). Students had opportunities to represent interactions of Earth's components and subsystems visually, and then to consider their own interactions with Earth's spheres. First, students listed many ways in which they depend on the Earth daily, and then created a visual diagram to display these interactions with "ME (biosphere)" at the center. Students were encouraged not only to list the subsystem and component (e.g., hydrosphere-water), but also to describe the interaction (e.g., I drink/cook with/bathe in water). Later, during the visit to the rock quarry, students used disposable cameras to photograph examples of interactions between Earth's systems. Upon returning to class, students worked collaboratively to construct a poster that showed how components of the Earth's subsystems were interacting in the rock quarry, using their photographs as evidence. One example of a direct experience of an interaction that students had during the quarry visit was the observation of holes that birds had made in the soft wall of the rock quarry pit. Students observed the entry and exit of birds into and out of the rock firsthand, providing a concrete example of how the biosphere and geosphere interact in the quarry. The coherence of the unit was fostered by the focus on interactions between Earth's systems, and the logical progression of ideas through many learning cycles.

Learning Goals Based on Benchmarks

National standards and benchmark documents put forth the concepts and skills that students should learn throughout their science education, as determined by members of the scientific and education communities (American Association for the Advancement of Science, 1993, 2009; National Research Council, 1996c). These documents can provide a basic framework for curriculum developers to guide reform-based projects with the purpose of helping students achieve scientific literacy. Due to the central position of standards in the formal educational setting, it is important that designed curriculum materials align to the standards that teachers are expected to teach. As each state has their own standards, it is impossible for a curricular unit to be aligned to the standards of all individual states. Therefore, it is reasonable to align new materials to the national standards and benchmarks as described in the National Science Education Standards and Benchmarks.

A set of benchmarks were chosen during the design of the Earth systems curricular unit to align to the general topic of interactions between the geosphere and hydrosphere. While it is appropriate to describe the development process as being based upon the national benchmarks, the local environment also provided a framework for the specific content that would be explored in this unit. The local setting and potential outdoor learning experiences guided me to a set of benchmarks that could be targeted in this unit (Appendix 2A). For example, "systems" are a common theme described in the benchmarks, thus it was important that students spend time learning about the big idea of the interconnectedness of Earth's subsystems. This was a theme carried throughout the entire unit, introduced at the beginning as students collected and classified Earth materials, and explored Earth's subsystems, with a focus on the geosphere and hydrosphere. During the rock quarry visit, students collected photographic evidence of the interactions of Earth's subsystems within that specific setting.

Contextualization, Personal Relevance, and the Local Setting

The field of Earth systems is relevant to humans in several areas including the procurement of Earth's resources (e.g., oil, ore deposits, water, gravel), and natural hazards (e.g., volcanoes, earthquakes, tsunamis). One way to integrate Earth systems concepts with students' lives is to help them understand the importance of these concepts to their lives and the local environment. Contextualization is the capacity of students to make connections between the science concepts of this unit and their lives, families, and community, in turn leading to an increased sense of personal relevance (Cognition and Technology Group at Vanderbilt, 1990; Rivet & Krajcik, 2004; Singer et al., 2000). This relevance makes it an ideal topic for grounding learning about the Earth in elementary, middle, and high school. Knowledge about the relevance of Earth systems science can help students to become better informed about their world, which will theoretically lead to generally more responsible citizens. Citizens of this country have the right to vote, meaning that they have power in the environmental decision-making that affect both themselves and others (Orion, Thompson, & King, 1996). Therefore, a more substantial emphasis needs to be placed on the importance of Earth systems topics on the lives of students in order to increase the relevance of this topic in the classroom.

Contextualizing science learning can be carried out through the use of a driving question and sub questions (Appendix 2B) that guide students in the exploration and investigation of important science concepts (Novak & Gleason, 2001; Orion et al., 1996; Rivet & Krajcik, 2004; Singer et al., 2000). Such an organization of a unit also fosters unit coherence. It is essential for students to discuss ways in which the content they are learning in science class is relevant to their own lives, their families and local community. Students should engage in experiences which can become concretized (Cognition and Technology Group at Vanderbilt, 1990). In addition, contextualizing the science content not only to students' personal lives, but also to their local environment, can help guide student learning. This is especially important in studies of Earth science, in which the spatial and temporal scales of observation are somewhat inaccessible, leading students to believe that geologic processes are not occurring in their own local setting (Ford, 2003).

In the Earth systems science unit, students were presented with a driving question (Krajcik, Blumenfeld, Marx, & Soloway, 2000): “Why does my city look the way it does?” This question could not be answered quickly or easily, and required an ongoing investigation into whether the rocks were naturally located on the school grounds, or if they were brought there by human intervention. From the onset of the unit, students grounded their observations and ideas in the local setting, and often engage in anchoring activities specific to their schoolyard. During the first outdoor learning activity, students collected a variety of sample materials that made up the Earth. Over the next several lessons, students worked to characterize, classify, and categorize their collected materials. Another example of an anchoring event was the extended field trip to the rock quarry towards the middle of the unit. Mrs. Hunter made countless references back to this experience in the second half of the unit, grounding discussions and activities in what students experienced firsthand during this field trip. The activities that were part of this field trip were relevant not only to students’ personal lives (e.g., “where does my water come from?”) but also to the local setting (e.g., “where does my city get the raw materials it needs to build roads and structures?”). Towards the conclusion of the unit, students return to this question, exploring a diversity of landscapes using photographs to determine the factors that influence the appearance of a location.

Another way in which the relevance to students’ lives was fostered was in the final mini-projects, in which students chose a topic of personal interest to research and present to the class. Such a project allowed students to take ownership of their ideas and explore additional topics related to the Earth systems unit (Hofstein & Rosenfeld, 1996).

Blending Formal and Informal Learning Contexts through Integrated Classroom, Laboratory, and Outdoor Tasks

Several suggestions can be taken from researchers studying teachers who conduct field trips as an integral part of the curriculum. Each of the three major learning settings—the classroom, laboratory, and outdoors—provides unique aspects to students’ experiences. Thus, a blending of these learning environments can provide a more effective overall learning experience, and are more likely to reach all types of diverse learners (Hofstein & Rosenfeld, 1996; Shepard, 2000). Orion (1993) encourages teachers to focus on the interaction between students and the environment, being careful not to come between the two. This can help students adopt a culture of actively constructing information from the environment directly, as opposed to absorbing information from the teacher. The experiences out-of-doors should be hands-on, and focus on activities that cannot be conducted effectively in the laboratory or classroom as they provide a unique role to the educational program. As Hofstein and Rosenfeld (1996) note, "learning contexts and learning methods should be mixed, in order to provide a good blend of learning experiences. In particular, compulsory school contexts should include informal learning experiences..." (p. 106). Similarly, the National Science Teachers Association (National Science Teachers Association, 1998) "recognizes and encourages the development of sustained links between the informal institutions and schools" (p. 54). Others describe the importance of integrating learning environments as a way to include field experiences in the science curriculum (Orion, Hofstein, Tamir, & Giddings, 1997). This design principle is central to the curricular unit, and is included to provide a different type of overall learning experience for students, many of who have only ever experienced field trips in an isolated and disconnected way. It is this integration that coherently ties the unit together, and provides a sensible sequence to the learning activities, and a need to change learning contexts throughout the unit.

Outdoor learning experiences can therefore be considered an informal learning context, yet the experiences that are part of the Earth systems science unit are integral to the curriculum, and integrated with the more formal learning settings of the classroom and laboratory. For example, the unit was organized around the field trip to the rock quarry that occurs halfway through the 8-week unit. In the classroom, students became conceptually and psychologically prepared for the field trip so that they had some prior knowledge for what they are about to experience in the field. Students discussed several agents of erosion such as water and wind, and how these can change the shape of geosphere materials. They conducted a hands-on activity in the laboratory environment, in which they transported plaster “rocks” in a tube, recording data about the changing shape of the rocks. When students went into the schoolyard and to the rock quarry, they could draw upon these prior experiences and developed conceptual knowledge to make sense of the interaction between the geosphere and hydrosphere in the real world. While in the outdoor setting, students observed a rock outcrop that showed several cycles of deposition of different sized sediments - a concept not yet encountered in the unit. The problem of how this type of phenomenon occurred is taken back into the classroom and discussed, followed by laboratory experiences to try to replicate their field observations. Thus, the field trip provided the rationale for students to return to the classroom and laboratory settings to try to determine how and why such a phenomenon occurs in the natural setting. This is one example of how the three learning environments were integrated during one portion of the Earth systems science unit.

Direct Experiences with Phenomena and Progression from Concrete to Abstract Concepts

The National Science Education Standards (National Research Council, 1996c) state that students should be taught science in a hands-on, minds-on, inquiry-based way that allows them to construct personal meaning regarding science, and to relate science concepts to societal issues. It is important for science to be taught so that students can engage in direct experiences, while engaging students' minds to ensure that they make sense of their observations and experiences. These principles of teaching and learning can be achieved through the use of curriculum materials that include direct experiences with phenomena, which provide opportunities for students to learn and to think about their learning. Exploring preservice teacher education can provide guidance as to how to further student learning. For example, O'Neal (2003) studied a field-based research experience with preservice teachers and found that "many [preservice teachers] elaborated that most of the concepts had much greater personal meaning, and were learned in less time than in the classroom, because of the experiential nature of the active, learning environment" (p. 69). This finding regarding preservice teachers suggests that teachers who make connections between science concepts and their personal lives may be more likely to facilitate students' development of these connections. In addition, the ideas should progress from concrete and direct experiences to abstractions and generalizations.

The inclusion of direct and concrete experiences as a foundational design principle for science curriculum materials can ensure that students are engaged in hands-on, minds-on science. By providing a more concrete engagement with Earth's systems and their interactions, students can gain a deeper understanding of concepts and skills that are often ignored in the traditional science curriculum (Birnbaum, 2004). The potential value of field trips can largely be attributed to the design principle of direct experiences with natural phenomena during such educational experiences. The specific contribution of the field trip cannot be easily discerned. Given the national science reform documents and standards of instruction (National Research Council, 1996a, 1996c), there is little doubt that the value of direct experiences with concrete phenomena is an essential design principle in science curriculum materials. Direct experiences can, and should occur in a variety of learning environments including the classroom, laboratory, and outdoor setting, to facilitate students' drawing connections and relationships between their experiences and their developing understanding.

An appropriate sequence of teaching complex concepts to students should progress from concrete to abstract (Dewey, 1902; Orion, 1993, 2007; Piaget, 1955). Students benefit from knowledge gained from earlier concrete experiences, making them better prepared for the more abstract portion of the unit. This can help students overcome difficulties inherent in making sense of abstractions (Orion, 1989). A curriculum that has been designed following the model put forth by Orion (1993) strives to prepare students for direct experiences, engage them in those experiences, and then draw abstractions from those experiences to more general scientific principles. However, with multiple cycles of learning in a curriculum, students can move from concrete to abstract, and return to concrete ideas in order to gain a deeper understanding of key concepts.

Direct experiences are important for students of all ages. When college level geology students conducted measuring tasks during hands-on activities, they were able to understand the formerly abstract concepts associated with geologic measurements through the use of a rock garden on campus (Calderone et al., 2003). Preservice teachers responded that "participating in research activities in authentic settings increased the personal relevance of the content when they were required to teach the same subject matter in their own classroom. Further, these respondents felt that they were able to impart this relevance to their students, based on their own experiences" (O'Neal, 2003, p. 69). Thus, there is an apparent interplay between individuals experiencing phenomena in direct and concrete ways, and the development of an awareness of personal relevance with scientific ideas.

In the Earth systems science curriculum, students had opportunities to interact with direct experiences in various learning environments. Every outdoor learning experience involved direct experiences in the local setting—either around the schoolyard or at the nearby rock quarry and landfill. During one experience, students visited the stream that runs alongside the school, and collected data about the stream's characteristics, such as depth of water, width, and velocity of flow. Students also engaged in direct experiences in the laboratory setting, for example, when they conducted a simulation of the weathering and subsequent rounding of angular "rocks" made of plaster, and discovered that as the rocks were weathered, sediment was formed. The observations students made during the visit to the stream provided a foundation for making sense of weathering and erosion when they returned to the laboratory. Data were collected that indicated that the total mass of the rock material stays the same, although the form changed. These direct experiences lead to a discussion of the more abstract principle of conservation of matter. The principle of conservation of matter is somewhat abstract compared to the more concrete experiences students engaged with in which they weathered samples representing rocks and formed sediment. Further, the laboratory experiences provided insight into a natural process that occurs on such a long timescale that it is somewhat impossible to directly experience in the natural word. However, the direct experiences with the movement of water and rock in the stream outside of the school was an important activity for which to later make generalizations.

Learning Cycles and Coherence

The concept of a learning cycle was put forth during the 1960s, and includes three stages: 1) exploration, 2) invention, and 3) discovery (Atkin & Karplus, 1962). During the *exploration* stage, students have direct experiences with concrete phenomena. During the *invention* stage, the teacher provides the vocabulary for the concepts students experienced firsthand, allowing them to more successfully communicate about these ideas. Finally, during the *discovery* stage, the students apply their new knowledge to a novel situation. Curriculum materials can consist of multiple learning cycles that result in a coherent unit if connections between components of the unit and subsequent learning cycles are fostered.

Orion's (1993) adaptation of Atkin and Karplus' (1962) learning cycle takes place many times over the course of the curricular unit, contributing to its coherence. Orion's model is useful for teachers and educators who seek to develop field related activities to integrate into an existing curriculum. Due to the integral nature of the outdoor learning activities to a unit that blends learning environments (Michie, 1998; Orion, 1993), the outdoor experience should be preceded by a preparatory unit, and followed by a summary unit (Figure 2.2). The purpose of the preparatory lessons was to prepare students for the

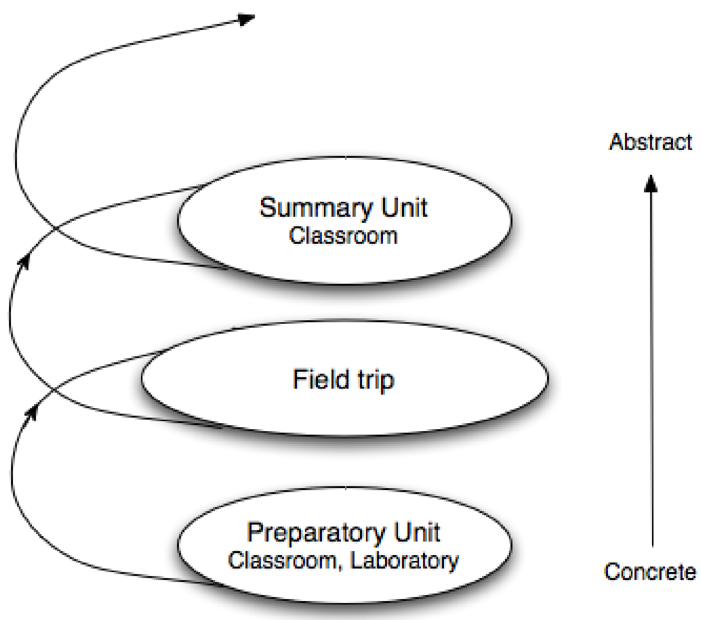

Figure 2.2. Orion's model of field trip development (diagram from Orion, 1993).

work that they would carry out during the visit to a field site. These lessons may take place in the classroom and laboratory settings, and should include exposure to the knowledge and practices in which students were expected to use during their visit. These lessons fostered a reduction in novelty space (Figure 2.3) such that students could focus upon their tasks while outdoors, rather than being distracted by the desire to explore a novel setting, geographical novelty, or their personal needs, psychological novelty (Orion, 1989, 1993).

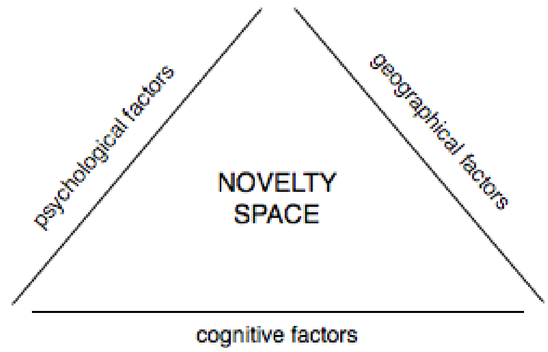

Figure 2.3. Novelty space includes three factors that can interfere with student learning during an outdoor learning experience, and should be reduced (diagram from Orion, 1993).

Students participated in the second stage of the learning cycle—the outdoor learning experience. The third stage was for summarizing, and helped students make sense of the tasks and observations they made during the outdoor learning experience. Again, this phase of the learning cycle should return to the classroom or laboratory setting. By engaging students in multiple rounds of Orion's adaptation of the learning cycle, the three learning environments—the classroom, laboratory, and outdoors—become integrated and blended, allowing students to make sense of the concepts they focused upon, in a variety of contexts, helping diverse learners make sense of, and organize their knowledge (Linn & Hsi, 2000).

In this unit, the following example illustrates a complete learning cycle according to Orion's adaptation. During the preparatory phase at the onset of the unit, students were asked to individually and collaboratively consider what is important for them to know about the Earth. After they recorded their responses and shared these during a whole-class discussion facilitated by Mrs. Hunter, students concluded that before they could answer their questions, they must have a general understanding of what materials make up the Earth, as many of the questions raised dealt with Earth's materials. In order to discover the types of materials make up the Earth, students prepared to go outdoors by discussing their task – to collect as many different types of Earth materials as they could find. During the following class, students began stage two of the learning cycle, and spent approximately thirty minutes collecting samples of materials that make up the Earth from their school yard. These materials were brought back into the classroom, and the next class period began the final stage of the learning cycle—summarizing. During summary lessons, students worked collaboratively with their collected samples, and described their characteristics. Students eventually grouped their samples in a logical way based on those that have similar characteristics. Each group shared with the class how they chose to group their materials, and finally, Mrs. Hunter described how scientists classify and categorize materials based on the Earth's subsystems (atmosphere, biosphere, geosphere, and hydrosphere). New vocabulary was introduced, and applied to students' existing direct experiences and knowledge regarding the materials they had collected. Mrs. Hunter explained that scientists classify and categorize Earth's materials to could then refer to rocks, sediment, minerals, and boulders as components of the "geosphere." This ended a single learning cycle that took place at the onset of the unit.

The inclusion of learning cycles within the unit ensured that students were given opportunities to engage firsthand with concrete materials, before generalizing their knowledge in a more abstract way. Students were able to utilize scientific vocabulary without difficulty throughout the remainder of the unit, as they had direct experiences about what these terms meant before being exposed to the more scientific way of description and classification. Immediately following this initial learning cycle, another learning cycle began with the first as a foundation, as students began to describe interactions between the Earth's subsystems, first in the classroom, and eventually in the outdoor setting later in the unit. Thus the learning cycles were connected to one another, beginning, ending, and connecting to the next, once a strong foundation is built for more sophisticated ideas (Figure 2.4). These connections help build a coherent structure across the unit.

Curriculum Artifacts, Assessment, and Projects

The development of artifacts is an important part of students' experience in science education, and can take on various forms, but is often a physical model or representation of students' thinking. One important aspect of student-developed artifacts is that they are publicly shared and discussed in the context of instruction, and can help guide students to deeper understanding about their learning (Singer et al., 2000). As artifacts can promote and facilitate discussion, they have the potential to serve an important role in the revision of ideas or mental models. In addition, artifacts can be used as formative and summative assessments as they provide a window into students'

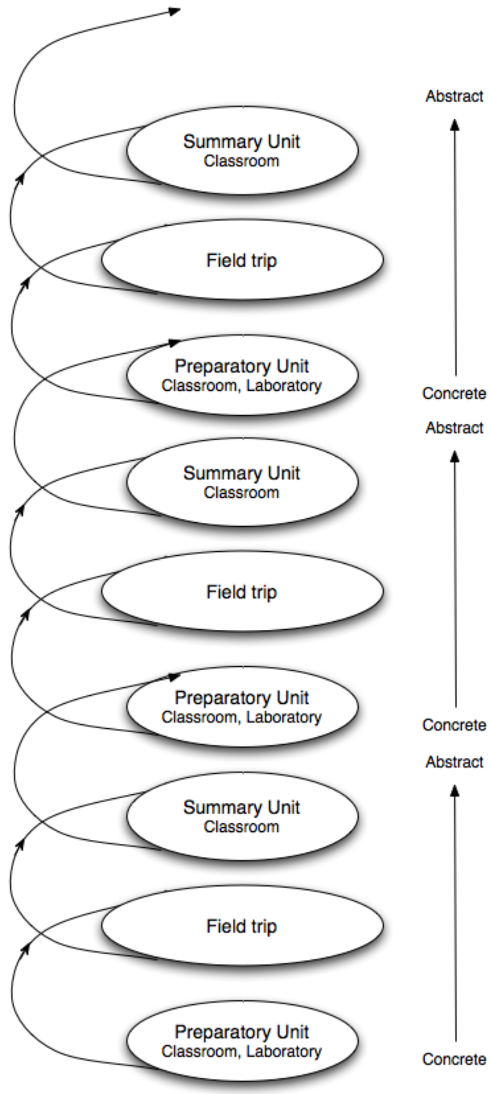

Figure 2.4. Learning cycles build upon one another throughout the unit to promote coherence and interconnectedness between learning environments (adapted from Orion, 1993).

thinking over the course of a lesson or unit (Minstrell, 1989). Artifacts can bring a unit to a close in the form of a research project in which students' task is to demonstrate some understanding of a certain topic by producing a final product (Perkins, 1993). Another example of an artifact is a driving question board (Singer et al., 2000), which is a public display in the classroom, where students can add questions and ideas, modify existing ideas, view other's work, and organize knowledge.

During the 8-week Earth systems science unit, students produced a variety of artifacts. Several examples included posters demonstrating interactions between components of the Earth's subsystems, diagrams showing how a contaminant might move from a landfill through the water system and into drinking water, and descriptions about how landscapes can change. Students also built physical models, including one with layers of different types of sediment to experiment with ways that lakes form. Mrs. Hunter chose to collect some student artifacts as a formative assessment, and to display others in a public space on the wall. In addition, Mrs. Hunter sectioned off a portion of the classroom wall for students' own questions, which remained a public artifact throughout the unit. Another source of artifacts was the photographs that students took with their disposable cameras during the visit to the rock quarry. Students incorporated these photographs into a group poster to describe the many interactions occurring between Earth's systems at the quarry. At the conclusion of the unit, students worked collaboratively to complete a mini-project that had personal relevance and interest. Examples of students' projects included building a physical model and explaining how water towers and water treatment plants operate (one was visible from the classroom window), a dynamic model about how sand dunes form (a topic relevant to Michigan), and an overview of various types of geoscientists.

Embedded Educative Teacher Supports

Due to the novel nature of using curriculum materials that integrate different learning environments—the classroom, laboratory, and outdoor settings—teachers both need, and express a desire for, well-developed curriculum materials to enact a curricular unit as effectively as possible (Michie, 1998). The types of teacher supports, or educative features (Davis & Krajcik, 2005) embedded within the curriculum materials can support the teacher in enacting a unit that integrates learning settings, while promoting teacher learning.

Teachers cite discomfort and minimal content knowledge regarding the use of the outdoors for teaching (Dahl, Anderson, & Libarkin, 2005). A comparison of in-service and preservice teachers' subject matter knowledge of geoscience concepts revealed that teachers hold many alternative conceptions, which act as a barrier to their own conceptual understanding and in turn the conceptual development of their students (Cochran &

Jones, 1998), highlighting the importance and value in providing teachers with support to facilitate teaching in the outdoor setting. This support can come in the form of educative features in the curriculum materials, as well as professional development, and access to an expert in the discipline being studied. The educative features embedded in the curriculum materials should act as cognitive tools to help teachers develop pedagogical content knowledge and pedagogical knowledge, as well as subject matter knowledge (Ball & Cohen, 1996; Davis & Krajcik, 2005) specific to Earth systems science. Further, the inclusion of educative features can promote knowledge integration as teachers learn new ideas through a variety of experiences and in various contexts (Davis & Varma, 2008) with the goal of developing the ability to use knowledge in a flexible manner (Ball & Bass, 2000). However, Remillard (2000) highlights the importance of accompanying support, such as professional development, in regards to the potential value of reform-based curriculum materials for improving teachers' development.

Mrs. Hunter and I discussed a variety of formats for the curriculum materials and teacher guide. Mrs. Hunter felt strongly about her desire to have the teacher materials embedded within the student materials. In other words, she wanted to be able to open her binder, see what students were looking at, and have the teacher supports on a single page. Therefore, I embedded the teacher supports in the margins of the student materials, by using the comment feature in *Microsoft Office-Word*.

One example of an educative feature was provided on the day in which Mrs. Hunter prepared her students to go on the field trip to the rock quarry. The materials included a brief rationale about the importance of preparation, which described research findings that indicate that the better students are prepared for an outdoor learning experience, the higher their learning gains. This concept of preparation is discussed by several researchers (Birnbaum, 2004; Disinger, 1984; Falk, Martin, & Balling, 1978; Orion, 1993; Orion et al., 1997). The curriculum materials guide Mrs. Hunter through a research-based rationale, to prepare students along three major categories before beginning the field trip: 1) her expectations of students, 2) learning activities, and 3) field trip logistics. This educative support not only acts as a rationale and guide to facilitate Mrs. Hunter's description of the upcoming outdoor learning experience for students' benefit, but it also decreases her own personal novelty space (Orion, 1993) in regards to what she can expect during her time in the field. The embedded supports are scattered throughout the entire curriculum, and provide ongoing, and just-in-time support regarding various aspects of the enactment.

Summary of Design Principles that Guided Development

The Earth systems science unit was developed based on a set of research-based design principles. The interaction of separate principles resulted in a coherent unit that provided relevant and firsthand experience with a variety of phenomena in blended learning environments, including the outdoor setting. The unit learning goals were based on AAAS benchmarks, but were focused on experiences in students' local setting. The learning cycle structure of the unit promoted coherence, and provided many instances to develop artifacts that synthesized key ideas.

Conclusion

Curriculum materials play an important role in science education, and can be examined using a systemic approach that explores the holistic system as interrelationships between key players in the educational system. Most recently, it has been recognized as one potential vehicle for reform-based changes aligned to educational research. Therefore, if curriculum developers design learning materials with research-based principles, such foundations can be incorporated into the curriculum over time. In addition, such materials can be educative for students as well as teachers, leading to a more expert teaching force as teachers become accustomed to using reform-based curriculum materials.

The specific topics to cover in curriculum materials, the instructional techniques, and the learning settings used can be carefully combined with what is known about science education to foster coherence. These key factors, along with research-based design principles can improve the educative nature of curriculum materials for both students and teachers. In this chapter, the development of an eight-week long Earth systems science unit was discussed. The inclusion of outdoor learning experiences that are integrated into the unit was a unique aspect of these curriculum materials, and one that can improve our current understanding of how learning environments can be blended

(Hofstein & Rosenfeld, 1996) to improve curricular coherence (Kali et al., 2008b; Shwartz et al., 2008). Curricular coherence is central to the most recent wave of science education reform, referred to as “the systemic approach” (Pea & Collins, 2008). This approach is characterized by gaining awareness as to the connections between scientific ideas, and in developing a desire to link ideas that are applicable to relevant aspects of our lives. There are many parallels between this new wave of reform, and the underlying design principles of curriculum materials that include an Earth systems approach. Specifically, the role of outdoor learning experiences as a learning setting with importance and value to a unit is a unique contribution to our understanding of how curriculum materials aligned to achieving this systemic reform may be structured. The particular ways in which outdoor learning experiences can foster coherence has not been fully explored, although several researchers have explored the contributions of this learning setting (Koran & Baker, 1979; Mason, 1980a) for improving students’ attitudes (Orion & Hofstein, 1991), learning experiences (Kempa & Orion, 1996; Orion & Hofstein, 1994), and thinking skills (Orion & Kali, 2005). More recently, the value of an Earth systems approach, which includes outdoor learning experiences, has been discussed as an effective way to achieve the goal of science for all (Orion, 2007; Orion & Fortner, 2003). However, exploring the ways in which the inclusion of outdoor learning experiences has value for the development of coherence has not been investigated.

Thus, the developed curriculum unit that was the focus of this chapter, and for which the following three chapters are grounded, was designed to foster an integrated understanding through curricular coherence. The curriculum aimed to help students gain awareness of their local setting to increase the relevance of the unit to their lives through a carefully designed unit. Students and their teacher were guided through an exploration of the driving question, “Why does my city look the way it does?” which targets Earth systems concepts related to interactions between components of the geosphere and hydrosphere, in the context of the complex nature of the Earth system. The interactions between Earth’s systems are made more concrete in the context of a systemic approach to science.

The design principles that guided the development of the Earth systems science unit include: using an Earth systems science approach, grounding the content on benchmarks, contextualizing the science to make it personally relevant to students, and grounded in the local setting. In addition, the materials blended three learning environments, including the classroom, laboratory, and outdoor settings. The inclusion of these three learning settings provided firsthand and direct experiences with phenomena that allowed students to move from a concrete to a more abstract understanding of science concepts. The activities occurred within a learning cycles framework to foster the transition from concrete to abstract, and to prepare students for learning experiences, and summarize after the firsthand exposure. Teachers' development was attended to with embedded educative supports that guided the teacher in the implementation of the unit. Students developed curriculum artifacts, including a driving question board, and a final project. These could be regarded as formative assessments throughout the unit, along with many questions that could be used to help the teacher determine how students were progressing in their thinking. Together, and with the outdoor learning environment playing a key role, these design principles at the foundation of the unit enhance the coherence of the unit to help students integrate their understanding through connected and interrelated ideas with explicit connections (Roseman, Linn, & Koppal, 2008). This chapter provided an example of curriculum materials that blended formal classroom and laboratory experiences with learning experiences outdoors, thus contributing to our understanding of ways in which to design such materials.

As an extension of the systemic approach to the development of the curriculum materials that focused on an Earth systems approach to science education, this project explores the educational context as a system as well. In this system (Figure 2.1), the school setting, context, and natural surroundings play an important role in the development of the curriculum materials, as well as the teaching and learning related to the usage of these materials. Given the basic foundation for the development of the curriculum materials discussed in this chapter, the following Chapter III explores the use of these materials from the perspective of the middle school students who participated in the enactment of the unit during an eight-week period.

Appendices

Appendix 2A: Relevant Benchmarks (bold type indicates the portions of the benchmarks addressed in the unit)

The Physical Setting: The Earth

AAAS Benchmarks
Water evaporates from the surface of the Earth, rises and cools, condenses into rain or snow, and falls again to the surface. The water falling on land collects in rivers and lakes, soil, and porous layers of rock, and much of it flows back into the oceans. The cycling of water in and out of the atmosphere is a significant aspect of the weather patterns on Earth. (4B/M7)
Fresh water, limited in supply, is essential for some organisms and industrial processes. **Water in rivers, lakes, and underground can be depleted or polluted, making it unavailable or unsuitable for life.** (4B/M8)
The benefits of Earth's resources—such as fresh water, air, soil, and trees—**can be reduced by deliberately or inadvertently polluting them.** The atmosphere, the oceans, and the land have a limited capacity to absorb and recycle waste materials. In addition, some materials take a long time to degrade. Therefore, cleaning up polluted air, water, or soil can be difficult and costly. (4B/M11bc)
Water can be a liquid or a solid and can go back and forth from one form to the other. If water is turned into ice and then the ice is allowed to melt, the amount of water is the same as it was before freezing. (4B/P2)

The Physical Setting: Processes that Shape the Earth

Waves, **wind, water, and ice shape and reshape the Earth's land surface by eroding rock and soil in some areas and depositing them in other areas**, sometimes in seasonal layers. (4C/E1)
Rock is composed of different combinations of minerals. Smaller rocks come from the breakage and weathering of bedrock and larger rocks. Soil is made partly from weathered rock, partly from plant remains—and also contains many living organisms. (4C/E2)
The formation, weathering, sedimentation, and reformation of rock constitute a continuing "rock cycle" in which the total amount of material stays the same as its forms change. (4C/H2)
Sediments of sand and smaller particles (sometimes containing the remains of organisms) are gradually buried and are cemented together by dissolved minerals to **form solid rock again.** (4C/M3)
Sedimentary rock buried deep enough may be re-formed by pressure and heat, perhaps melting and recrystallizing into different kinds of rock. These re-formed rock layers may be forced up again to become land surface and even mountains. Subsequently, this new rock too will erode. Rock bears evidence of the minerals, temperatures, and forces that created it. (4C/M4)

Chunks of rocks come in many sizes and shapes, from boulders to grains of sand and even smaller. (4C/P1)

The Human Organism: Human Identity

People need water, food, air, waste removal, and a particular range of temperatures in their environment, just as other animals do. (6A/P2)

The Human Organism: Physical Health

The environment may contain dangerous levels of substances that are harmful to human beings. Therefore, the good health of individuals requires monitoring the soil**,** air**,** and **water and taking steps to make them safe.** (6E/M5)

The Designed World: Materials and Manufacturing

The development of new materials and the increased use of existing materials by a growing human population have led to the removal of resources from the environment much more rapidly than they can be replaced by natural processes. Disposal of waste materials has also become a problem. Solving these problems requires systematic efforts involving both social and technological innovations. (8B/H7)

Common Themes: Systems

A system can include processes as well as things. (11A/M1)

Thinking about things as systems means looking for how every part relates to others. The output from one part of a system (which can include material, energy, or information) **can become the input to other parts. Such feedback can serve to control what goes on in the system as a whole.** (11A/M2)

Any system is usually connected to other systems, both internally and externally. **Thus a system may be thought of as containing subsystems and as being a sub-system of a larger system.** (11A/M3)

Appendix 2B: Guiding Questions of the Earth Systems Science Unit

1. What is important for me to know about the Earth?
2. What materials make up the Earth?
3. What characteristics make up materials?
4. Can my materials be classified in any way?
5. What questions do you have so far?
6. Where do the rocks around my school come from?
7. What are some characteristics of the different rocks I found?
8. Why do our samples have different properties?
9. How did the rocks you found around your school get there?
10. How does transportation distance affect the shape of a rock?
11. What are the rocks from around my school like?
12. What factors affect rocks around my school?
13. How are rivers important to the weathering and erosion of rocks?
14. What did the ground around the stream look like in the past?
15. Where did the rock that used to be in the river valley go?
16. When it rains, where does the water go?
17. What is beneath my feet?
18. Summary of Visit to the Livingston Rock Quarry
19. What questions did you answer at the quarry? And what new questions arose at the quarry?
20. Why do lakes form in some places and not others?
21. Why does it matter if water is close to or far from the surface?
22. Is the water from the rock quarry safe to drink?
23. Step back for a minute... Let’s organize our knowledge before moving on
24. How are rock and water connected?
25. Why do rocks look different from each other?
26. Where do granite and rhyolite form on Earth?
27. Are there volcanic (igneous) rocks around my school?
28. What are the other types of rocks that exist on Earth?
29. How do streams affect the landscape?
30. Why do places on Earth looks so different from other places?
31. How does what I’ve learned in this unit relate to me?

CHAPTER III

Students' Learning Outcomes and Perspectives on the Role and Value of Outdoor Learning Experiences Embedded in an Earth Systems Science Unit

Abstract

One challenge in middle grade classrooms has been to expose students to key ideas in the science in a way that promotes learning while engaging learners in personally relevant phenomena in a local context. A curricular unit was designed that grounds Earth systems concepts in students' local environment, while engaging them in integrated classroom, laboratory, and outdoor learning experiences. In this unit, students and their teacher explored the driving question, "Why does my city look the way it does?" which targets Earth systems concepts related to interactions between components of the geosphere and hydrosphere, in the context of the complex nature of the Earth system. One teacher and 111 sixth graders participated in this curricular enactment over an eight-week period. A mixed methods research approach was used to explore students' perceptions of the role and value of outdoor learning experiences, as well as investigate whether a curriculum of this type can help students learn. Data sources included one-on-one interviews, pre and post-content knowledge assessments, and surveys about students' attitudes towards field trips and experiences learning outdoors. The results of this study indicated that the outdoor learning environment played a valuable role in students' experiences, in fostering connections between activities and relevance to students' lives, and in the interaction between the cognitive and affective aspects of learning. It was found that lower ability students were not necessarily aware of coherence and had differing perceptions of learning in the outdoor setting, compared to higher ability students. Nearly all students achieved substantial learning gains in the context of a curriculum including three integrated environments—the classroom, laboratory, and outdoors. This study has implications for curriculum developers, as the outdoor setting was found to have a valuable contribution to students' perspectives regarding coherence and engagement. In addition, the findings indicated that teachers require greater support in guiding all students to develop a coherent understanding of key science ideas in the context of an Earth systems science unit.

CHAPTER III

Students' Learning Outcomes and Perspectives on the Role and Value of Outdoor Learning Experiences Embedded in an Earth Systems Science Unit

Introduction

The classroom and laboratory are the central learning environments in science curriculum materials, with limited attention to the potential value of the outdoor learning setting. Given the focus over the last decade on inquiry-based practices within science education reform (National Research Council, 1996c; National Research Council (NRC), 2000), outdoor learning experiences that foster inquiry practices can be regarded as a legitimate component of a curriculum. As the acquisition of science literacy remains a central goal of recent waves of reform in science education (American Association for the Advancement of Science, 1989; Pea & Collins, 2008), the contribution of the outdoor setting to promoting curricular coherence remains largely unexplored.

An examination into the roots of science education and what is known about how students learn reveals that because scientists ground their learning in a study of phenomena rather than books about phenomena (DeBoer, 1991), that one might expect that the historical emphasis on science as a study of the environment and the natural setting would have resulted in a different type of science education than is seen today (DeBoer, 1991). Instead, science education curriculum materials typically used have minimal coherence (Roseman, Stern, & Koppal, 2010), not only across the entire school curriculum, but within the science curriculum (Chen & Stroup, 1993), and further within smaller units of study. Scientific disciplines are divided and separated from one another (Chen & Stroup, 1993; National Research Council, 1996b), and experiences take place largely within the confines of the four walls of a classroom (National Science Foundation, 1997). However, "in the natural world, the common science disciplines are not isolated from each other or from other intellectual fields, as they are in school"

(McComas & Wang, 1998, p. 340). Drawing attention to the interrelationships between natural phenomena, and the relevance of science to society fosters a greater sense of coherence as the usefulness of science becomes clear (Roseman et al., 2008), moving us closer to the ultimate goal of science literacy for all (American Association for the Advancement of Science, 1989).

I argue that the outdoor setting should be a legitimate component of a curriculum when natural phenomena that lend themselves to this setting are the focus of study. For outdoor experiences to be integrated with the more traditional learning environments (Hofstein & Rosenfeld, 1996; Orion, 1993), requires a deeper understanding of the role and value of the outdoor setting in science education. Burkholder (2003) stated, “there are few pedagogical methodologies that are more effective than immersing a student in an experience that engages all the senses in a manner that helps him or her to understand… abstraction…in a much more immediate and profound way than one can hope for in a classroom” (p. 22). However, if Burkholder’s ideas are to be more widely applied, the potential value of integrated outdoor learning experiences must be explored from the students’ perspective in order to gain a deeper understanding of what measured outcomes might be expected, and whether these outcomes are valuable enough to warrant inclusion of the outdoors as a component of the formal school learning environment. Specifically, this study explores the role and contribution of outdoor learning activities for promoting curricular coherence of an Earth systems science unit, from the perspective of middle school students, and students’ learning outcomes resulting from the use of this unit.

Overall, this portion of the study focuses on the middle school students involved in the study, who participated in the curricular enactment (Figure 3.1). However, as previously discussed, this aspect of the entire study is only one component in the systemic approach used in this project. While this paper focuses on the curriculum as it relates to students, the interactions between the students and teacher, and in the context of the school and surroundings are important factors in gaining a holistic understanding of this system.

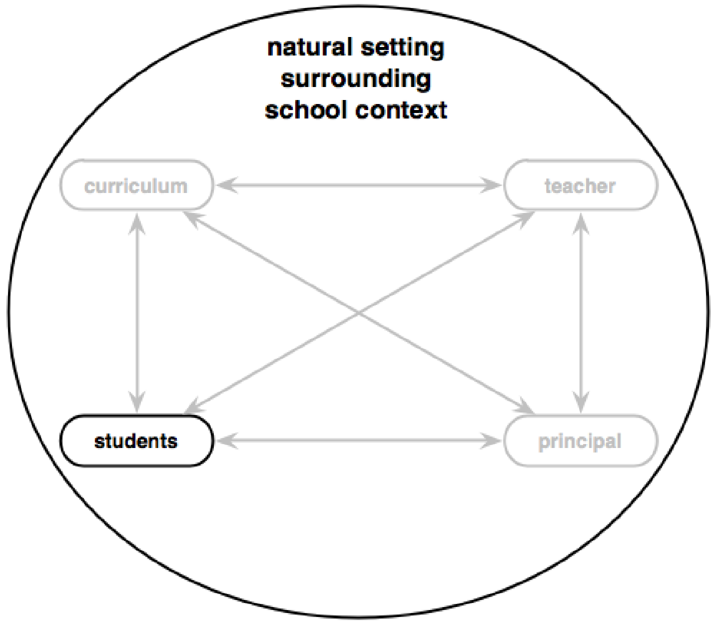

Figure 3.1. Focus on students' experience in the context of the systemic approach to exploring the integration of outdoor learning experiences in the formal school curriculum.

This study included three phases in order to approach this systemic problem: 1) designing and developing a curricular unit (Chapter II); 2) studying the students' perspective of the enactment (this Chapter) along with the participating teacher and school principal's perspectives (Chapter IV); and 3) an analysis of the collected data in order to improve the educative nature of the curriculum unit in the next iteration of the materials (Chapter V). During phase 1, a concerted effort was made to begin with concrete phenomena, and then to move to abstractions after these phenomena have been observed either in the indoor or outdoor classroom, as the school yard permits. The outdoor learning experiences were integrated with other learning activities that took place in alternate settings. Currently, few examples of such a curriculum exist (e.g., Orion & Fortner, 2003). Instead, the majority of research related to outdoor learning has explored isolated events. The Earth systems unit can serve as a model for how the outdoor setting can be integrated with other activities to result in coherent curriculum materials, as they play an important role in student learning. As a result of the paucity of coherent materials that include an outdoor component, little is known regarding students' perspective of the role that outdoor learning experiences play during the enactment of an eight-week Earth systems unit.

The literature contains a variety of phrases to describe learning in the outdoors including field work (Kempa & Orion, 1996; Mason, 1980b; Sharp, 1988), field trips (Harvey, 1951; McNamara, 1971), outdoor education (Hammerman, Hammerman, & Hammerman, 2001), and excursions (Atyeo, 1939; Bennett, 1965) among others. The commonality between these various phrases is experience in the outdoor setting. The outdoor environment can be considered as an informal and alternate learning setting (National Science Teachers Association, 1998), just as the laboratory is an alternate learning setting to the classroom in the formal school setting. In this unit however, the informal activities are tightly integrated with the more traditional learning activities. I will primarily use the phrase "outdoor learning experience" to indicate a learning activity that takes place outside the classroom walls.

Outdoor Learning Experiences in this Study

Preparation is a necessary part of field trip implementation and can reduce the effect of novelty, which can interfere with learning. Falk, Martin, and Balling (1978) found that when initially exposed to a new learning setting, students experienced a decrease in learning outcomes, but after becoming familiarized, students were capable of greater mastery of concepts. Exposure to a novel environment, new content knowledge, and/or new experiences is known as the novelty space, and should be reduced to maximize learning potential (Orion, 1993; Orion et al., 1997). Orion's model of field trip structure promotes the reduction of novelty space through three phases, each of which takes place in a different learning environment: a preparatory unit (classroom or laboratory), the field trip (outdoors), and a summary unit (classroom or laboratory).

Orion's model was applied to the Earth systems science unit, which prepared students for making sense of phenomena they would encounter during a visit to a local rock quarry. This included classroom, laboratory, and outdoor activities regarding the interaction of Earth's subsystems, and the natural processes responsible for movement of geosphere material on and within Earth's surface. At the rock quarry, students encountered concrete opportunities to examine ways that components of Earth's systems were interacting, and to raise new questions regarding the deposition of rock material in a graded bed. In addition, students encountered machinery used to process and sort geosphere materials, and simulated this process during a hands-on activity. Students also considered the presence of lakes in the quarry. After this field trip, students spent the following weeks making sense of the rock quarry experiences through classroom and laboratory activities. This third phase moved students from the concrete foundation to more abstract concepts related to groundwater flow and deposition of sediment as a result of the interaction of parts of Earth's four systems.

Engagement and Contextualization through Outdoor Learning Experiences

In an Earth systems science curriculum, outdoor learning experiences play an important role in providing an authentic and relevant context in the local environment as the foundation for learning (Ford, 2003). In project-based science, this aspect of curriculum materials is referred to as contextualization (Krajcik et al., 2000). In addition, outdoor learning experiences in the local context can facilitate students' engagement in relevant science learning. "Something seen in its natural state arouses more enthusiasm than it does through the medium of written or photographic representation" (Sharp, 1988, p. 6). A study of the literature reveals that there is evidence to suggest that engagement with learning can be increased through experiences with relevant natural phenomena (Benz, 1962; Birnbaum, 2004; Brady, 1972; Disinger, 1984; Folkomer, 1981; Harvey, 1951; Hofstein & Rosenfeld, 1996; Kern & Carpenter, 1984; Koran & Baker, 1979; Michie, 1998; Mirka, 1970; Orion & Hofstein, 1991; Sisson, 1982; Smith, 2005). "Concrete objects that the children are in touch with most of their lives, have a greater meaning to them. They can visualize a greater relationship between what they are learning and real life situations" (McNamara, 1971, p. 18). Thus there is value to teaching young people how their school learning is related to life outside of school (Hammerman et al., 2001; McNamara, 1971).

Comparisons between Instructional Methods

Much of what is known about the value of field trips comes from research comparing instructional methods. Many of these studies are included in Mason's (1980a) annotated bibliography of research involving field trips with various age groups, Disinger's (1984) review of field trip studies between 1970 and 1984, and Friese, Pittman, and Hendee's (1995) review of studies regarding the use of the wilderness. Mason concluded that nearly all of the studies reviewed demonstrated that students learn well from field activities, and have increased motivation when learning outdoors. The majority of research involving outdoor learning experiences is in the context of isolated activities, and typically draws comparisons between different methods of instruction. This research is important for its contribution to our understanding of the value of such isolated experiences for student learning and engagement. However, the current study contributes insight into the role and value of integrated outdoor learning experiences.

In summary, additional work is needed in order to adequately evaluate the potential value of integrated field trips as a legitimate component of curriculum materials. Koran and Baker's (1979) literature review suggests that students demonstrate various types of outcomes as a result of field trips, yet knowledge gains are not consistently viewed as a legitimate rationale for using field trips as an instructional technique. Instead, for example, positive student attitudes towards such experiences are more commonly noted. This is one rationale for the current research study in which I demonstrate some of the different types of outcomes (Mason, 1980a) that students might demonstrate when using a curriculum that includes outdoor learning experiences integrated with other learning environments. The current study was not a comparison between teaching methods as others have conducted, but rather an exploration of the student outcomes—cognitive and affective—following an enacted science program. The apparent lack of value prescribed to educational field trips (Michie, 1998) suggests that there remains a minimal awareness of the potential value afforded to students by outdoor experiences. Specifically, the role that such experiences can play in promoting coherence (Kali et al., 2008b)in a curriculum has been unexplored.

Due to the focus and design of many past studies as comparisons between instructional methods, the potential value of integrated learning environments over an extended period of time has been largely unexplored. In addition, there are rarely sufficient details regarding the instructional methods or curricular materials used, which are discussed in detail in Chapter II. Thus, this study explores the student perspective of the role and value of outdoor learning experiences in the context of an Earth systems science unit about the local setting.

Methods

Research Questions

In this study, I explore two research questions: 1) *What are students' perspectives of the role and value of outdoor learning experiences in the context of the Earth systems science unit?* and 2) *did students demonstrate learning gains through the use of the Earth systems unit?*

Research Approach

I used a mixed methods approach similar to the work of Ben-zvi-Assaraf and Orion (2005a), in which quantitative and qualitative tools allowed for a "zoom-in approach." This involves collecting a large set of quantitative data from all participating students using pre-post Likert questionnaires and pre-post content knowledge assessments, and collecting qualitative data from a smaller subset of students through structured interviews before and after the curricular enactment. The combination of these data sources resulted in a rich perspective into student learning and their perspectives regarding the role and value of outdoor learning experiences in the Earth systems science unit.

Research Tools and Data Analysis

Quantitative data sources.

Students completed a content knowledge instrument pre and post enactment to allow for a comparison to determine the extent of learning gain or loss over the course of the unit. The instrument consisted of a combination of multiple-choice assessment items developed and under copyright by Project 2061 (American Association for the Advancement of Science) that have undergone a rigorous development and evaluation procedure (detail on this development process at http://www.project2061.org/research/assessment.htm), along with open-ended items developed for this study. The content knowledge instrument was limited to analysis of the identical items between the pre and posttest. The multiple-choice items were scored as correct or incorrect. The open-ended items (Appendix 3A) were coded using a rubric, developed after four iterations of revisions. Validity was determined by matching learning goals with questions. Inter-rater reliability was eventually 100% after discrepancies were iteratively resolved by consensus on 50% of the data.

Orion et al. (1997) developed and content-validated an instrument called the Science Outdoor Learning Environment Inventory (SOLEI) in Israeli high schools. This instrument (Appendix 3B) has been found to be sensitive for measuring the extent of students' involvement in the learning process during an outdoor learning activity by differentiating between active and passive learning. Active learning is correlated with constructivist approaches and the integration of field experiences with classroom activities. The authors suggest the potential of this instrument for use in studies of outdoor learning environments. Before the curricular enactment, the SOLEI was administered to all students who were instructed through verbal and written directions to consider their prior experiences with field trips when completing survey. Following the enactment, the SOLEI was administered again, and students were guided to focus on their experiences in the context of the Earth systems unit. The instrument was provided to students who read the items while Mrs. Hunter read each item aloud, and then paused to allow students to record their responses. This method increased the chances that students would complete the questionnaire carefully and completely, as the instrument was originally developed and field tested with older students. All data were entered into a database, and the Cronbach's alpha coefficients of reliability were calculated for one relevant scale of the post-enactment survey based on students' shared experiences. The scale regarding the integration of field trips with regular classroom activities had a Cronbach's Alpha coefficient of 0.7, which is acceptable according to Hatcher and Stepanski (1994). Orion et al. (1997) report a similar, but slightly higher Cronbach's alpha coefficient of 0.76 for their study conducted with 643 high school students. There is no evidence to suggest that there is a loss of this instrument's reliability along the integration scale with a younger sample population. The mean scores for the relevant scale of the SOLEI instrument were compared pre to post-enactment using a paired T-test and is discussed in the following section, and a distribution analysis was conducted for each item in the scale (Appendix 3E).

Orion and Hofstein (1991) developed an instrument to measure students' attitudes towards scientific field trips along five dimensions. They found that the instrument was sensitive for comparing students of different ages and gender. In this study, the instrument (Appendix 3C) was administered to students before and after the curriculum enactment to explore changes in students' attitudes toward science field trips. Similar to the SOLEI, the students' pre-test responses on the survey were based upon past experiences with field trips which all students had experienced throughout their school years, while directions during administration of the post-enactment survey guided students to focus on the Earth systems unit. The directions and each item on the inventory were written on the instrument, which was given to students, as well as read aloud by Mrs. Hunter. The Cronbach's alpha coefficients of reliability for the relevant subscales on the post-enactment survey were 0.9 for the learning tool scale, and 0.7 for the social aspect scale. Item #12 was excluded from all analyses for reducing the alpha coefficient substantially. These reliability coefficients were comparable to those reported by Orion and Hofstein (1991) which were 0.87 and 0.71, respectively. The mean scores for the two relevant scales of the attitude instrument were compared pre to post-enactment using a paired T-test and is discussed in the following section, and a distribution analysis was conducted for each item in the two scales (Appendices 3F and 3G).

Qualitative data sources.

In order to gain a better understanding of the rationale behind students' thinking, and their opinions of the curriculum and the content they learned, I interviewed a subset of twelve students, evenly distributed throughout the four classes, and with regard to gender and science ability as determined by Mrs. Hunter. Two students from each grouping were chosen for in-depth interviewing (Table 3.1). These same students were interviewed at the conclusion of the unit as well. All proper names used are pseudonyms. Several questions were added to the post-enactment interview protocol (Appendix 3D) in order to gather data on students' perceptions of their experiences throughout the curriculum unit. The interviews provided a more in-depth perspective than the quantitative instruments. This allowed for clarification and deeper probing into students' ideas.

Audio interviews were transcribed, while lengths of pauses and other noises (both verbal and non-verbal) unrelated to the content were irrelevant and excluded. Students' responses were examined for common themes across all interviews, regardless of the

Table 3.1 *Breakdown of Twelve Interviewed Students*

Science Ability	Male	Female
Low	Charlie Karl	Dana Fran
Medium	Greg Leo	Elizabeth Jessica
High	Andrew Isaac	Bethany Helen

probing question, facilitated by the qualitative data analysis software, NVivo. After all interviews were transcribed, I conducted a preliminary examination of the post-enactment interviews with all twelve students in order to identify salient categories. The unit for coding was an expressed idea (Minichiello, Aroni, Timewell, & Alexander, 1990) related to a thematic category. Each coding unit was assigned to free nodes that represent salient themes in students' expressed ideas. It was inappropriate to use common linguistic units, such as words, sentences, or paragraphs as the coding unit (Zhang & Wildemuth, 2009) due to the importance of context in the discussion of the themes during the interviews. The coding scheme was not mutually exclusive, and the expression of an idea was coded into as many categories as was appropriate. The data were dichotomous, in that each coding unit was determined to be either non-representative of a coding dimension (0) or representative of a coding dimension (1). Nine categories were identified (Table 3.2), and validity was established with another individual who confirmed that a subset of expressed ideas were themes present in the data corpus. Inter-rater reliability was completed for approximately 10% of the coding units by myself, and another individual (Ph.D. in Science Education). Cohen's kappa was calculated to determine the level of agreement between two sets of dichotomous data. The kappa statistic represents the approximate correlation between the scores of two raters. It was calculated as a means to determine the amount of improvement in agreement that both raters showed above chance, divided by the maximum amount of improvement in agreement that could have been shown (Wood, 2007). For this data, which represents 333 valid cases and opportunities for agreement, the kappa statistic was computed to be 0.860. According to Landis and Koch (1977), kappa statistics between 0.81 and 1.00 represent an "almost perfect" (p. 165) strength of agreement.

Table 3.2 *Thematic Categories and Coding Dimensions with Number of Coded References--Post-Enactment Interviews*

Theme	Description	# total references
Relevance	Experiences that are authentic, meaningful, and relevant to students' lives	94
Outdoor experiences as a tool	Outdoor learning experiences as a tool for concretization of science concepts	30
Interactions with phenomena	Students physically interacted with, and were involved with phenomena	31
Concrete experiences	Direct, firsthand, hands-on experiences with phenomena	70
Positive comparisons	Positive comparisons of unit activities with traditional science class experiences	34
Negative comparisons	Negative comparisons of unit activities with traditional science class experiences	3
Engagement	Outdoor learning experiences as fun, interesting, engaging, and a fun way to learn	43
Variety	Variety in the types of experiences, activities, and settings for learning	18
Coherence	Connections across the curriculum, between activities and amongst concepts	21

Quotes presented were used in two ways: 1) when the ideas expressed are representative of most students, and 2) when the ideas expressed represent an alternative perspective to the majority of students. It is important to note that students were unaware that I was the curriculum developer, only that I was a researcher studying how students were learning in their science classroom; therefore I do not believe students withheld their honest opinions regarding the unit.

An exploration of the interview data and survey data together provided greater insight into students' perspective of the role and value of outdoor learning experiences in the Earth systems science unit. The themes that emerged from post-enactment interviews revealed several of the salient aspects of the role and value of outdoor learning experiences from the students' perspective (Table 3.2), and this data was considered in relation to the survey data to identify students' perspectives of the role and value of outdoor learning experiences throughout the unit. The prevalence of the theme across the subset of twelve students is indicated in Figure 3.2. For example, certain themes arose in all interviews such as the relevance of the concepts students were learning to their lives, and the opportunities for authentic and firsthand interactions with phenomena throughout the Earth systems unit. Other themes were only expressed by a portion of the students. For example, 50% of the students (n=6) described connections between activities and concepts throughout the unit. However, the theme related to connections and coherence that arose throughout the interviews is aligned to the scale of the SOLEI that deals with connections between the indoor and outdoor learning experiences. Thus, this aspect of the data corpus highlights one example of the zoom-in approach, in which the large amount of quantitative data can be supported and explored in greater depth by the qualitative data. The analysis of the quantitative and qualitative data sources together also can be used to highlight salient aspects of students' perspectives regarding the ways in which the field trip is viewed as a tool for learning. One attitude survey scale focused on this aspect of the field trip, and the during interviews, students expressed their perception of the outdoor learning experiences as a way for them to learn. Therefore, the analysis of the qualitative data was investigated in relation to the survey data to explore themes more deeply.

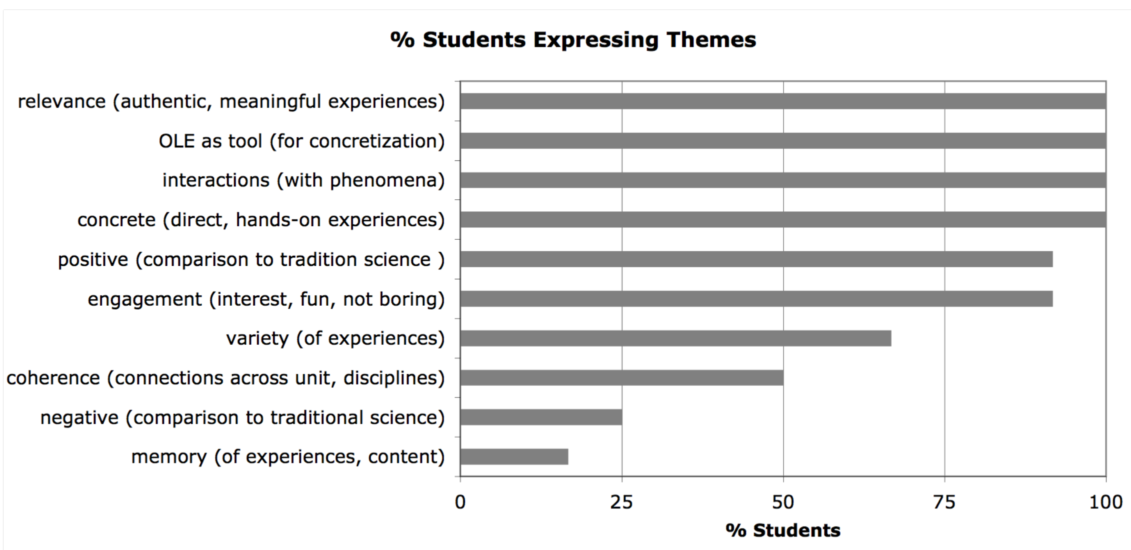

Figure 3.2. Percentage of students (n=12) who expressed each theme during the post-enactment interviews.

The frequency of expression also indicated the salience of each theme across all students (Figure 3.3). For example, while 100% of students expressed ideas related to their interactions with authentic phenomena during the unit, across all interviews, that theme arose 31 times. In contrast, the relevance was a much more frequently expressed theme with about 94 references across all interviews. However, due to the structured nature of the interview protocol, which probed specifically for students' perception of the relevance of the unit concepts to their lives, it is expected that all students would have discussed this theme, and that it would be referenced more times than other themes that emerged.

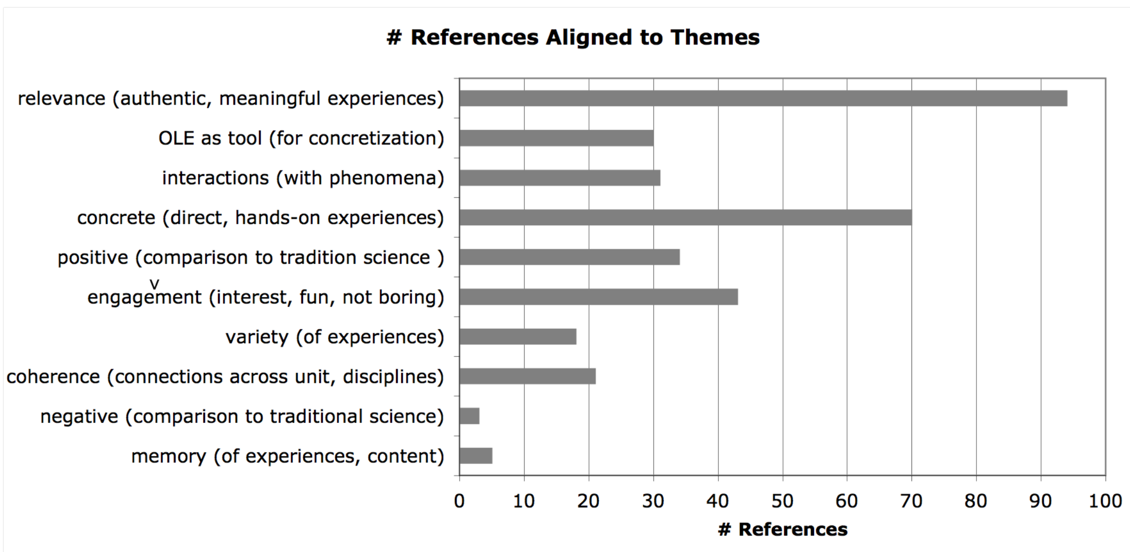

Figure 3.3. The number of references to each theme across all students (n=12).

Findings

Value and Role of Outdoor Learning Experiences

In order to explore the first research question regarding students' perspectives of the role and value of outdoor learning experiences in the unit, I triangulated between the quantitative and qualitative data sources. The quantitative survey data provided insight into the perceptions of the entire population of students, while the interview data provides more in-depth insight into the perceptions of the role and value of a small subset of the population. These findings suggest that outdoor learning experiences played an important role in fostering coherence throughout the unit, increasing students' engagement with learning, and concretizing science through opportunities to interact with phenomena directly.

Outdoor learning experiences foster coherence.

One role that outdoor learning experiences played in the Earth systems unit was in contributing to the sense of coherence throughout the unit. Specifically, one scale of the SOLEI measured students' perceptions of the integration between indoor and outdoor learning activities. Due to the design of this study as a pre-post enactment comparison with the same group of students, I conducted a dependent samples t-test of the integration scale on the SOLEI data. This test accounts for the differences in mean scores from pre to post-enactment for each individual student, and is appropriate as the data are normally distributed for this scale. A comparison of the pre and post-enactment means across the sample of students revealed statistically significant differences with $t(107) = 5.75$, $p < 0.001$, with a change in the positive direction (Table 3.3).

Table 3.3 *SOLEI Means for Integration Scale--Pre to Post-Enactment Comparison Using a Paired t-test. Likert scale 1-5*

SOLEI Scale	# Items	df	Mean (SD)		ΔMean (SD)	*t*	*p*-value
			Pre	Post			
Integration of field trip and regular classes	9	107	3.56 (0.47)	3.86 (0.50)	0.30 (0.55)	5.75	< .001

A distribution analysis for each of the survey items in the integration subscale (Appendix 3E) indicates the strong level of students' agreement with the items. These findings are in alignment with the curriculum design principle inherent in Orion's (1993) model of the development and integration of outdoor learning experiences with classroom and laboratory activities.

A further exploration of the SOLEI integration scale stratified by students' ability level according to Mrs. Hunter revealed that the change in means from pre to post-enactment was statistically significant for a subset of the students, specifically, the medium, high, and very high ability students (Table 3.4).

Table 3.4 *Stratified Analysis by Ability Level Comparing Mean Scores for the SOLEI Integration Scale using a Paired t-test*

SOLEI Scale	Ability Level	df	Mean (SD)		Δ Mean (SD)	*t*	*p*-value (2-tailed)
			Pre	Post			
Integration of field trip and regular classes	Medium	49	3.65 (0.46)	3.86 (0.51)	0.21 (0.56)	2.6	.012
	High	21	3.52 (0.44)	3.97 (0.46)	0.44 (0.54)	3.9	.001
	Very high	19	3.43 (0.48)	4.01 (0.34)	0.58 (0.43)	5.9	< .001

Next, I noted the expression of a coherence theme throughout the interview data with a subset of students (Figures 3.2 and 3.3). The role of outdoor learning experiences in fostering connections between concepts and activities was an aspect of some students' experiences. Fifty percent of the interviewed students (n=6) expressed perceptions of outdoor learning experiences as fostering connections and coherence throughout the unit.

As Mrs. Hunter had divided students into three ability groups (low, medium, high) for the interviews, I explored the average number of expressions of the coherence and connections theme in the interviews (Figure 3.4), and found that only the medium and high ability students cited this aspect of their experience regarding outdoor learning experiences in the unit. In order to determine if the apparent differences between these three ability groups was statistically significant, I conducted a nonparametric Kruskal-Wallis test. This test was chosen because of the small sample size (n=12) of the interviewed students, and the sample size of each ability group (n=4). Due to the small sample size, the data are not normally distributed. The Kruskal-Wallis test is the nonparametric equivalent of conducting an ANOVA, which assumes normality. This test converts the number of observations of the coherence theme in the interview data into ordered ranks, and compares the mean of the rank for each group to determine if they are equivalent. For example, for the medium ability students, two students had no expressions of coherence in their interviews, one had two expressions, and one had six expressions. When placed in rank order with the entire sample of twelve students, the average rank was 6.63 (3.5+3.5+7.5+12/4)[*]. This test revealed that for the coherence

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[*] Data Table for Determination of Kruskal-Wallis Average Rankings

Order	1	2	3	4	5	6	7	8	9	10	11	12
Rank	3.5	3.5	3.5	3.5	3.5	3.5	7.5	7.5	9.5	9.5	11	12
Obs.	0	0	0	0	0	0	2	2	3	3	5	6
Group	low	low	low	low	med	med	med	high	high	high	high	med

theme across all twelve interviewed students, the differences in the mean ranks were statistically significant (Table 3.5). The raw data for each student's expression of ideas is included in Appendix 3F.

Table 3.5 *Nonparametric Kruskal-Wallis Test (n = 12)*

Ability Level	n	Observations (# expressions of coherence theme)	Mean Rank	χ^2	*p*-value
Low	4	0, 0, 0, 0	3.5	6.11	.047
Medium	4	0, 0, 2, 6	6.63		
High	4	2, 3, 3, 5	9.38		

Note. Observations represent the raw data, which is the number of times the coherence theme was mentioned in each interview. The mean rank is the average of the ordered position of the observations for each ability group.

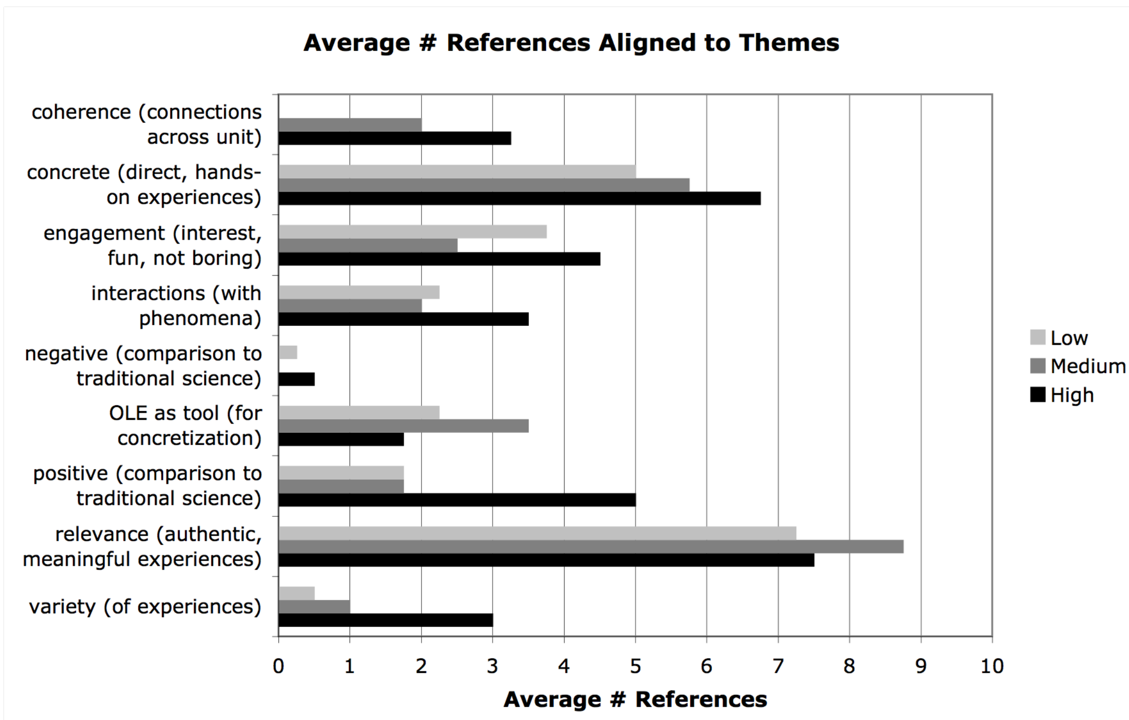


Figure 3.4. Average number of expressions of each theme according to students' ability level.

Given the findings from the SOLEI data and interview data, I found alignment amongst these sources in regard to the theme of coherence and connectedness. In other words, the salient finding regarding the differences between ability groups along the theme of coherence and connections from the SOLEI survey was supported by the data from the subset of interviewed students, which indicated that higher ability students were more aware of coherence throughout the unit and the connections fostered between indoor and outdoor learning activities. Specifically, six students expressed this theme during their interviews. This finding was limited to the medium and high ability students, with none of the lower ability students referencing this aspect of the role of outdoor learning experiences in the unit.

A brief survey of students' field trip experiences prior to the onset of the Earth systems enactment revealed a large number of isolated experiences that were likely unrelated to and disconnected from the curriculum (Table 3.6). Outdoor learning experiences, such as the type students participated in throughout the Earth systems unit, were not mentioned as prior experiences. It is likely that the statistically significant change in students' perceptions of the integration of fields trip and indoor activities is due to the types of prior field trip experiences they had encountered. Students seemed to have expressed an awareness of the contrast between prior experiences and the outdoor learning activities that took place in the Earth systems unit. More importantly, this contrast was in a positive direction.

Table 3.6 *Students' Prior Field Trip Experiences*

Type of Field Trip	Examples of Personal Experiences Listed by Students
Museums	• Planetarium • Zoo • Creekside museum
Agricultural activities	• Apple orchard • Pumpkin patch • Corn maze
Outdoor education	• 5th grade camp • Kirkdale Park • Highland Nature Center
Industrial plants	• Dairy Queen • Jiffy muffins plant
State government	• Jail house • Police station • State capital
Recreational	• Rollerama • Picnic • Hockey game

Thus, students described the role of outdoor learning experiences as fostering a sense of coherence throughout the unit during their interviews. For example, Andrew explained why he believed the field trip to the rock quarry was important to the unit. "I think it was important to the unit cause later we said a lot of stuff about the quarry. Like the experiments and stuff like the one we just did about sampling the water" (Interview with Andrew, 5/28/09). Andrew was aware of the connections to the quarry that were made upon returning to the classroom and laboratory. Specifically, he linked the collection of lake water from the rock quarry to testing this sample's water quality following the visit.

Greg was unable to attend the rock quarry field trip. I asked him how that trip may have been important to the unit, and he responded by explaining that there were connections fostered after that experience.

Greg: Because a lot of things that we are doing now was based on that. Like a lot of, towards the end, in the first couple weeks after that, we did a lot towards that from it.

Researcher: From the field trip?

Greg: Yeah. What we learned and saw there. (Interview with Greg, 6/1/09)

Greg recalled that the concepts they were learning about towards the end of the unit were based on the rock quarry trip, and the experiences students had during that trip. Later in the interview, Greg described his prior experience during a field trip to a museum, which he explained was unrelated to what he was learning in school.

Researcher: Okay. And which of those do you think would help you learn the least?

Greg: Field trips to museums. Cause sometimes, like for instance when I was in another grade we would be learning about something on a total different topic and then we would just go somewhere say like the Henry Ford Museum and it had nothing to do with it.

Researcher: Okay. … How do you think a field trip outdoors is different from that experience?

Greg: Cause when we're going outdoors, I mean in the classes, we're actually going to the place where it all kind of starts happening. Cause when it's in science it's just more easier, cause you're actually you're not going off topic and stuff. You're going to the place. (Interview with Greg, 6/1/09)

Greg explained that his prior experience with a museum field trip seemed isolated from the school curriculum. In contrast, he described the outdoor learning experience has integrated and connected to the topics students had been learning about in science class at the time. Thus, some students noted the clear connections between the indoor and outdoor experiences in the Earth systems unit.

Isaac described his perception of the role of the outdoor learning experiences in the unit, and expressed some frustration at the interconnectedness of the activities in that missing a day could be difficult for later activities. “It seemed like you had to keep data and… remember the data that you had and you had to keep flipping back to the pages. It seemed like if you were absent one day it would really screw you up” (Interview with Isaac, 5/28/09). Although Isaac expressed difficulty with missing school due to the coherence of the unit, he later explained how the rock quarry trip specifically, was important to the unit.

Researcher: Do you think that that field trip to the rock quarry was important to the unit?

Isaac: Yeah because it, in the book after that, they related back to it a lot and it kind of gave you the idea of how the--of what they do with rocks and why it’s actually, why rocks matter in some ways. (Interview with Isaac, 5/28/09)

Isaac took the theme of coherence one step further than all other students when he highlighted a connection between science and social studies after I asked him about what makes up the Earth system.

Isaac: Well the rock cycle and water cycle, the carbon/oxygen cycle which we learned about in social studies and that’s like how the Earth recycles carbon from cars, and trees take in the carbon and they put out oxygen when humans use it. It’s what we breathe out--carbon and it’s kind of like the trees and the humans both giving out something that the other one needs. And the other person takes in what the other thing gives out. If one of them were to be wiped out then the other one would to. (Interview with Isaac, 5/28/09)

Being able to make connections between different disciplines is a greater extension of the coherence theme expressed by students during the interviews.

As a counter example, when Jessica was asked about the importance of the rock quarry trip, she stated that there was no connection, and that that experience was not important to the unit.

Researcher: Do you feel like that field trip to the quarry was important for the whole unit?

Jessica: Not really because we did other things, like what’s beneath my feet, and other things. It didn’t really relate to the rock quarry.

Researcher: Okay, so other activities you did in school weren't related to the rock quarry?

Jessica: No. (Interview with Jessica, 5/29/09)

Interestingly, Jessica's mention of "What's beneath my feet" was the subquestion that guided the entire rock quarry field trip, yet she explicitly stated that indoor activities were unrelated to the visit to the rock quarry. Thus, connections made by Mrs. Hunter during the curricular enactment did not reach all students.

Outdoor learning experiences promote interactions with phenomena.

One idea that was expressed by all students was that the Earth systems unit was active and involved learning activities that required students to physically interact with materials, rather than reading and writing exclusively. This physical activity occurred both within the classroom setting, and outdoors. Bethany emphasized the outdoors when she described the interaction.

Researcher: I want you to be honest and tell me what was your opinion of the Earth science unit that you're just about to finish?

Bethany: I find it more interesting than other science classes partially because there was more labs and interaction stuff. And instead of just looking at pictures and stuff, we actually went there and saw it for ourselves. And we were more independent with our things instead of just be given stuff and expecting to know it by just looking at pictures or being told. (Interview with Bethany, 5/29/09)

Bethany connected her interest level with this unit specifically, to the laboratory and outdoor activities in which she had the opportunity to interact with concrete materials. She liked the level of independence that she experienced while outdoors, and contrasted this to being given pictures, or being lectured by the teacher. Later, Bethany stated, "there's more distractions outside but it's really nice being out there instead of just staying in the classroom and just looking at pictures and stuff. Seeing it is actually, like having an interaction is better. Cause I understand it better" (Interview with Bethany, 5/29/09).

Students mentioned that collecting samples was an aspect that they liked about the outdoor learning experiences during the interviews, without being prompted. The following quotes represent students' ideas regarding the collection of samples to work with in the classroom.

Researcher: So you went outside several times during the unit, just around the school grounds. What did you like about going outside and why?

Greg: How we got to collect samples and stuff, and actually test on it and stuff like that. Like how we used the acid on some of the rocks, and taste the salt. (Interview with Greg, 6/1/09)

The details that Greg provided as to why he liked collecting samples deal with the sensory perceptions of the experience. When he was outside, he collected samples, and tested them by putting acid on the rocks, and tasting them. The reaction between acid and rocks produces a fizzing sound, and bubbles appear, while other rocks taste salty due to their mineral composition. These experiences are enjoyable to students due to their concrete and heavy sensory nature.

Jessica had similar opinions regarding the collection of samples during outdoor learning activities, specifically in relation to how that could help her learn about her environment.

Researcher: Which, if any of these, do you think could help you learn about your environment?

Jessica: Field trips outdoors. Cause you can go outside and you can actually do hands-on things about the things around you, like rocks, you can take them and do tests on them in the water and do different tests on the water and the rocks. (Interview with Jessica, 5/29/09)

She explained that collecting samples, such as water and rocks could help her learn about her environment. She described collecting samples as a hands-on activity. In summary, the themes related to students' interaction with phenomena through hands-on, direct experiences were prevalent in their perceptions of the role and value of outdoor learning experiences. Students of all ability levels described this aspect of the field trip.

Outdoor learning experiences foster the fun of learning.

I conducted a dependent samples t-test to compare the pre-post mean scores for the sample of students. This test accounts for the differences in mean scores for each individual student, and is an appropriate test to use due to the normal distribution of the corpus of data. Comparisons of students' mean responses for two scales of the attitude survey were explored, and students had shifting attitudes along both dimensions, which included their view of the field trip as a learning tool, and the social aspect of the field trip (Table 3.7). This suggests another perceived value of the field trip from students' perspectives is as a tool for learning in the context of science class.

The positive difference in mean for the learning tool scale ($t(106)=3.13$, $p = .002$) indicated that the post-enactment scores were higher than the pre-survey scores. In other words, students' perspectives of the field trip as a learning tool increased significantly from pre- to post-curriculum enactment. It is important to note that students had a relatively high level of agreement with the learning tool items on the pre-enactment

Table 3.7 *Comparison of the Attitude Means Using a Paired Samples t-test. Likert scale 1-4. N = 107*

Scale	# items	df	Mean (SD)		Δ Mean	*t*	*p*-value (2-tailed)
			Pre	Post			
Learning Tool	12	106	3.18 (0.42)	3.30 (0.44)	0.11	3.13	.002
Social Aspect	6	106	2.72 (0.54)	2.55 (0.50)	-0.17	-4.06	< .001

survey, but that these attitudes still increased substantially throughout the Earth systems unit. The mean difference for the social aspect scale is negative ($t(106) = -4.06$, $p < .001$), meaning that the pre-enactment scores were higher than the post-enactment scores. This is a move in a positive direction, in that the outdoor learning experiences were not seen primarily as a time for students to be social, but rather these were experiences meant to help students learn concepts in the context of science class.

Again, I found alignment between the attitude survey data and the interview data. For example, the role of outdoor learning experiences in fostering a more engaging learning experience arose across 92% of the students interviewed. This was also the third most frequently expressed theme. Additionally, the outdoor learning experiences as a tool for learning through exposure to concrete phenomena was expressed by 100% of the interviewed students. Greg shared both what he liked, and why he liked the activities that involved the outdoor learning environment.

Greg: I liked when we went to the lake and how we got to show the kind of things that we got to do, like illustrations that we made and stuff, the construction paper. How we got to go outside a lot.

Researcher: Okay. And can I ask why you liked that? Going outside?

Greg: It was just more easier to explain stuff, to get it and understand it and stuff. And more funner than just writing, handwriting. (Interview with Greg, 6/1/09)

Greg described how he liked that he had the opportunity to visit a lake outdoors, and then illustrate what he had learned about the lake by making a poster when he returned to the classroom. Greg provided an affective reason for liking the outdoor learning experiences when he stated that it was more fun than writing, but he also provides a cognitive reason in that going outside made it easier to explain and understand the subject matter. This affective-cognitive connection is a trend throughout students' interviews. Greg's positive opinions were linked to understanding the conceptual content of the unit, and the engaging experience of going outside.

Researcher: Okay. Which of those activities on this list do you find most enjoyable?
Fran: Two actually. Hands on activities and field trips outdoors.
Researcher: Okay. And can you explain why you like those?
Fran: Cause field trips outdoors you learn and as you learn you're still having a lot of fun. (Interview with Fran, 5/28/09)

Similar to Greg's perspective of having fun while learning, Fran also expresses this idea in which she sees a visit outdoors as a learning activity, but mentions that she can still have fun while learning.

Elizabeth was another student who liked the experience of going outside as part of the learning activities. When asked what she would tell a younger student about this unit they might use next year, Elizabeth explained, "I would say that it's my favorite topic we did. It would probably be yours. We get to go outside and we got to go on a field trip and stuff" (Interview with Elizabeth, 5/29/09). The outdoor activities were mentioned in relation to this topic being her favorite that she had studied during the school year.

Helen described her overall positive opinion of the unit, and specifically the outdoor learning experiences by explaining why she thought they helped her learn.

Helen: I think it was pretty well done cause we got to go outside and do different things.
Researcher: So why do you think going outside helps you learn? What about it helps you learn more?
Helen: Cause like you have the fresh air so your brain would probably be working better and then you'd be having more fun and I pay attention to when they're talking, when the teacher is talking and stuff. And it seems like the teachers also enjoy it better. (Interview with Helen, 5/29/09)

This conversation with Helen provided a novel insight into the perception of her teacher's attitudes. She believed Mrs. Hunter enjoyed teaching outside more than inside the classroom. Helen may have picked up on subtle differences in Mrs. Hunter's attitude allowing her to compare her experiences indoors and outdoors. Another student, Bethany summarized her opinion regarding the importance of engagement in association with learning when she stated, "I don't think anybody wants to learn anything from anything that's boring" (Interview with Bethany, 5/29/09).

In addition, a stratified analysis of the attitude survey was conducted to explore whether specific groups of students experienced changes in attitudes throughout the curricular enactment (Table 3.8).

Table 3.8 *Stratified Analysis of Differences in Mean Scores Using a Paired t-test*

Attitude Scale	Ability Level	df	Mean (SD)		ΔMean (SD)	*t*	*p*-value (2-tailed)
			Pre	Post			
Learning Tool	High	21	3.17 (0.45)	3.29 (0.53)	0.125 (0.26)	2.24	.036
Social Aspect	Very high	19	2.73 (0.59)	2.48 (0.57)	-0.250 (0.23)	-4.81	< .001

The high ability students had significant differences in their mean scores for the field trip as a learning tool scale ($t(21)=2.24$, $p = .036$). The positive difference in the mean score for the learning tool scale indicated that higher ability students were more apt to view the field trips that were part of the curricular unit as a learning tool compared to their prior experience with field trips, such as those listed in Table 3.6. The very high ability students had a negative change in their view of the field trip as a social event ($t(19)= - 4.81$, $p < .001$). This change is regarded as positive from the perspective of learning embedded in the school setting, in which the focus should not be on the social aspects of the field trip, but rather on the field trip as a tool to promote more concrete learning.

In summary, the first research question asked *what are students' perspectives of the role and value of outdoor learning experiences in the context of the Earth systems science unit?* The data indicate that: 1) outdoor learning experiences can promote coherence within a curricular unit; 2) higher ability students were more aware of the connections between activities and learning environments than the lower ability students, as determined by the SOLEI data for all students, and confirmed by the interview data with a subset of students; 3) students explained that outdoor learning experiences promote the direct interaction with phenomena; 4) outdoor learning experiences are regarded as a tool for learning, but also enhance students' engagement, or fun of learning; and 5) higher ability students were more aware of the ways in which the outdoor experiences could be used as a tool for learning, and regarded field experiences less as a social event.

Student Learning in the Earth Systems Science Unit

The second research question focused on student learning across the population of students, and the findings from the content knowledge assessment are presented which represent students' learning gains over the course of the enactment.

Again, Mrs. Hunter characterized each student based on her perceptions of their ability levels. These groups were used to stratify students' mean pre and posttest content knowledge scores (Table 3.10). The mean change from pretest to posttest are presented. Figure 3.5 presents the data from Table 3.10 so that trends in the content knowledge assessments can be observed more readily. Due to the normal distribution of the data, the sample size, and the pre-post design of the study, I conducted a dependent samples t-test, which compared the pre-post enactment test scores for each individual. For the entire sample of students, $t(110)=21.5$, $p<.001$). These findings indicate that students of all scientific abilities achieved positive learning gains in content knowledge as determined by a comparison of the mean pretest and posttest scores.

However, there was a small sample size for the very low and low ability students. Therefore, I conducted a nonparametric Wilcoxon signed ranks test which can determine if the differences from pre to posttest were significant for small sample sizes in which the data is not assumed to be normally distributed, and for which the data are paired, or dependent. A nonparametric Wilcoxon test for the group of very low ability students revealed that the mean gain was not statistically significant ($p = 0.07$). A Wilcoxon test for the low ability students revealed that the mean gain on the content knowledge assessment was significant ($p=.007$).

I conducted a dependent sample t-test for the medium, high, and very high ability groups due to the larger sample sizes, and the satisfied assumption of a normal distribution. Due to the paired nature of this test, it is used to compare the pre and posttest scores for each individual student. The t-test revealed significant mean differences from pre to posttest scores for these three groups of students (Table 3.9).

To determine how substantial these content knowledge gains were, I calculated the effect sizes for each stratum of ability level. The effect size is calculated as the difference in the means scores divided by the standard deviation of the pretest score (Hojat & Xu, 2004). These effect sizes were quite large, according to Cohen's convention and interpretation of effect sizes in which 0.2 is considered a small effect, 0.5 is considered a medium effect, and 0.8 is considered a large effect (Cohen, 1988). The effect sizes for this student population ranged from 1.3 to 2.3, all of which can be considered extremely large effect sizes of crucial importance. However, it should be noted that these conventions for determining the meaning of an effect size typically pertain to studies in which there is a control group and a treatment group. Studies involving a pre-posttest design typically demonstrate large effect sizes due to the lack of a control group. Ideally, effect sizes would compare the meaningful significance and effectiveness of this curricular unit, compared with a group of students who did not use the unit. However, this study was designed to explore the use of a unit that integrates outdoor learning experiences in order to determine the role and value that such experiences can play in a formal education program. Therefore, for the very low ability students, there was a large effect size (1.3), although this was not statistically significant due to low power (n=5). For the low ability students, the effect size was only slightly larger (1.5), and here was significantly different ($p < .01$) because of greater statistical power (n=11). For the average, high, and very high ability students, the statistical power was sufficient ($n > 20$ for all groups), and the mean learning gains were statistically significant with a substantial effect size in all cases.

Thus, this data indicate that all students achieved learning gains over the course of the eight-week Earth systems science unit, as measured by the content knowledge assessment. Nearly all students demonstrated statistically significant learning gains as a result of this intervention. The very low ability students, for which there were only five in the entire sample population, demonstrated learning gains, for which the learning gains approached significance ($p = .07$).

To reiterate, the focus of this Chapter is on the experiences of the students who used the designed curriculum, rather than a comparison of various instructional methods. Therefore, it is important to be able to demonstrate that most students can achieve significant and substantial learning gains with such a curriculum that uses an Earth systems approach, and that integrated a variety of learning tasks including those in the

Table 3.9 *Mean Test Scores (out of 26) and Change for All Students, and Stratified by Ability Level. Wilcoxon Test (ability = 1, 2) and Paired Samples t-test (ability = 3, 4, 5)*

Science Ability	df	Mean Score (SD)		Δ Mean (SD)	Test Statistic	*p*-value (2-tailed)	Effect Size
		Pretest	Posttest				
All students	**110**	**12.0 (3.3)**	**18.8 (3.7)**	**6.8 (3.4)**	**t =21.5**	**< .001**	**2.0**
1 (very low)	4	8.8 (2.2)	12.8 (5.0)	4.0 (3.2)	Z = -1.8	.070	1.3
2 (low)	10	8.9 (2.8)	15.9 (4.0)	7.0 (4.8)	Z = -2.7	.007	1.5
3 (average)	51	11.2 (2.8)	18.7 (3.3)	7.5 (3.3)	t = 16.3	< .001	2.3
4 (high)	22	13.7 (2.4)	19.8 (2.7)	6.2 (2.7)	t = 10.8	< .001	2.3
5 (very high)	19	14.7 (3.0)	21.2 (2.2)	6.5 (3.0)	t = 9.9	< .001	2.2

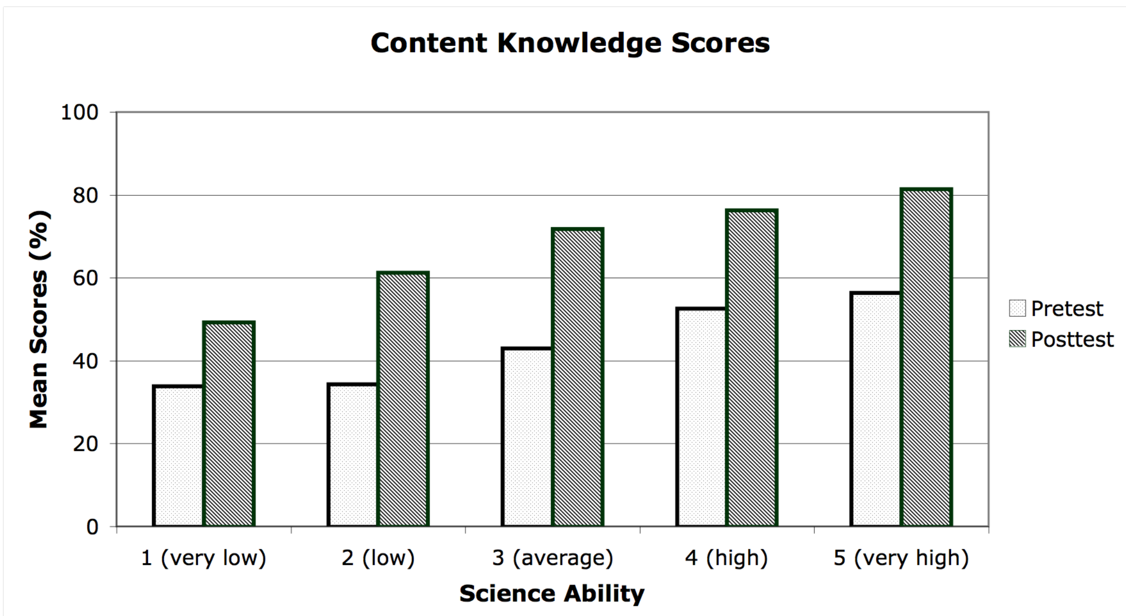


Figure 3.5. Mean pre and posttest scores stratified by ability level in science.

classroom, laboratory, and outdoor learning environments. In addition, this data suggests that students of all ability levels from very low to very high can achieve learning gains with a curriculum of this type. The data indicated that this type of curriculum succeeded in addressing the needs of students at all ability ranges. The gradual progression of ideas from concrete to abstract, as fostered by the outdoor learning experiences, was found to be applicable for all students.

The posttest contained an additional seven items that measured students understanding of the conservation of rock and water within the Earth system (Table 3.10). The desired response for each item is “stays the same”.

Table 3.10 *Conservation of Matter Items on Posttest Content Knowledge Assessment*

When water evaporates, the TOTAL AMOUNT of water in the Earth system (increases, decreases, stays the same).
When rock is mined at a quarry, the TOTAL AMOUNT of rock in the Earth system (increases, decreases, stays the same).
When water precipitates, the TOTAL AMOUNT of water in the Earth system (increases, decreases, stays the same).
When a volcano erupts, the TOTAL AMOUNT of rock in the Earth system (increases, decreases, stays the same).
When water infiltrates into rock, the TOTAL AMOUNT of water in the Earth system (increases, decreases, stays the same).
When rocks are weathered in a river, the TOTAL AMOUNT of rock in the Earth system (increases, decreases, stays the same).
When sediment is deposited in a lake, the TOTAL AMOUNT of rock in the Earth system (increases, decreases, stays the same).

The total number of correct responses for this set of items was recorded, and the mean scores for this set are included in Table 3.11 for all students, and for each ability level stratum (Figure 3.6). When only the students who responded, “stays the same” to all seven of these items are isolated, they all fall into the medium, high, and very high ability levels (Table 3.11). The percentage of students answering all of these items correctly within a particular stratum increases with ability level.

Table 3.11 *Mean Scores (out of 7) for Conservation of Matter Items, Stratified by Ability Level (n=111)*

Science Ability	n	Mean score	Mean score (%)	# (%) students scoring 100%
All students	**111**	**4.4**	**62.1**	**29 (26%)**
1 (very low)	5	1.6	22.9	0 (0%)
2 (low)	11	2.2	31.1	0 (0%)
3 (average)	52	4.0	56.9	10 (19%)
4 (high)	23	5.4	77.0	8 (35%)
5 (very high)	20	6.0	85.7	11 (55%)

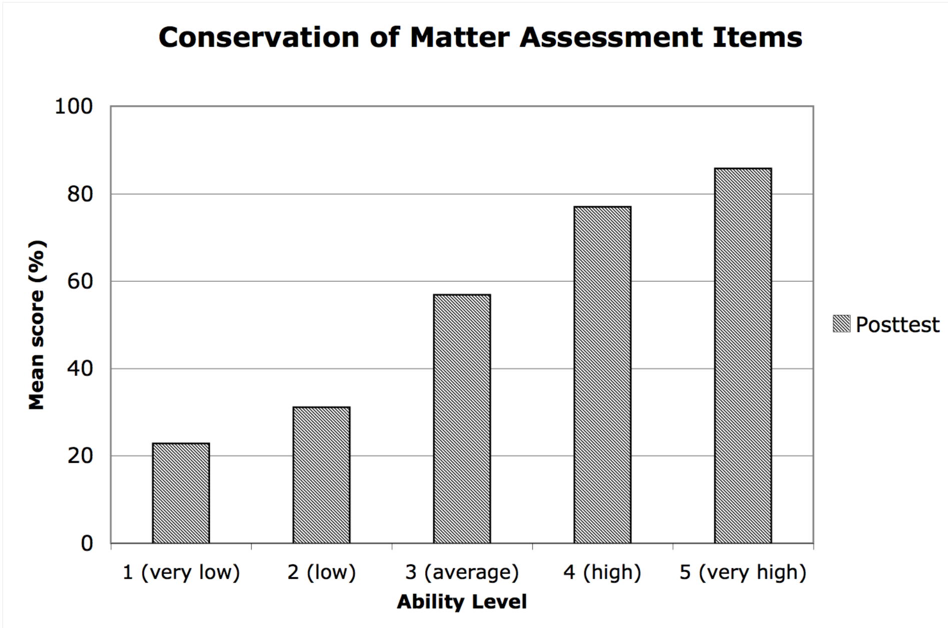


Figure 3.6. Mean scores (%) for the seven conservation of matter questions on the posttest.

Students' actual responses to this set of seven conservation of matter items are shown in Table 3.12. The percentage of students who responded to each item with increases, decreases, or stays the same is presented.

Table 3.12 *Students' Responses to Conservation of Matter Items (n=111)*

Conservation of matter item (Table 14)	% of students answering INCREASES	% of students answering DECREASES	% of students answering STAYS THE SAME
Water evaporates	5.5	27.3	67.3
Rock mined at quarry	7.5	30.8	61.7
Water precipitates	25.7	9.2	65.1
Volcano erupts	49.5	11.7	38.7
Water infiltrates into rock	11.7	19.8	68.5
Rocks weathered in a river	13.5	17.1	69.4
Sediment deposited in a lake	20.7	10.8	68.5

This data suggests that that when students did not have a clear and applicable understanding of principle of conservation of rock and water in the Earth system, they responded to these statements using logic about what happens to rock and water on a smaller scale, given the processes described. Nearly a third of the students answered that rock mined at a quarry will decrease the total amount of rock in the Earth system. If students were answering these items while thinking of a smaller scale as previously discussed, then it would be logical for students to say that mining rock from a quarry will lead to a decrease in the total amount of rock, at that quarry. An alternative explanation for this finding, given the amount of time spent discussing this setting, and the field trip to the rock quarry throughout the unit, is that students considered how rock is used, after it is mined. A considerable amount of time was spent discussing the importance of rock to society. Students experienced an outdoor learning activity during the first half of the unit in which they explored the school grounds, and came up with a list of objects in their surroundings that are made of natural materials from the Earth. This list included objects such as sidewalks, asphalt, light posts, a water tower, and bricks that make up the school building. If students remembered this activity and reasoned that those objects in their surroundings are no longer considered "rock", but rather asphalt, or bricks for example, then I expect that they would have been more likely to respond that rock mined at a quarry results in a decrease in the total amount of rock in the Earth system, as 30% of the students responded.

Reasoning that the total amount of water and rock in the Earth system will stay the same, regardless of the processes taking place, is a skill that requires one to consider an entire system, or in this case, subsystems, such as the hydrosphere or geosphere, as well as the entire Earth system. This data indicate that the higher ability students were more able to access this skill when considering the conservation of matter in regards to the hydrosphere and geosphere systems in the context of the Earth system.

In summary, the second research question asked *did students achieve learning gains through the use of the Earth systems unit?* The data indicate that: 1) all students achieved learning gains as measured by the pre and posttest; 2) with the exception of the very low ability students, all students achieved statistically significant and substantial learning gains; and 3) higher ability students were better able to answer questions related to systems thinking skills and the principle of conservation of matter than the lower ability students.

Discussion

This chapter explored two questions: 1) *What are students' perspectives of the role and value of outdoor learning experiences in the context of the Earth systems science* *unit?* and 2) *did students achieve learning gains through the use of the Earth systems unit?*

Role and Value of Outdoor Learning Experiences

The quantitative survey data, combined with the qualitative interview data provided insight into students' perspectives of the outdoor component in the context of an Earth systems science curriculum unit, and extends our understanding of the contribution of the outdoors to education. One aspect of students' perspective on the role of outdoor activities was in the fostering of connections and coherence throughout the unit. Orion et al. (1997) described the sensitivity of the SOLEI for differentiating between various educational approaches. For example, their study demonstrated that students participating in a more passive approach to a field trip expressed less agreement regarding the level of integration between the outdoor and indoor activities, compared with students who participated in a more active field trip experience.

In the current study, I compared students' perceptions before and after a curricular enactment, and found that there was a significantly positive change in students' ideas regarding integration. Given students' reports regarding the isolated field trips they had experienced prior to the beginning of the unit, and the design principle of integrating field experiences with classroom and laboratory experiences, this is not a surprising finding. Specifically, the role of outdoor learning experiences for fostering coherence has not yet been explored and therefore provides evidence that extends the claims about the ways in which to develop coherence made by Roseman et al. (2008). Direct experiences with sensory-rich phenomena (Dewey, 1902) during outdoor learning experiences integrated with indoor activities (Orion, 1989) are one way to promote coherence. By surrounding students with relevant phenomena in their local surroundings, this study found students can develop connections and interrelationships between scientific concepts, activities, and between these concepts and their personal lives in the context of a constructivist framework, by extending the work of Singer et al. (2000) to a novel learning setting—the outdoors.

Further, a new finding related to this aspect of the role of field trips is that lower ability students were less aware of the integration between indoor and outdoor activities, and of connections between ideas throughout the unit, compared with the medium and higher ability students. This finding was in alignment to the qualitative interview data, strengthening the validity of this finding. As coherence was a design principle used during the development of the Earth systems science unit, this finding suggests that curricular coherence (Roseman et al., 2008) must be well-supported, both within printed curriculum materials, and by teachers, in order for all students to benefit from the connections that a coherent unit can foster. Coherently designed curricula can provide opportunities for students to develop integrated understanding as opposed to a more piecemeal collection of unrelated ideas (diSessa, 2006). These connections are important for helping students learn and to eventually become aware of the relevance of science content to their personal lives (Krajcik et al., 2000; Singer et al., 2000). This study found that some students need extra support in developing links and making connections between interrelated ideas. This is an important finding as it can guide a teacher in providing more explicit support to foster the development of connections between ideas to reach all students. Richardson (1996) highlights the important influence of working with diverse students on teaching practice. Awareness of the needs of different students is not only an aspect of the need for developing pedagogical content knowledge, but also an issue relating to promoting coherence and connectedness among all students (Cochran & Jones, 1998). Such support would ideally be in the form of educative features (Ball & Cohen, 1996; Davis & Krajcik, 2005) within curriculum materials, that offer suggestions to the teacher for guiding lower ability students to also make such connections, while also developing a teacher's pedagogical knowledge. These educative features in curriculum materials should be combined with other forms of support, such as professional development activities (Putnam & Borko, 2000), and opportunities to observe other teachers promoting coherence.

The interview data revealed that students view one valuable aspect of outdoor learning experiences as promoting and providing opportunities to interact with phenomena. This is aligned to research on the theoretical understanding of the role of field experiences in providing firsthand and direct exposure to phenomena (Bransford et al., 2000; Dewey, 1902; Krajcik et al., 2000; McNamara, 1971; Orion, 1993; Piaget, 1955). Such activities allow students to build understanding upon concrete and authentic interactions (Hammerman et al., 2001; Orion & Kali, 2005). One well-accepted role of outdoor learning experiences is in providing access to concrete experiences, and the findings from this study demonstrated that students are aware of, and value this aspect of field trips. However, students must also use their minds while conducting such activities. Conducting hands-on activities outdoors alone, is insufficient for meeting goals of science education (O'Neal, 2003). Rather, students must be guided in fostering the construction of personal meaning and relevance of activities to society (Ford, 2003; Krajcik et al., 2000). The Earth systems unit provided many opportunities for students to make scientific concepts relevant to their personal lives, and students expressed an awareness of these opportunities. Combining this finding with the finding regarding students' perceptions of the role of field trips for fostering coherence suggests that students are aware of the value in outdoor experiences. Specifically, these experiences can help students integrate their ideas with scientific concepts in order to promote personal relevance. A finding that requires greater exploration from this study is that Isaac's discussion of connections to other school disciplines, such as social studies, suggests that some students may be more capable of developing cross-content connections than others. This aspect was not supported in the unit, but provides a great opportunity to develop increasingly coherent curricular that cross disciplines within (McComas & Wang, 1998), and outside of science (Chapter IV).

Researchers have explored the value of outdoor learning experiences from a motivational and positive attitudinal aspect (Benz, 1962; Brady, 1972; Disinger, 1984; Folkomer, 1981; Harvey, 1951; Kern & Carpenter, 1984; Koran & Baker, 1979; Michie, 1998; Mirka, 1970; Sisson, 1982; Smith, 2005), and typically found that such experiences can improve students' attitudes towards science. However, these studies are often in relation to isolated rather than integrated field experiences (Birnbaum, 2004; Hofstein & Rosenfeld, 1996; Orion & Hofstein, 1991). This study provides evidence that integrated outdoor learning experiences can also improve students' attitudes along positive dimensions. Further, the improvement is in the context of students' perspective of the field trip as a tool for learning, rather than simply as a social experience. This is aligned to the findings of Orion and Hofstein (1991) who demonstrated that high school students experiencing outdoor learning activities "perceived the field trip less as a social-adventurous event, and more as a learning event" (p. 519). In addition, the younger high school students in Orion and Hofstein's (1991) study reported more positive attitudes in relation to the social aspects of the field trip compared with older students, while the perspective of the field trip as a learning tool was more salient for older students than for younger students. Specifically, no changes from pre to post-enactment were found for the learning aspect for younger students in Orion and Hofstein's study. This is in contrast to the findings of the current study with middle school students, which revealed that the Attitude survey was a sensitive instrument for exploring middle school students' perceptions and attitudes along the educational and social aspects of the outdoors. These findings were supported by student interviews, in which the interactions between the cognitive and affective aspects of the outdoor learning experiences were mentioned. Students communicated that outdoor activities help them learn, but are concurrently engaging. Additional research to explore the relationship between students' age, and their perceptions of the field trip as an educational tool is necessary to maximize the potential of this type of learning environment with students of all ages.

As described in the Findings section, students of varying ability levels experienced certain dimensions of the field trip differently. Benz (1962) summarized her review of the literature, and concluded "superior pupils tend to profit more from field trips than pupils with average to less-than-average ability" (p. 43). Regardless of whether Benz believes superior students profit more academically or affectively, I cannot draw this same conclusion based on the findings from the present study. While it is true that students' attitudes varied along the dimensions measured by the instruments used, depending on their ability level, these do not indicate that the higher ability students profited more. I did find that the high and very high ability students reported shifting attitudes along two dimensions of the scales of the attitude survey which were statistically significant, yet the lower and average ability students had positive attitudes overall, both before and after the enactment regarding their opinions of field trips (Appendices 3F and 3G).

Learning Gains

The purpose of this study was not to draw comparisons between various instructional methods as has been done by researchers in the past (Bennett, 1965; Brady, 1972; Folkomer, 1981; McNamara, 1971), but rather to explore and draw generalizations regarding the types of outcomes that might be expected when students use a curriculum designed to integrate outdoor learning experiences with more traditional learning environments. The findings from this study indicate that students achieved significant learning gains, as measured by the pre and post-enactment content knowledge assessments. Therefore, there is potential for a curriculum of this type to help students learn, and it is an important finding that students of all ability levels were able to succeed during this curricular unit, and suggests that there are aspects of a curriculum of this type that play a role in promoting student learning.

The posttest examined students' ability to reason about the principle of conservation of matter. While Mrs. Hunter decided not to use this term, students discussed the Earth's subsystems, and the finite amount of material within each system. For example, it is important for students to understand that no new water is being produced when it rains, but rather the water is being cycled through different phases of matter, and through different reservoirs. The conservation of matter items provided students with familiar and previously encountered processes, and asked students if the total amount of water or rock in the Earth system would increase, decrease, or stay the same. Questions of this sort require systems thinking skills, in addition to content knowledge regarding the components and processes targeted (Ben-zvi-Assaraf & Orion, 2005a; Ben-zvi-Assaraf & Orion, 2005b; Kali, 2003; Kali, Orion, & Eylon, 2003; Raia, 2005).

My findings suggest that higher ability students have more developed systems thinking skills, as 55% of the very high ability students answered all seven questions in this set correctly. Of the high ability students, 35% answered all of these questions correctly, while 19% of medium ability students answered these questions correctly, and none of the very low and low ability students answered all questions correctly. An examination of the actual responses provided by students indicate that certain Earth processes are more difficult to reason through, such as how a volcanic eruption does not lead to an increase in the amount of rock on Earth, a question in which only 39% of all students answered correctly. Nearly half of the students believe a volcanic eruption results in an increase in rock material in the Earth system, a logical response given sixth graders limited knowledge of plate tectonics at this point in their schooling. These findings provide a unique perspective as to the systems thinking skills of students with varying ability.

Previously, Ben-zvi-Assaraf and Orion (2005a) found that students enter and leave junior high school with a fragmented understanding of the water cycle, and little understanding of the cyclic nature of this system. However little is known regarding the variability among students of differing ability levels and the development of their systems thinking skills. In addition, the findings from this study regarding students' conceptions of conservation of matter in the Earth system further support the role of outdoor learning experiences in promoting coherence and connections across the curriculum. Without such concrete experiences, Ben-zvi-Assaraf and Orion (2005a) suggest that students' alternative frameworks can be derived from the instructional method. Cognitive constraints in students' ability to make use of systems thinking skills and cyclic skills may also hinder students' understanding of the principle of conservation of matter (Ben-zvi-Assaraf & Orion, 2005a), although Kali, Orion, and Eylon (2003) suggest that through effective practice with integration of concepts, students are able to develop cyclic and systems thinking skills.

No statistically significant relationships were found between students' ability level, as determined by Mrs. Hunter, their content knowledge assessment based upon the instruments used in this study, and their opinions regarding outdoor learning experiences. This is a crucial finding, or lack thereof, as it indicates that *all* students have the potential to benefit greatly from the learning opportunities that outdoor experiences integrated with other types of instruction can provide. The specific contribution of the outdoor learning environment to student learning is difficult to measure without a controlled experimental study design, but this study indicates that integrated outdoor learning experiences play an important role from students' perspectives.

The purpose of this study was to explore the outcomes of a reform-based curriculum effort from the students' perspective. This study did not involve a comparison of different instructional methods, but rather examined a single method, and the role that a curriculum of this type can play in middle school students' experiences. The eight-week curriculum was based on an Earth systems approach and dealt with interactions between components of these systems, through integrated classroom, laboratory, and outdoor experiences grounded in the local environment.

Specifically, outdoor learning experiences were an integral part of this curriculum, and should be a legitimate component of the science curriculum when appropriate. The findings of this study indicate that a curriculum of this type provides opportunities for students to make connections between concepts, and to relate these concepts to their personal lives. However, lower ability students require extra support in making connections of which higher ability students are comparatively more aware. Integration of learning activities in the outdoors into the traditional learning environments also allowed students to recognize the outdoor experiences as a tool for learning, rather than as a social event. The attitude survey data support this claim through a comparison of students' prior field trip experiences and those in which they participated throughout the Earth systems unit, and was shown to be sensitive for comparing middle school students of varying abilities. In addition, the outdoor learning experience was found to be valuable due to an interaction between cognitive and affective aspects of learning. Students associated outdoor learning activities as an opportunity for them to learn while feeling engaged in that learning. Finally, a curriculum of this type was found to help students achieve substantial learning gains as determined by a pre-post assessment. Additionally, more support is needed to help all students develop systems and cyclic thinking skills to make sense of key ideas in science, such as the principle of conservation of matter.

Conclusion

This study has implications for the design of curriculum materials that include integrated outdoor learning experiences. This is not an aspect of curriculum materials that has been studied in great depth, although some researchers have explored the ways to successfully integrate indoor and outdoor learning activities within the formal school setting. The findings from this study suggest that while outdoor learning activities can be integrated into the formal setting as a legitimate learning environment, that there are some difficulties inherent to their use. Mainly, curriculum materials should be designed to better support all students in making coherent connections between scientific ideas and activities. Further, the ways in which all students can be encouraged to perceive field trips as an opportunity to learn should be explored more fully in future research. This study contributed to what we know about students' perceptions of field trips in school, but much more needs to be explored with students of varying ages and ability levels. The implications of this study for improving the design of the Earth systems science unit, and curriculum materials in general will be discussed in Chapter V, as I return to the overall systemic and holistic approach to incorporate the findings from the various chapters of this dissertation in order to improve the curricular unit.

Conclusions from this research suggest that an educational program that integrates classroom, laboratory, and outdoor learning activities does not discriminate. In other words, all students, regardless of ability level, profited from this curricular unit as far as their emotional experience, and their cognitive learning gains. While the findings show that students of varying ability level have differences in experiences along certain dimensions, field trips, along with other learning activities have the potential to help students move towards becoming scientifically literate citizens. This research is valuable as it provides an alternative perspective of the potential value of field experiences for middle school students. Rather than comparing isolated instructional techniques, I have described the type of curricular enactment (Chapter II), and provided a window into that enactment from the perspective of the participating students. The question of whether this technique is superior to an alternative technique was not dealt with in this research study. Instead, the changes in students' attitudes, experiences, and knowledge were presented and discussed as it relates to a curricular enactment involving a variety of instructional techniques, some of which are novel to middle school students.

In conclusion, Linn, Kali, Davis, and Horwitz (2008) suggest ways in which educational policy can promote the widespread use of coherent curricula including through the careful design of instructional materials. The current study indicates that curriculum materials can be designed to help students learn about the Earth system while promoting coherence through the integration of the classroom, laboratory, and outdoor setting. This study indicates that there is a specific and important contribution of the outdoor learning environment in such a curriculum from students' perspectives, yet further research is needed to examine how teachers can be supported in guiding all students to become aware of coherence.

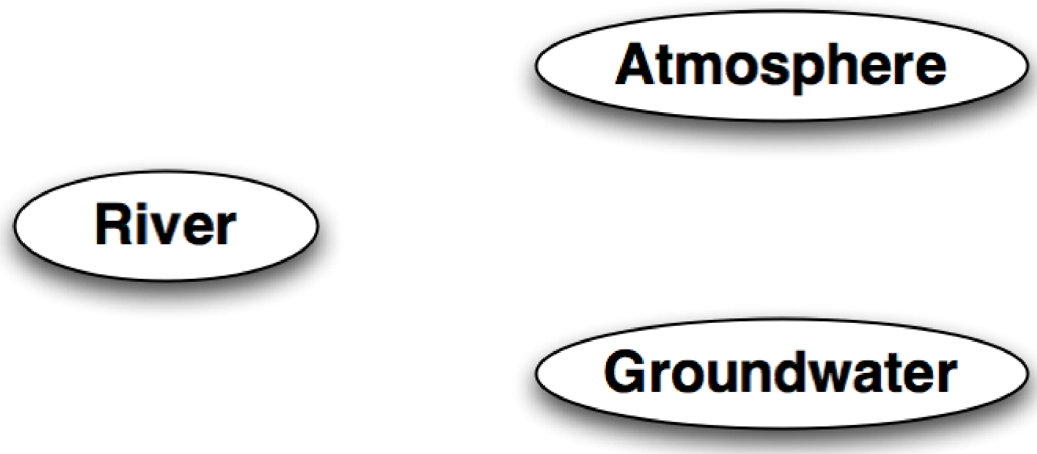
In the following Chapter IV, I explore the introduction of the Earth systems curriculum unit to the school system, from the perspectives of the teacher and school principal, in an effort to explore this reform-based innovation in a systemic, and holistic way. The impact on the students, and their perspective is a crucial exploration for any educational innovation. However, the perspective of the teacher who uses such an innovation to guide her teaching, and the school principal responsible for approving the use of such a curriculum, must also be explored in an effort to gain a broader understanding of the introduction of a curriculum to the educational system.

Appendix 3A: Portion of the Content Knowledge Assessment

12. Liquid water at the earth's surface cannot __________.

A. evaporate.
B. flow.
C. infiltrate.
D. precipitate.

13. The three places listed below are some of the places where water can be found on Earth. Draw arrows to show how water can move among them. <u>Label each arrow</u> with the water movement process.



14. Which process produces igneous rocks?

A. erosion of surface rocks
B. volcanic activity
C. earthquake activity
D. deposition of sediments

15. Small pieces of rock exposed to weather wear away and collect in layers. Sometimes these layers join back together to make __________ rock.

A. metamorphic
B. mineral
C. igneous
D. sedimentary

16. Explain how chemicals from trash and litter could affect your drinking water. Be as detailed as you can.

17. Explain how a company that constructs new buildings could affect the environment. Be as detailed as you can.

18. Use the Law of Conservation of Matter to explain why it is important that humans become more aware of the environment. Be as detailed as you can.

19. Give one (1) example of how the <u>hydrosphere</u> and <u>geosphere</u> interact on Earth.

20. List three (3) different ways that you have impacted the Earth today.

-
-
-

Appendix 3B: Science Outdoor Learning Environment Inventory (SOLEI) (Orion et al., 1997)

Directions: Please think about your experiences with field trips in school ***over the past 8 weeks (Earth Science unit)***. Read each statement carefully, and circle the number that corresponds to your level of agreement. Your answers are confidential and your teacher will not see them. Please be honest.

1. Before a field trip, we receive detailed information about the expected schedule.
2. My own learning during field trips can be difficult when it is too crowded.
3. The field trip is an activity that encourages student learning.
4. Many students do not understand what they should do during the field trip.
5. The learning method used in field trips does not encourage my own thinking.
6. Students are able to depend on each other for help during field trips.
7. Students have little chance to get to know each other during field trips.
8. Students are able to express themselves freely during field trips.
9. A large part of the field trip involves listening to the explanations of the field trip leader.
10. The field trip is managed like this: the teacher lectures and the students write in their booklet.
11. The teacher uses useful teaching materials for her explanations.
12. The teacher is not attentive to the students' questions and comments during field trips.
13. The field trip work is unrelated to the topics that we have studied in the classroom prior to going on the field trip.
14. What we do during field trip activities helps us to understand the ideas learned during regular science classes.
15. Our regular science class is integrated with the field trip activities.
16. Students do not put much effort into learning activities during field trips.
17. We do not use what we have learned from our regular science class session during field trips.

18. The teacher is involved with personal matters while the students are conducting the field trip's assignments.

19. Worksheets are helpful for individualized learning during field trips.

20. The field trip activities are carefully designed.

21. During field trips students help each other according to the difficulty of the task.

22. There is an opportunity for students to pursue their own particular science interests during field trips.

23. The teacher assists those students who have difficulties in their assignments during field trips.

24. The materials and equipment that students need for the field activities are readily available.

25. Our field trips are not well organized and planned.

26. During field trips students can learn ideas from other students.

27. During the field trip, samples are collected for study later in school.

28. Students discuss their learning assignments among themselves during field trips.

29. The teacher uses observations from the field trip during later explanations in the classroom.

30. Students are allowed to go beyond the regular field trip assignments and do some study on their own.

31. Worksheets are not important for my own learning during a field trip.

32. During field trips, the teacher gives most of her attention to a specific group of students.

33. Students who are generally silent in the classroom can be more outgoing during the field trip.

34. What we do in our regular science class is unrelated to our field trip activities.

35. The teacher is not ready to listen to the students during field trips.

36. Before going on field trips we have only a general idea about what to expect.

37. The teacher behaves in a friendly manner toward the students during field trips.

38. Students engage in social activities rather than in learning activities during field trips.

39. The field trip is used for investigating and solving problems that arise during the regular classes.

40. The teacher tries hard to help all the students who need assistance during field trips.

41. There is a lot of wasted time during field trips.

42. The learning activities during field trips encourage me to think.

43. Students spend a lot of time during the field trip being involved in investigating outdoor phenomena.

44. During field trips there is little collaboration between students while carrying out the tasks.

45. Field trips focus on phenomena that cannot be investigated in the classroom.

46. During field trips students can get to know each other much better than in the classroom.

Appendix 3C: Attitude Survey (Orion & Hofstein, 1991)

Directions: Please think about your experiences with field trips in school ***over the last 8 weeks (Earth Science unit***). Read each statement carefully, and circle the number that corresponds to your level of agreement. Your answers are confidential and your teacher will not see them. Please be honest.

1. The field trip helps me understand material learned in class.
2. What I like most about field trips are the jokes told by my friends.
3. The field trip is a waste of time.
4. What I like about a field trip is the adventure; e.g., climbing mountains, crossing rivers, etc.
5. I would like to participate in more field trips since this is a good way to learn the subject.
6. I would like to have more field trips since they are a lot of fun.
7. The things I observe during a field trip do not help me in understanding the material taught in class.
8. I like field trips that involve a lot of walking.
9. It is a pity that we do not have more field trips, since this is an enjoyable way to learn.
10. What I like most on field trips are the adventures.
11. I like to go on field trips, since it is important for me to understand the environment in which I live.
12. I return from field trips with a lot of experiences.
13. The field trip increases my awareness of environmental issues.
14. After a field trip, I do not remember the explanations given by the teacher.
15. The field trip is important since it demonstrates and illustrates the concepts learned in class.
16. In the field trip, working with worksheets interferes with my enjoyment of the event.

17. The material learned during a field trip will remain in my memory for a long time.

18. I would like to have more field trips, since it helps me learn about nature conservation.

19. I do not like field trips that include a lot of walking.

20. The good atmosphere with my friends during a field trip is the main reason for my enjoying the event.

21. Working on my own during a field trip is important for understanding the learning material.

22. The field trip does not contribute to my connection with the United States.

23. I would like to have more field trips, since they help in building class spirit.

24. Learning in the classroom is more effective than learning during a field trip.

25. The field trip increases my enjoyment of the subject matter.

26. Familiarity with different parts of the United States increases my connection to my country.

27. The field trip does not increase my interest in the learning material.

28. For me, the field trip is important, since it helps in getting to know more friends.

29. I understand natural phenomena better after observing them on a field trip.

30. I like field trips despite the difficulties of being outside.

31. Field trips make me take an interest in and search for additional information on the Internet or in books.

32. The comments and jokes made by classmates during a field trip interfere with my ability to concentrate on learning.

Appendix 3D: Student Interview Protocol (post)

Thank you for agreeing to talk with me again. I would like to ask you some questions now that you are nearly finished with the Earth Science unit. Please think about the ideas you've learned in this unit. Do you have any questions for me before we get started? I'm going to turn the tape recorder on now.

This is participant # ___ ___ ___. I'm going to ask you some questions, and I want you to answer as best you can, and in as much detail as you can. I want to understand your ideas so I will be taking some notes.

Please be honest: What is your opinion of the Earth science unit you just finished? (What did you like about the unit? What did you dislike about the unit?)

If you were going to tell a younger student, coming into 6th grade, about this unit, what would you say?

How did what you learned in this unit connect/relate to the real world? (aka: what connections were made?)

Tell me about the field trip to the rock quarry. (What did you do there?) Was that field trip important to the unit? Explain.

You went outside several times during this unit. What did you like/dislike about going outside? Why?

On this sheet, you'll see a list of different science activities you might do in science class. Which of these have you done during this Earth Science unit?

Which of the activities in this list do you find most/least enjoyable? Why?

Which of the activities in this list do you think you can learn the most/least from? Why?

Which, if any, of the activities do you think could help you learn about your environment?

What did you learn about your local setting in this unit?

Are there rocks around your school?

Yes	Describe the rocks around your school. Were they always there, or were they moved there somehow? How were they moved there?
No	Where can you find rocks? Describe those rocks. Why are they not around your school?

Explain to me what the rock cycle is. Can you please draw the rock cycle as best you can.

Explain to me how rocks form.

What activities in this unit helped you learn about this?

This is the diagram you drew of the water cycle a few days ago. Is there anything you want to change? (OR: Your teacher assigned homework to draw and explain the water cycle. As of today, she doesn't have yours, but I'd like you to do it now, and then I'll be sure you get credit for the homework. Here is a sheet of blank paper.

(If groundwater is missing: What can you tell me about groundwater? Where would it go on your diagram?)

Where does the water cycle start? Where does it end? Explain.

Explain to me how a river forms.

What activities in this unit helped you learn about this?

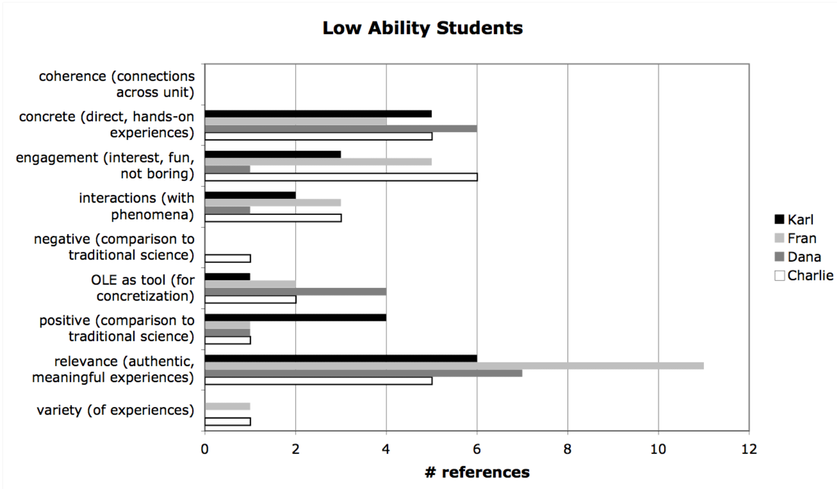
What does the word “system” mean to you? Please tell me anything you can. Can you give me any examples of a “system”? If yes, Why is that a system?
The EARTH can be considered a system. Knowing that the Earth is a system, I’d like you to draw me a picture of the things that you think are part of the Earth system. Please label your diagram.
Why might it be important to learn about rocks and water? How is water relevant to your life? How are rocks relevant to your life? Do you think you affect your environment? How? Does your environment affect you? How?
Please look at Photo 1. Explain to me what you see in this photo. Can you tell me what systems are interacting in this photo, and how? Please look at Photo 2. Explain to me what you see in this photo. Can you tell me what systems are interacting in this photo, and how?
Great! We’re all done. Do you want to ask me anything? Thank you for your help!

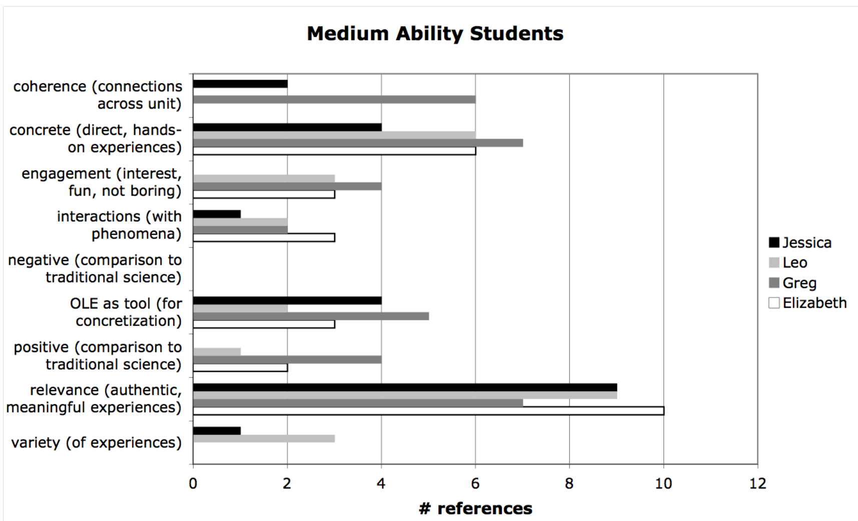
Appendix 3E: SOLEI—Integration Scale--Distribution Analysis
Reverse coded items are indicated by "(rev)"

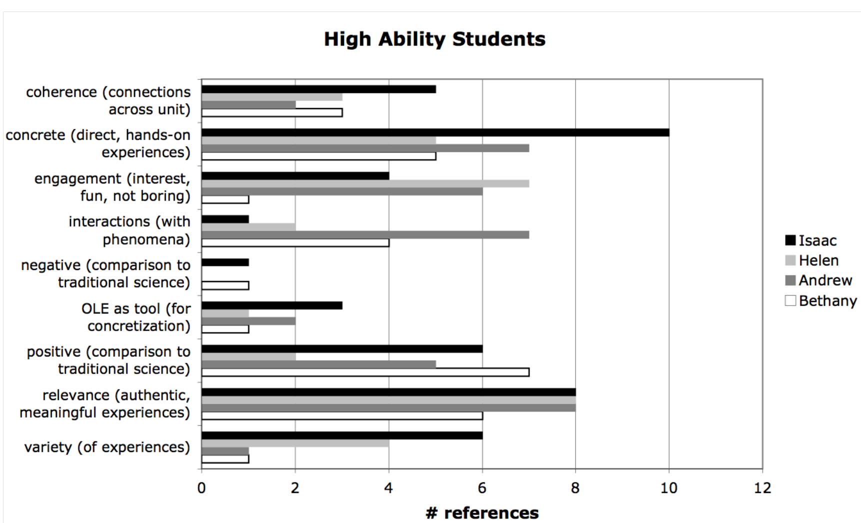
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The field trip work is unrelated to the topics that we have studied in the classroom prior to going on the field trip. (rev)					
PRE	31.5	23.4	25.2	18.0	1.8
POST	39.8	31.5	19.4	6.5	2.8
What we do during field trip activities helps us to understand the ideas learned during regular science classes.					
PRE	0.9	7.2	16.2	53.2	22.5
POST	0.9	4.6	13.9	50.9	29.6
Our regular science class is integrated with the field trip activities					
PRE	9.0	22.5	38.7	25.2	4.5
POST	0.9	6.5	31.5	50.9	10.2
We do not use what we have learned from our regular science class session during field trips. (rev)					
PRE	22.7	43.6	20.9	10.0	2.7
POST	29.6	47.2	13.0	7.4	2.8
During the field trip, samples are collected for study later in school.					
PRE	6.3	18.9	30.6	32.4	11.7
POST	0.9	2.8	19.4	48.1	28.7
The teacher uses observations from the field trip during later explanations in the classroom.					
PRE	1.8	1.8	24.3	52.3	19.8
POST	0	1.9	16.8	58.9	22.4
What we do in our regular science class is unrelated to our field trip activities. (rev)					
PRE	25.2	47.7	20.7	2.7	3.6
POST	40.2	45.8	9.3	3.7	0.9
The field trip is used for investigating and solving problems that arise during the regular classes.					
PRE	2.7	18.9	42.3	30.6	5.4
POST	7.5	15.0	30.8	31.8	15.0
Field trips focus on phenomena that cannot be investigated in the classroom.					
PRE	2.7	9.0	32.4	37.8	18.0
POST	3.7	12.1	25.2	41.1	17.8

Appendix 3F: Number of Expressions of each theme--Post-Enactment Student Interviews

Grouped by ability level







Appendix 3G: Attitude Survey—Learning Tool Scale--Distribution Analysis

Reverse coded items are indicated by "(rev)"

	Strongly Disagree	Disagree	Agree	Strongly Agree
The field trip helps me understand material learned in class.				
PRE	3.6	11.7	65.8	18.9
POST	3.7	1.9	56.1	38.3
The field trip is a waste of time. (rev)				
PRE	58.6	30.6	6.3	4.3
POST	59.8	37.4	0.0	2.8
I would like to participate in more field trips since this is a good way to learn the subject.				
PRE	2.7	7.2	36.0	54.1
POST	0.9	4.7	39.3	55.1
The things I observe during a field trip do not help me in understanding the material taught in class. (rev)				
PRE	42.3	47.7	7.2	2.7
POST	52.3	44.9	1.9	0.9
It is a pity that we do not have more field trips, since this is an enjoyable way to learn.				
PRE	4.5	4.5	42.7	48.2
POST	1.9	4.7	39.3	54.2
After a field trip, I do not remember the explanations given by the teacher. (rev)				
PRE	16.2	58.6	16.2	9.0
POST	20.6	66.4	10.3	2.8
The field trip is important since it demonstrates and illustrates the concepts learned in class.				
PRE	0.9	5.4	68.5	25.2
POST	0.9	6.5	56.1	36.4
The material learned during a field trip will remain in my memory for a long time.				
PRE	5.5	28.2	45.5	20.9
POST	4.7	18.7	54.2	22.4
Learning in the classroom is more effective than learning during a field trip. (rev)				
PRE	36.4	45.5	15.5	2.7
POST	37.4	41.1	16.8	4.7

The field trip increases my enjoyment of the subject matter.				
PRE	2.7	6.4	50.0	40.9
POST	2.8	3.7	45.8	47.7
The field trip does not increase my interest in the learning material. (rev)				
PRE	31.8	56.4	7.3	4.5
POST	39.3	51.4	6.5	2.8
I understand natural phenomena better after observing them on a field trip.				
PRE	1.8	10.9	56.4	30.9
POST	0.9	4.7	63.6	30.8

Appendix 3H: Attitude Survey—Social Aspect Scale--Distribution analysis

Reverse coded items are indicated by "(rev)"

	Strongly Disagree	Disagree	Agree	Strongly Agree
What I like most about field trips are the jokes told by my friends.				
PRE	20.7	45.0	24.3	9.9
POST	22.4	54.2	19.6	3.7
I would like to have more field trips since they are a lot of fun.				
PRE	1.8	8.1	41.4	48.6
POST	1.9	12.1	44.9	41.1
The good atmosphere with my friends during a field trip is the main reason for my enjoying the event.				
PRE	4.5	40.5	36.9	18.0
POST	8.4	47.7	30.8	13.1
I would like to have more field trips, since they help in building class spirit.				
PRE	7.3	19.3	50.5	22.9
POST	10.3	21.5	48.6	19.6
For me, the field trip is important, since it helps in getting to know more friends.				
PRE	6.4	36.4	43.6	13.6
POST	14.0	55.1	25.2	5.6
The comments and jokes made by classmates during a field trip interfere with my ability to concentrate on learning. (rev)				
PRE	23.4	32.4	26.1	18.0
POST	18.7	34.6	26.2	20.6

CHAPTER IV

The Teacher and School Principal's Perspectives of Outdoor Learning Experiences Embedded in an Earth Systems Science Unit

Abstract

A curriculum that includes outdoor learning experiences integrated with classroom and laboratory activities has the potential to help students learn with an Earth systems approach. Due to the limited research regarding the use of such a curriculum, this study explored the teacher's experience specifically in regard to the role of outdoor learning experiences in the unit. The principal's perspective of the use of novel curricula also influences curricular enactment. A qualitative research approach explored a series of six interviews with the participating teacher, and a single interview with the school principal. The interviews with the teacher explored her perspective of the value and role of outdoor learning experiences in the context of an Earth systems science unit. The interview with the principal explored school policies, and the value and challenges of field trips, as well as his perception of his role in supporting teachers. Findings highlighted the teacher's perspective of the potential of outdoor learning experiences in promoting curricular coherence, providing firsthand experiences, increasing student engagement, and raising student awareness of the relevance of science. The principal viewed the inclusion of outdoor learning activities as an example of risk-taking and creativity on the part of the teacher. He acknowledged the potential value of the outdoor learning environment, which was closely aligned to the teacher's perspective. However, he also discussed the need to balance the value with the challenges associated with field trip activities. This study revealed the teacher's and principal's perspectives of the role and value of outdoor learning experiences integrated within an Earth systems science unit.

CHAPTER IV

The Teacher and School Principal's Perspectives of Outdoor Learning Experiences Embedded in an Earth Systems Science Unit

Introduction

The use of novel curriculum materials can be regarded as highly interconnected with science education reform, although some see these as separate issues (Powell & Anderson, 2002). I see the development and use of curriculum materials as a tool administrators can adopt, and teachers can use, in order to move us closer to the goal of improving science education in the United States. Powell and Anderson's exploration revealed a great complexity in the determination of the role of curriculum materials in teacher's practice. Further, this complexity is highly dependent on the context, characteristics, and needs of a school.

In this chapter, I provide insight into the important roles of the teacher and principal in the context of the use of a curricular unit that integrates several learning environments. I highlight the teacher's (Mrs. Hunter) perspective enacting a unit using curriculum materials with specific research-based design principles (Chapter II), which include integrated learning environments, grounded in activities in the local setting. In addition, I discuss the perspective of the school principal, Mr. Ford (all proper names are pseudonyms) who approved and supported Mrs. Hunter's use of these curriculum materials. This chapter is a window into the experience and perspectives of Mrs. Hunter and Mr. Ford, as I provide a more holistic view of the role of curriculum materials in the educational system.

Curriculum reform, "a systemic approach to changing what is taught in science, as well as how it is taught" (Powell & Anderson, 2002, p. 108) cannot be isolated from the important and highly personal work of teachers in the classroom. However, curriculum developers can design materials to facilitate teachers' classroom enactment. These materials can be designed to align with what is known about teaching and learning. In this study, the materials were developed with several design principles (Table 4.1).

Table 4.1 *Design Principles of Earth Systems Science Unit*

Earth systems science approach	e.g., Ben-zvi-Assaraf & Orion, 2005
Learning goals based on benchmarks	e.g., AAAS, 1993; Rivet & Krajcik, 2004
Contextualization, personal relevance, and the local setting	e.g., Singer et al., 2000; Ford, 2003
Blending formal and informal learning contexts through integrated classroom, laboratory, and outdoor tasks	e.g., Hofstein & Rosenfeld, 1996; Orion, Hofstein, Tamir, & Giddings, 1997
Direct experiences with phenomena and progression from concrete to abstract concepts	e.g., NRC, 1996; Orion, 1993
Learning cycles and coherence	e.g., Kali, Linn, & Roseman, 2008
Curriculum artifacts, assessments, and projects	e.g., Minstrell, 1989; Singer et al., 2000
Embedded educative teacher supports	e.g., Davis & Krajcik, 2005

A disconnect between teachers' beliefs and knowledge, and the principles upon which the curriculum materials were developed can lead to dissonance as a teacher enacts a unit, while a closer alignment smoothes the adoption of new materials.

The reform of science education in the United States has gone through many stages, some of which have called for significant changes to the way science is taught (American Association for the Advancement of Science, 1989, 1993; DeBoer, 1991; National Research Council, 1996c; Powell & Anderson, 2002). Powell and Anderson (2002) note that in general, the view of science education in the United States has become more inclusive in a variety of ways, tending to the students, teachers, *and* curriculum, while Fullan (2007) suggests that educational change is dependent upon what teachers do and think. Therefore, it is necessary to gain a deeper understanding of the thinking behind teachers' classroom practice, and the influence of the school principal and policies on the teachers' practice. This chapter will focus on the perspectives of the teacher and principal in the context of the enactment of the Earth systems science curricular unit described in Chapter II.

There is a great demand on teachers to shift their teaching to more inquiry-oriented practices (National Research Council, 1996a). Yet, this can be a troublesome task without appropriate tools to facilitate the enactment of the desired science teaching standards. "Teachers using reform-oriented materials need to modify their teaching practices so they are consistent with the ideas embodied in the materials. Ideally, these teachers will be in schools where their attempts to enact a reform agenda are supported and encouraged" (Powell & Anderson, 2002, p. 113). This highlights the role of curriculum materials, but it is the way that Mrs. Hunter uses this tool that is the focus of this chapter.

Any information can be represented in multiple ways. When this occurs in the educational context, teachers gradually develop pedagogical content knowledge (Magnusson, Krajcik, & Borko, 1999; Shulman, 1986), characterized by having a diverse and integrated knowledge base. Teachers with this type of knowledge can guide their students to develop connected and integrated knowledge as well. Cochran and Jones (1998) suggest that exposing teachers to various ways of representing information can help teachers, both preservice and inservice, develop pedagogical content knowledge. Although Richardson (1996) suggests that the most promising changes in teachers' beliefs and practices is likely to occur at the inservice, rather than preservice stage, supporting the design of this study to explore the Mrs. Hunter's perception of a novel instructional strategy, such as teaching outdoors. Experiences learning and teaching outdoors may help teachers develop their knowledge regarding ways of facilitating students in learning in an integrated way, as well as making decisions regarding when it is most appropriate and valuable to use different instructional strategies (Magnusson et al., 1999).

Remillard (2005) discusses the ambiguity of the word "curriculum" in that it is often used to describe various aspects of educational settings, including printed materials, the intended or designed curriculum, as well as the enacted curriculum. The role of the principal in making curricular decisions, as well as the "teacher-curriculum relationship" (p. 212) are not well-understood, and require a deeper level of study regarding these complex interactions. Brown (2009) also considers the teacher-curriculum relationship as it relates to teacher practice, and the perspective of curriculum as a tool that can be customized to different situations. Brown (2009) suggests that "curriculum materials assist people (in this case, teachers) in achieving goals that they presumably could not or would not accomplish on their own" (p. 20).

I return to the systemic approach that guided the design of this study. Each chapter explores a different set of components that make up the educational system. In the current Chapter, the aim is to contribute to our knowledge of a single teacher's perspective on the role and value of innovative curriculum materials that include outdoor learning experiences, and how those materials can be used effectively, and supported by the principal in the school context. This will provide insight into the ways in which a curriculum of this type is valued and the role that it can play within a formal school setting from the unique perspective of these two key players in the educational system. Again, this portion of the study is based upon the Earth systems science curriculum unit (Chapter II) that was enacted with middle school students (Chapter III) over an eight-week period. In an effort to gain a broader understanding of the introduction of this unit to this particular school system, and the complexities inherent in this system, I explore the innovation from two additional participants' perspectives (Figure 4.1).

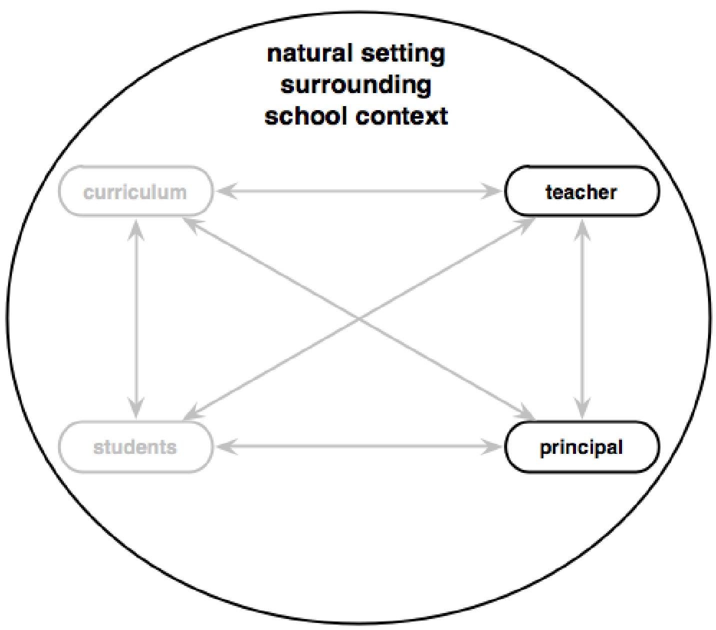


Figure 4.1. Focus on the teacher's and principal's experiences in the context of the systemic approach to exploring the integration of outdoor learning experiences in the formal school curriculum.

Teachers' Experiences Using the Outdoor Setting as Learning Environment

This section describes some of the challenges that teachers face in the incorporation of outdoor learning experiences into the science curriculum. Some of these challenges can become barriers that prevent a teacher from using such activities. For others, these challenges are limitations that can be overcome with support from other individuals such as school administrators, curriculum developers, other colleagues, and professional development facilitators.

Challenges of using outdoor learning experiences.

Conducting field trips within the formal school curriculum is accompanied by a variety of difficulties. Mason (1980b) described the most common hindrances to conducting field trips, cited by teachers:

> 1) lack of planning time; 2) lack of resource people for assistance; 3) failure of the school to assume trip risk; 4) lack of a satisfactory method for covering classes; 5) restrictions placed on field work by school regulations; 6) lack of administrative leadership, support, and encouragement; 7) lack of funding; 8) limited available transportation; 9) too much 'red tape'; and 10) excessive class size. (p. 320)

It is interesting to note that the most commonly cited barriers to teachers' use of field trips in the school curriculum are general, such that they might be cited about the adoption of any novel program. In addition to #1 and 2, several of the other barriers, including #6, 7, 9, and 10 could also be about any curricular reform, and is not specific to the inclusion of outdoor learning experiences. This suggests that outdoor learning experiences are not outside the realm of *different* types of instruction that requires additional time, effort, and support, when compared to the more traditional instructional methods. Therefore, while the challenges cited by teachers are very real, and relevant, many of them are not necessarily a challenge inherent in outdoor learning activities, but instead are challenges teachers face on a daily basis as part of their practice.

Michie (1998) described similar factors that limit teachers' participation and planning of outdoor learning experiences, but also describes teachers' opinions regarding the outcomes, and benefits of organizing and conducting field trips. Despite these numerous hindrances reported by teachers and described by Mason and Michie, many report having a strong desire to do more field work than they currently do. Mason (1980) cites Hickman (1976), who reports “teachers will conduct field trips if given the means and opportunity” (p. 321). One goal of this project as a whole, was to provide “the means and opportunity” for a teacher to use curriculum materials that would facilitate the use of field trips as an integral part of a curricular unit.

Time should be spent exploring students’ alternative conceptions and prior knowledge, which could be said of any educational activity (Driver, Guesne, & Tiberghien, 1985). Many students’ ideas are deeply held beliefs about the world that have been largely unexamined (Dove, 1998; Libarkin & Kurdziel, 2001). Kusnick (2002) found that even those students who had had college level courses in geology still maintained deeply held misconceptions about rock formation, the scales of space and time, and the impact of humans on Earth processes. Kusnick concluded that students need authentic tasks to challenge their ideas. Similarly, others collected data from over 100 K-12 teachers, and determined that both preservice and inservice teachers hold many alternative conceptions that can act as a barrier to the development of their own conceptual understanding, as well as that of their students. This highlights the concern regarding teachers’ content knowledge in the outdoor setting (Dahl et al., 2005). Such studies draw attention to the value of providing teachers with support needed to facilitate teaching in the outdoor laboratory. This support can come in the form of educative features in the curriculum materials, as well as professional development, and access to an expert in the discipline being studied.

The lack of expertise of the average Earth science teacher partially explains the uninviting coverage of Earth systems science topics in the K-12 curriculum. Smith and Neale (1989) found that many teachers feel inadequate, or believe they lack expertise regarding subject matter knowledge. A more substantial emphasis needs to be placed on the relevance of Earth science topics to the lives of students in order to increase the coverage of this topic in the classroom. Researchers from the University of Wisconsin-Milwaukee have collaborated with Milwaukee Public Schools, and the Urban Tree House Project to develop Earth science materials for preservice and inservice teachers that focus on the Earth science of the local setting. Included in these materials are field guides to local parks, the Lake Michigan shoreline, and information about the local geologic environments and soils (Kean, Posnanski, Wisniewski, & Lundberg, 2004). They reported that the newly discovered resources present in their local environment energized the public school teachers. Meanwhile, the students at these schools were being exposed to applications of Earth science that relate to their lives.

Opportunities for teachers to explore the methods and value of outdoor learning experiences.

Several practical suggestions present in the literature can guide teachers as they plan outdoor learning experiences. Orion (1993) encourages teachers to focus on the interaction between students and the environment, being careful not to come between the two. This can help students adopt a culture of actively constructing information from the environment directly, as opposed to accumulating information from the teacher. The experiences out-of-doors should be hands-on, and focus on activities that cannot be conducted in the classroom or laboratory. While Williams and Linn (2002) suggest, “often, instruction using hands-on exploration neglects mindful engagement” (p. 417), outdoor learning tasks should provide opportunities for the observation of phenomena, asking questions, collecting data or evidence, and recording ideas, thereby engaging students minds as well as their hands.

One important role of the teacher is to prepare students by reducing their novelty space (Orion, 1989, 1993). Orion defines novelty space as consisting of three factors: novelty of the field environment (geographical), prior knowledge (cognitive), and prior experience outdoors (psychological). Reducing the novelty space—the combination of these three factors—can result in maximum learning potential during the field excursion. In a curricular unit, outdoor experiences should be preceded by a preparatory unit, and followed by a summary unit, according to Orion’s (1993) model of field trip integration. Just as students need to be adequately prepared to participate in outdoor learning activities, teachers require appropriate professional development experiences to guide them in the instruction that takes place outdoors (Michie, 1998). In addition, students should have opportunities to visit a field site on multiple occasions in order to develop questions that can be the basis of future visits (Birnbaum, 2004). The same can be said for teachers, who should visit a field site in order to forecast the types of questions and ideas students may provide. In turn, this provides an opportunity for teachers to develop increasingly sophisticated questions and responses throughout a unit as their knowledge grows and they become more aware and curious about their surroundings and local environment.

Teacher preparation should involve personal experiences both learning and teaching in the outdoor setting. O'Neal's (2003) study of secondary science teachers who participated in a field-based research experience, reveals that teachers who are instructed in the use of field activities as part of the curriculum, have a much greater comfort level with learning in the outdoor setting. These teachers were also more capable of developing activities for their students that make use of the field for Earth science concepts. This suggests that preservice teacher programs could be modified to include a field studies component, as exposure to this type of learning technique, and eventually teaching technique can have a profound effect on teachers own practice (Michie, 1998, p. 8). Earlier, Mason (1980b) found that the teachers' own interest in doing field work, or participating in field activities in the outdoor laboratory is directly related to the amount of time a teacher will spend conducting field activities with students.

The significance of having well-developed curriculum materials was highlighted in Michie's (1998) study, as this allows teachers to develop their expertise of teaching in the field setting. "Teachers felt that there were many venues they could visit but they did not have the time to prepare teaching materials for them" (p. 9). Well-developed curriculum materials that integrate field trips with other learning environments can facilitate teachers' practice during novel experiences as well, but little is known about how the integration of formal and informal learning activities can occur (Hofstein & Rosenfeld, 1996). The inclusion of educative features (Davis & Krajcik, 2005) embedded within the curriculum materials can further support a teacher in conducting activities that may be outside the typical repertoire of teaching.

Based on their literature review, Koran and Baker (1979) summarized their findings with seven generalizations that can help teachers conduct field trips to any location outside of the classroom, including visits to the outdoors. These include that: 1) the teacher needs to be familiar with the site, and needs clear learning goals, and students need to know these goals; 2) advance organizers can help provide structure to students for integrating new ideas/concepts; 3) student attention needs to be focused on the objectives of the field trip; 4) activities should have differing levels of difficulty; 5) practice the field trip to determine the appropriate structure and sequence; 6) a combination of media can lead to more positive outcomes (field trip and slides or movies); 7) evaluation of field trip is essential, and should be done in different ways depending on the attribute/outcome being measured. Not only are these generalizations applicable to teachers conducting field trips, but can also be used as guidelines for curriculum developers. Several of these generalizations were incorporated into the Earth systems science unit designed for this study (Chapter II), including learning goals based on benchmarks, the use of learning cycles and coherence, blending formal and informal learning contexts, and assessment.

Disinger (1984) sought to determine the type of preparation for conducting field trips, that would be most effective for teachers. Three treatment groups were compared: one group received an orientation during a workshop, another receiving mailed printed materials, and the third group was oriented by a resource person from the field trip location. He found that the most effective preparation for the teacher was the pre-trip orientation during the workshop. Disinger concludes that because teaching in the classroom setting is easier than in other learning environments, and because one cannot assume that the value of field activities are obvious, that it needs to be proved through research studies, that there is value to teaching and learning in the outdoor setting.

One example of field trips being used as professional development is during a summer institute for urban teachers in Milwaukee. This program focuses on outdoor experiences around the beaches of Lake Michigan. These areas are in close proximity to the teacher's school district. This program encourages positive field trip practices for the teachers, and provides teachers with experiences that demonstrate the feasibility and value of taking students to these same locations during the school year as part of the science curriculum (Kean & Enochs, 2001). Thus field trips as professional development provide an alternative teaching technique to model the use of the outdoors as a learning environment.

The National Science Foundation put forth some suggestions for collaborative relationships between geoscience researchers and K-12 teachers. "Efforts would ideally involve the same teacher(s) over a period of years, have a significant field experience component, and be structured not only to build the geoscience skills of teachers in a particular area but also to provide opportunities for the teachers to translate their experiences to activities for use in their classrooms" (National Science Foundation, 1997). The NSF highlights the important contribution of the field experience, and the ability of geoscience researchers to guide teachers in conducting field activities.

Orion and Kali (2005) conducted a study of Israeli teachers and their students using a learning program called "The Rock Cycle" which is a learning technology centered around helping students learn the content associated with the rock cycle, as well as to improve their scientific thinking skills. One important finding from this study is that there was significant variability in the magnitude of learning gains on pre and post program measures between classes as some classes increased their mean scores much more than other classes. This was true even for classes taught by the same teacher. Case studies of three different types of teachers revealed that their characteristics are important in the success of a set of curriculum materials. The teacher's openness to new teaching methods, scientific background knowledge, and their enthusiasm for the curriculum can have significant effects on student learning. This study highlights the importance of the teacher's role in providing students with new and positive learning experiences. Students' apparent enthusiasm for learning outdoors is a powerful incentive to teachers to use such instructional techniques when appropriate (Chapter III).

Mrs. Hunter's perspective provided insight into this type of reform. However, to gain a more systemic view of this enactment, I also explored the principal's perspective of curriculum reform as it related to Mrs. Hunter's enactment of the Earth systems science unit.

The Role of the Principal in Curriculum Reform

The school principal plays a central role in the overall work that happens in the institution. A principal's personality, actions, beliefs, and knowledge can have a range of influences, positive, negative, and neutral on the members of the educational community. This community includes other administrators, curriculum specialists, teachers, students, and parents. Due to the structure of the typical school, the principal's characteristics can have influences on all other members of the community in a variety of ways. A principal who is supportive of curriculum, and more generally, educational reform can facilitate the teacher's experimentation of novel instructional methods. An administrator who does not support this can create barriers that limit the teacher's ability to experiment with practice (Fullan, 2007).

Some of the hindrances to field trips reported in Mason's (1980) study dealt with administrative issues, yet "it is essential for school officials to become aware that field activities are necessary for the understanding of many Earth science concepts" (p. 321). Without the support and encouragement of the school leadership, it can be difficult for teachers to successfully conduct outdoor learning activities.

There is no doubt that principals have an extremely difficult job. The impossible expectations of principals are illustrated in Evan's (1995, p. 5) imaginary search for a principal who is a miracle worker. Evans sheds light on the great expectations that the educational systems has for principals, who have a high rate of leaving the field due to discouragement in being unable to meet external and internal expectations, as described by Duke (1988). These expectations can add a difficult dimension to the principal's job as the decision-maker regarding curriculum choices.

Thus, there is great complexity in the role of the school principal. In general, the role of the principal is "central to promoting or inhibiting change" (Fullan, 2007, p. 156). However, the particular role of the principal is still uncertain. School leaders are expected to carry out a multitude of difficult changes in the school, with limited resources. To further the problem, additional demands are being added, while existing demands remain. Fullan (2007) summarizes the research surrounding the role of school leaders as "the principal is key, but we haven't yet figured out how to position the role to fulfill the promise" (p. 168).

Methods

Research Questions

The research questions relevant to Mrs. Hunter's and Mr. Ford's perspectives of the unit are:

1) What does the teacher see as the role of outdoor learning experiences in this curricular enactment?
2) What does the principal see as his role in the enactment of a novel curriculum by a teacher in his school?

3) What are the values and challenges that must be considered in the adoption of a curriculum that involves local and extended outdoor learning experiences?

Research Approach

I used a qualitative approach to explore the teacher's experience enacting the curricular unit over the course of eight-weeks through a series of six interviews. I used the same approach for gathering data regarding the role of the school principal in the context of the enactment of a novel type of curriculum. This approach resulted in a rich perspective into each participant's beliefs surrounding the use of outdoor learning experiences.

Research Tools and Data Analysis

I conducted a series of six interviews with Mrs. Hunter throughout the course of the enactment. The first interview took place immediately before she began teaching the unit, and five additional interviews occurred approximately every seven to ten days throughout the enactment. The final interview took place at the conclusion of the unit. The interviews followed a semi-structured format. This involved a set of pre-determined questions I asked Mrs. Hunter. I included additional probing questions to deepen the discussion or clarify her ideas, as appropriate. I used a set of specific questions, some of which were repeated from week to week, and others that were novel according to the appropriate context of the interview (Table 4.2). The interview protocols (Appendix 4A) were adjusted and altered before each subsequent interview in order to target the specific foci in relation to the instructional context. For example, following the field trip to the rock quarry, I asked Mrs. Hunter a set of questions that were specific to that experience, but which were not relevant for earlier interviews. Each interview lasted between 22 and 43 minutes, and was conducted at the end of the school day in Mrs. Hunter's classroom.

In addition, the school principal, Mr. Ford was interviewed on a single occasion towards the beginning of the unit. This interview protocol (Appendix 4B) was semi-structured, with planned topics of discussion and question, which allowed for probing of specific ideas as they naturally arose (Table 4.3). The interview took place in Mr. Ford's office during a scheduled appointment on April 23, 2009, partway through the curricular enactment.

Interviews with Mrs. Hunter and Mr. Ford were fully transcribed in a top-to-bottom format (Ochs, 1979). The area of interest and focus of analysis in the interviews with Mrs. Hunter was on the discussion of conceptual ideas around issues related to four categories: 1) the practicalities of the curricular enactment; 2) the outdoor learning experiences which represented a relatively novel teaching technique for her; 3) perceptions of student gains; and 4) perceptions of the unit's influence on her teaching

Table 4.2 *Schedule and Topics of Focus for each Interview with Mrs. Hunter*

Interview #	Date (2009)	Interview Focus	Length (mins)
1	March 30	Baseline interview, prior experiences teaching Earth science, preconceptions about enactment, expected personal and student experiences	22:49
2	April 17	Format of curriculum materials, unit big ideas, unit flow, role of outdoor learning experiences, impact on personal practice	24:00
3	April 27	Format of curriculum materials, unit big ideas, unit flow, role of outdoor learning experiences, impact on personal practice	30:17
4	May 5	Rock quarry field trip experiences, connecting to classroom activities, role of outdoor learning experiences, barriers of outdoor instruction	42:06
5	May 19	Format of curriculum materials, unit big ideas, unit flow, role of outdoor learning experiences, impact on personal practice, connecting to classroom activities, comfort with enactment	38:05
6	June 8	Mini-projects, overall impressions of unit, relevance of unit to students' lives, role of outdoor learning experiences, expected takeaway messages by students	40:23

Table 4.3 *Focus of Interview with Mr. Ford*

Interview #	Date (2009)	Interview Focus	Length (mins)
1	April 23	Policies regarding field trips around, and away from school, barriers associated with field trips, value of field trips, support for teaching using novel instructional techniques, importance of learning about local environment	35:51

practice. Similarly, the interviews with Mr. Ford focused on the following categories: 1) school policies; 2) supporting teachers in their practice; and 3) outdoor learning experiences. The transcription of lengths of pauses and other noises (both verbal and non-verbal) unrelated to the content were irrelevant and excluded. Episodes of laughter were included in the transcription of the interviews with Mrs. Hunter, as her demeanor was often of a convivial nature. Including "(laughs)" in the transcript allowed me to discern when Mrs. Hunter was communicating humor or joking. This is apparent in the audio interview file, but is difficult to make sense of from reading a transcript.

The data were analyzed separately for the group of teacher interviews, and the principal interview using the qualitative data analysis software, NVivo. After all interviews were transcribed, I conducted a preliminary examination of the first three interviews with Mrs. Hunter, in order to identify dimensions of each of the thematic categories. The unit for coding was an expressed idea (Minichiello et al., 1990) related to a thematic category. Each coding unit was assigned to free nodes that represent dimensions of relevant categories. It was inappropriate to use common linguistic units, such as words, sentences, or paragraphs as the coding unit (Zhang & Wildemuth, 2009) due to the importance of context in the discussion of the themes during the interviews.

The resulting list of free nodes included twenty dimensions across four thematic categories for the interviews with Mrs. Hunter (Table 4.4, Appendix 4C), and nineteen dimensions across three thematic categories for the interview with Mr. Ford (Table 4.5). Although the coding scheme was not developed *a priori*, the assignment of the dimensions to a category is logical given the foci of the interviews. The expression of an idea often fell under multiple dimensions, and the coding scheme is not mutually exclusive. For example, a single passage can be coded as both a potential student gain, and an affordance of an outdoor learning experience. This method of coding a single coding unit into several categories was necessary due to the attention to context; thus, a passage was coded into as many themes and dimensions as was appropriate. The goal of this analysis was to evaluate the expression of ideas by Mrs. Hunter and Mr. Ford in order to gain insight into the attention paid to various dimensions of their perspectives related to the enactment of curriculum materials that integrate outdoor learning experiences. Due to the differing total number of coded references for each interview, I examined the percent coverage of the more frequently discussed dimensions (Table 4.4) across time for each individual interview (Figure 4.2). Percent coverage is calculated as the number of characters (i.e., letters, punctuation marks, etc.) in a coded passage as a fraction of the total number of characters in the source (i.e., transcript). This calculation was used as an analogy for estimating the amount of time devoted to a theme throughout an interview.

The purpose of coding was to analyze the relative frequency of the expressions of dimensions within the categorical themes across all interviews in order to determine which dimensions are central components of each individual's perspective (Table 4.6). Inter-rater reliability was completed by myself and another individual (Ph.D. in Mathematics Education) on approximately 14% of the data. Cohen's kappa can be used to determine the level of agreement between two sets of data. The data were dichotomous, in that each coding unit was determined to be either non-representative of a coding dimension (0) or representative of a coding dimension (1). The kappa represents the approximate correlation between the scores of two raters. It was calculated as a means to determine the amount of improvement that both raters showed above chance, divided by the maximum amount of improvement that could have been shown (Wood, 2007). For this data, which represents 540 valid cases and opportunities for agreement, the kappa statistic was computed to be 0.689. According to Landis and Koch (1977, p. 165), kappa statistics between 0.61 and 0.80 represent a "substantial" strength of agreement. Quotations from interviews were chosen to provide a more in-depth exploration of each participant's ideas.

Table 4.4 *Thematic Categories and Coding Dimensions and Number of Coded References for Interviews with Mrs. Hunter*

Thematic Category: Curricular Enactment		
Unit weaknesses	Descriptions and opinions of the weaknesses of the unit	5
Mini-projects	Experiences leading students in carrying out free-choice projects	7
Curriculum materials	Experiences using printed student and teacher curriculum materials	18
Unit strengths	Descriptions and opinions of the strengths of the unit	21
Content connections	Ability to make connections between activities and lessons	29
Teacher opinions	Teacher communicates her own opinions of the unit	34
Student opinions	Teacher's observations about students' experience during unit	41
Thematic Category: Outdoor Learning Experiences		
Challenges	Challenges of outdoor learning experiences	16
Descriptions of activities	Descriptions of unit activities that took place outdoors	22
Rock quarry trip	Experiences anticipating and during visit to rock quarry	28
Role in unit	Role that all outdoor learning experiences play in the unit	29
Affordances	Value of outdoor learning experiences	33
Thematic Category: Student Gains		
Big ideas	Big ideas students learn in unit	6
Local setting	Examples of student learning about their local setting	16
Relevance	Relevance of the unit to students' lives	42
Potential gains	Other potential student gains	46
Thematic Category: Teaching Practice		
Support from others	Perceived collegial support for teaching	5
Past experiences teaching	Past experiences teaching Earth science	22
Comfort	Teacher's comfort level teaching this unit	23
Influence of unit	Ways in which the unit influenced teacher's practice	47

Table 4.5 *Thematic Categories and Coding Dimensions and Number of Coded References for Interview with Mr. Ford*

Thematic Category: School Policies		
Field trip policies around school	School policies relevant to outdoor learning experiences on school grounds	1
State expectations	The school must meet expectations put forth by the state	2
Field trip policies away from school	School policies relevant to field trips away from school grounds	3
Curricular decisions	Decisions about the curriculum are handled within the school	4
Balancing value and challenges	Role of the principal in making curricular decisions that balance value and challenges	6
Thematic Category: Supporting Teachers in their Practice		
Management	Ensuring teachers trust students	1
Teachers as experts	Teachers are decision makers in their classrooms	1
Collegial support	Teaching using curricula can promote a sense of community within, and outside the classroom	4
Creativity	Encouraging creativity in teacher's practice	5
Supporting teachers	Supporting teachers in their practice	5
Risk-taking	Encouraging risk-taking and trying new techniques	6
Thematic Category: Outdoor Learning Experiences		
Time challenges	Time-related challenges of outdoor learning experiences	2
Direct experiences	Outdoor learning activities provide direct experiences	3
Local setting	Importance of outdoor learning experiences for learning about the local setting	3
Disruption challenges	Challenges of outdoor learning experiences related to disruption	3
General value of field trips	Value of outdoor learning experiences	5
Curricular connections	Teachers need to promote curricular connections, both within and between disciplines	7
Engaging students	Outdoor learning experiences engage students	7
Financial challenges	Financial-related challenges of outdoor learning experiences	10

Table 4.6 *Summary of Central Components of Participants' Perspectives*

Central Components of Mrs. Hunter's Perspective	Central Components of Mr. Ford's Perspective
Important role of outdoor learning experiences in the curricular enactment • Influenced teacher's practice o Facilitating coherence across unit o Providing firsthand experiences o Increasing student engagement and motivation o Facilitating awareness of relevance to students	Mr. Ford views his role as principal is to • Support teachers in their practice by o encouraging risk-taking and creativity • Balancing o Value of outdoor learning experiences with the challenges regarding their enactment

Mrs. Hunter's Perspective of the Value and Role of Outdoor Learning Experiences in the Curricular Enactment

The series of interviews with Mrs. Hunter revealed her perceptions as to the ways in which the integrated outdoor learning experiences influenced her teaching practice. Mainly, she perceived that the inclusion of the learning activities outdoors 1) facilitated the development of coherence and connectedness across the Earth systems science unit, 2) increased students' engagement with the enactment and motivation to learn, 3) facilitated her ability to help students become aware of the relevance of science content to their lives, and 4) increased her self-awareness of her behaviors and their impact on the environment. Each of these dimensions of the role of outdoor learning experiences and their influence on Mrs. Hunter's practice over time is described.

Several outdoor learning experiences around the school grounds were included throughout the Earth systems unit, with a more extended outdoor experience to a local rock quarry (Chapter II). The rock quarry visit occurred about midway through the curricular enactment, just before Interview #4. The patterns in percent coverage of these key dimensions of Mrs. Hunter's perspective will be discussed.

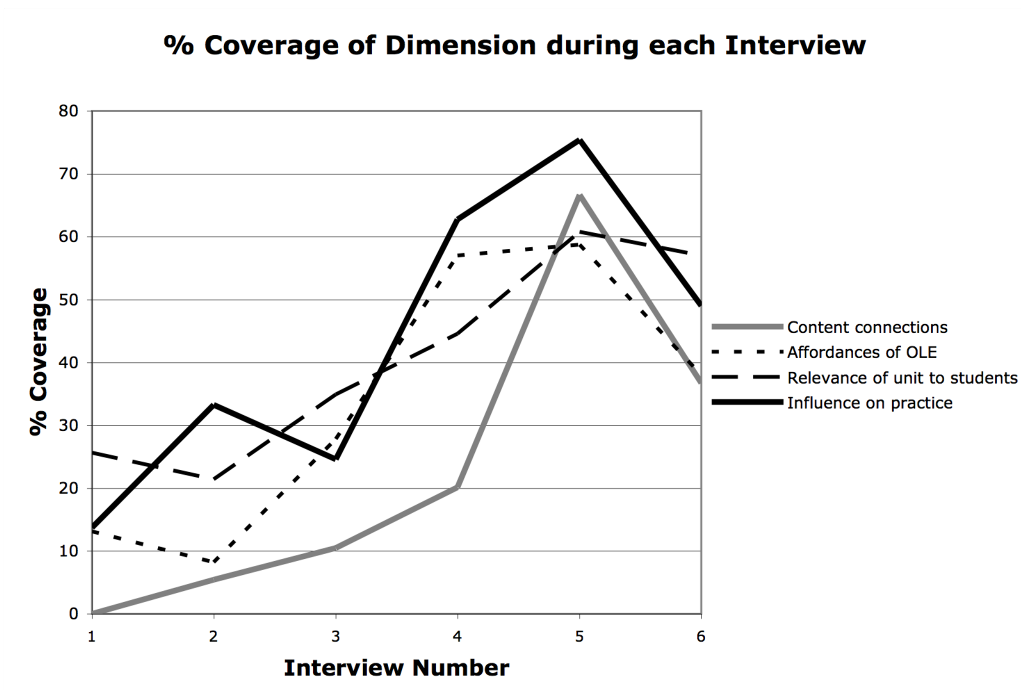


Figure 4.2. Percent coverage of key dimensions of Mrs. Hunter's perspective of the curricular enactment over time

Facilitation of coherence and connectedness.

Mrs. Hunter was confident in her ability to draw connections between science concepts and activities with the opportunities supported in the curriculum. This is an important aspect of the curriculum materials that were designed as a coherent set of activities and ideas. The components of the curriculum are connected, rather than a set of isolated activities. Mrs. Hunter's confidence in her ability to make connections from lesson to lesson was apparent throughout the interviews. One way in which the materials facilitated coherence was through the use of collected materials for later activities. For example, in interview #2, Mrs. Hunter described the ways in which she saw the activities in the unit flowing together.

Researcher: Okay, so what about the flow of the unit so far? Do you feel like you're able to make connections from lesson to lesson?

Mrs. Hunter: Yes, I think so, yes. Very much so. Especially, like we actually used the samples [that students had collected outdoors]. (Interview #2 with Mrs. Hunter, 4/17/09)

From the beginning of the unit, Mrs. Hunter acknowledged the opportunity to make use of the samples that students had collected during an outdoor learning experience, which helped her connect the activities by drawing attention to the origin of the materials with which students were working.

Later in the curriculum, Mrs. Hunter explained how the field trip to the rock quarry provided many more opportunities to make connections between concepts.

Researcher: What experiences have you been able to draw on in class, that are related to the rock quarry field trip?

Mrs. Hunter: Oh jeez, seems like a lot in the last few days. The water table, and you know how far down it is. The graded bed. Sediment and in general, geosphere materials like we saw at the quarry. We're soon to be sampling the water quality, so that will be eventually coming up. … Oh, the interactions that we've talked about with the posters, the plants grow in the geosphere.

Researcher: Do you think the unit would be progressing differently in any way if you were unable to take students outside and to the quarry?

Mrs. Hunter: Yeah, I was thinking about that … how important it was for us to have a successful field trip to the quarry. Because so many lessons since then have [hinged] on it. … Of course you could teach it, but I think it would be harder. It's much easier to be able to refer back. You know "how deep do you think you were standing when you were at Mrs. Nelson's station?" … that's a very concrete question. They were there. … Probably it's written in one of the pages…. It would be hard to make those connections as easily. You would be doing a lot of drawing, and looking at pictures,

> and trying to get them to understand. I think that concrete-ness at this age is really important. They were there. You could touch it, draw it, feel it. Lay in it. (laughs) (Interview #4 with Mrs. Hunter, 5/5/09)

Mrs. Hunter clearly stated her belief that the outdoor learning experiences were strongly tied to other learning activities that occurred after the visit to the rock quarry. She highlighted her reliance on that visit for illustrating concepts during activities in the classroom and laboratory, and mentioned that it facilitated the drawing of connections among concepts. She linked opportunities to make connections with the importance of providing concrete experiences with middle school students. Her awareness of these connections was supported by the substantial increase in the percent coverage (10%, 20%, 66%) during interviews 3, 4, and 5 respectively, which occurred immediately following the rock quarry visit (Figure 4.2). Mrs. Hunter believed students were aware of the connections to the outdoor experiences when they had returned to the classroom, and suggests that this might be a new experience for them. She stated, "I think the kids are sort of surprised that we're still talking about it. … 'Oh! She's still camped on that quarry visit. That was early May!'" (Interview #5 with Mrs. Hunter, 5/19/09).

During the final interview, Mrs. Hunter's opinion of her own ability to make connections throughout the unit was communicated as she described the day that she guided students in filling out a post-enactment survey about their experiences with the unit.

Researcher: So anything else about the flow of the unit, like day to day connections? Do you feel like you were struggling to sort of relate things to--yesterday we did x or y?

Mrs. Hunter: I don't recall any major blocking. … Like 'gosh how do I pull this along?' … I think that it was a pretty good amount of time before the quarry, enough build up to get the information they needed before we got there … I think it was pretty good. And one of the survey questions was … 'did your teacher connect lessons back to the field trip'… I'm like 'you better put strongly agree.' I mean how many times did I refer to Mrs. O'Bell's station in the last two weeks or four weeks … I hope they put strongly agree 'cause I feel like I did that. [After] the quarry, it seemed like I started, 'remember at the quarry,' many many sentences. (Interview #6 with Mrs. Hunter, 6/8/09)

Mrs. Hunter believed that she had clarified the overall coherence of the unit, specifically in relation to the rock quarry visit as she references the survey question that probed students' experiences with connections during the unit. Although Mrs. Hunter did not actually tell students “you better put strongly agree,” her mention of these thoughts indicates her belief that she had put substantial effort into helping students make coherent connections facilitated by outdoor activities across the unit, and her hope that students recognized her efforts.

During the fourth interview, Mrs. Hunter recognized connections to the activities that followed the rock quarry visit, yet during the final interview, she discussed the preparation before the visit, and the connections to the visit that followed. This highlighted her greater awareness at the conclusion of the unit of the role that the outdoor learning experience played in the overall coherence of the unit (Figure 4.2). Approximately two weeks following the rock quarry visit, Mrs. Hunter spent a great deal of time discussing coherence and connectedness across the unit. This finding suggested that it was not until she reached the conclusion of the unit that Mrs. Hunter was fully aware of the extent of the coherence that the outdoor learning experiences fostered. She discussed the idea of connections and the flow of the unit during all six interviews, but the amount of time devoted to this dimension reached a maximum approximately one week before the end of the enactment. This finding indicated the importance of firsthand experience teaching a curricular unit to develop expertise. Mrs. Hunter stated that she collects “little tricks up your sleeve as far as labs, demos, examples. Every year you get to be a little better.” (Interview #5 with Mrs. Hunter, 5/19/09).

Direct experiences with phenomena.

Mrs. Hunter frequently mentioned aspects of the curricular enactment that were coded as affordances of outdoor learning experiences, and often overlapped with the dimension regarding potential student gains. Outdoor learning experiences provided opportunities for Mrs. Hunter to expose students to concrete phenomena in a firsthand and direct way. She describes the importance of outdoor learning experiences in providing direct experience in relation to the concepts upon which students are focusing.

Researcher: What role do you see the outdoor learning experiences playing in [the] activities? Were they necessary? Were they helpful?

Mrs. Hunter: Yes. Yes to both of those. Like the geosphere activity when we went and collected the materials. I think that it just helps them remember vs. like ‘okay, here’s what the geosphere is made of’ vs. they have actually physically collected a couple of them. That’s *much* better. Or if we were talking about the different spheres, and they can relate to something collected from outside, like 'this belongs to the geosphere…' I think anything that is hands-on is just going to help them. … that's how they remember it. Yeah, they're 11. They're not adults. So they need to be able to touch, feel and move. (Interview #2 with Mrs. Hunter, 4/17/09)

Mrs. Hunter believed that students need sensory input to make sense of their world; therefore the outdoor activities are a technique that was useful for providing such experiences. In a later interview, Mrs. Hunter explained that it was crucial for students to be able to have direct experiences in which they can use their senses. Because students were physically present in the outdoor setting, experiencing their surroundings in a concrete way, Mrs. Hunter believed that students made connections to the scientific concepts they were learning about in relation to the visit to the rock quarry. During the final interview with Mrs. Hunter, I asked her how she regarded the usefulness of the field trips in the Earth systems science unit.

Mrs. Hunter: Because they could see it firsthand versus like in years past you teach the water table. You draw on the board, here's the water table. Above it is unsaturated. … the diagrams--you [draw] like crazy. … 'And why was it so smushy between the two stations?' Oh cause we were only standing right above [the water table]. The firsthand. Right there with it. And then the birds-they're flying over your head as they go into the sides [of the rock] where their nests are built, like the little biosphere interaction there. (Interview #6 with Mrs. Hunter, 6/8/09)

Mrs. Hunter described the contrast between how she has taught the concept of the water table in the past, with how she approached this concept during the enactment of the Earth systems science curriculum. In this unit, she provided an opportunity for students to experience what it felt like to stand just above the water table at the rock quarry. Overall, Mrs. Hunter perceived that the firsthand and concrete experiences with phenomena during the outdoor learning experiences were a substantial contribution to the curricular enactment.

Perceptions of student engagement.

Mrs. Hunter believed that the outdoor learning experiences had an important affective component for students, mainly in the added excitement, novel and unique experiences, the different types of activities, and overall engagement that such experiences fostered. Mrs. Hunter saw the outdoor learning experiences' affective component as crucial to students' educational experience in science class.

Researcher: What do you see as the strengths or the affordances of using the outdoors for teaching those concepts?

Mrs. Hunter: So I think any time you can get them outside to give them examples of sediment, or soil, that is just going to increase their interest level, and especially Earth science, which I find to be, typically, not their favorite subject. So anything that I can get them to be like 'oh, let's go outside and get a rock sample, or take the water' … anything you can do to engage them physically in the activity … to go outside a little bit. I think that will just automatically increase their interest level. (Interview #1 with Mrs. Hunter, 3/31/09)

Mrs. Hunter saw a connection between students' interest level, and the hands-on nature of outdoor learning experiences. The physical involvement with an activity was one aspect that had the potential to increase interest level, which she indicated was of particular importance in Earth science. In another interview, Mrs. Hunter reiterated her belief about students' generally low interest levels in regards to Earth science, as well as her own personal background, which she perceived was not strong.

Researcher: So what is your opinion of the unit, up until this point? …

Mrs. Hunter: I really like it myself. And I'm coming in from not really an Earth science background. It's not really my science of choice. And so I think it has been engaging for the students which I think is a challenge for Earth science sometimes. It's not always their first thing. And I anticipate rock collections will be trickling in next week. (Interview #2 with Mrs. Hunter, 4/17/09)

Despite her own background, and her belief about students' low interest levels in Earth science, Mrs. Hunter believed students were finding the unit engaging and interesting, such that they might begin bringing in their own rock samples.

Later, Mrs. Hunter again explained that she believed there was a strong motivational aspect to the outdoor learning experiences.

Researcher: What role do you see [the outdoor learning experiences] playing in the curriculum? …

Mrs. Hunter: I think that they are helpful in a couple different ways…. I think, everyday they come in, and 'can we go outside?' It sorta sparks that little—like if they were on the edge about 'Maybe I'm gonna stay home today,' or maybe 'she's gonna go out.' It sorta makes them want to come. (Interview #3 with Mrs. Hunter, 4/27/09)

The possibility of going outdoors in science class was cited as one potential thought a student might have when considering whether to come to school or not. Thus Mrs. Hunter saw a strong motivational component in the opportunity to participate in an outdoor learning experience during the school day. She later explained that the outdoor activities help keep students involved in the unit.

Mrs. Hunter: I think it helps them stay engaged. … they're kinda always, 'are we gonna go outside?' I don't always tell them anymore. We could go outside today. They don't always know. Spur of the moment sort of. It's not really spur of the moment, but in their heads, it's like 'oh we're going outside' which is kinda how I want to keep it I think. (Interview #4 with Mrs. Hunter, 5/5/09)

Mrs. Hunter believed students saw her decision to take them outdoors as a spontaneous and spur of the moment instructional choice. This was an aspect she believed helped to keep them engaged, which is perhaps linked to her belief that students consider the opportunity to go outside when deciding whether to come to school or not.

At the conclusion of the unit, I asked Mrs. Hunter what she saw, overall, as the role of the outdoor learning experiences in the curricular enactment. She responded, "Well I think that number one it would keep them engaged which is always kind of pivotal to them learning anything. If they are bored, that's it, you're done." (Interview #6 with Mrs. Hunter, 6/8/09). Overall, Mrs. Hunter acknowledged the strong affective component of the outdoor learning experiences in the Earth systems unit. As she explained, if students are not interested, it is difficult to conduct instructional activities. One theory Mrs. Hunter shared as to why students were motivated by the prospect of going outdoors in science class was related to a change in pace.

Researcher: Do you feel like it's worth the extra time and effort that it takes to go outside, or to go on fieldtrips, and why?

Mrs. Hunter: Yes. Well, I think that the kids' interest level—it's much easier to teach a unit that the kids are excited, and wanting to [participate] … never have I said 'we're going to go outside today' and they're not all cheering and excited. … So I think the student engagement being higher …. Something other than the same old, everything is the same, until ya die! (laughs). (Interview #5 with Mrs. Hunter, 5/19/09)

Mrs. Hunter saw changes from the normal routine as playing an important role in students' interest levels. She described students as excited and wanting to go outdoors, attributing some of this excitement to the fact that going outdoors was unique and different from "the same old."

Highlighting relevance of curriculum to students' lives.

A valuable contribution of the outdoor learning experiences to the curricular enactment was in their potential to make science relevant to students. Mrs. Hunter described a phenomenon with personal and local relevance—the erosion of sand dunes. This concept was not dealt with explicitly in this unit, though Mrs. Hunter acknowledged the potential of using an example of a concept with certain characteristics.

Mrs. Hunter: I was thinking of the erosion … something that would make sense to them. Like how they can help. … All the kids usually have been to the sand dunes, and we talk about [it]. [Signs tell] you 'Do not walk here' and 'there are plants planted there,' and why would it matter to follow those directions, and if you don't, what's going to happen? They're not gonna be there anymore, because the plants help keep the sand there, …, so try to make things, like I said before, sort of matter to them, … 'Do we like to go to the beach?' (Interview #1 with Mrs. Hunter, 3/31/09)

Mrs. Hunter recognized the ways in which she could relate outdoor experiences, including those that occur in students' leisure time, to science concepts. At the conclusion of the unit, three groups in different sections chose to study sand dunes for their mini-project. During this same interview, I asked Mrs. Hunter why it might be important for students to learn about their local setting. She explained ways that she has made science relevant to her students in the past, and then described her own personal experience with a neighbor potentially contributing to groundwater contamination.

Mrs. Hunter: Yes, because they live here, and I don't think they realize the impact that we have on our surroundings. Just everyday little things. I remember, a few years ago, an example of that is, we were learning about the water cycle, and the kids you know, they were like, we were talking about groundwater, and how, you know if you pollute that, that's it! You know? This is what we drink from, this is what we have to keep clean. …Like years ago, I used to know a guy that would dump his oil in the drain in the city. He'd go out to the curb and just pour it into the drain, from his car. …and we'd talk about like 'how bad is that?!' It's really bad. And he probably didn't know any better. He figured he was just dumping it down the drain you know. And we'd talk about the implications of that. (Interview #1 with Mrs. Hunter, 3/31/09)

This example illustrated a contribution of experiences in the outdoors that can help students relate science concepts to their daily lives. Mrs. Hunter recognized the value in helping students develop a greater awareness of their local setting and their potential impact on the Earth. In another example, she pointed to the outdoor learning experiences as a way to help students become more aware of the origin of resources they use daily. "What do we have around *us*, and the samples from *our* schoolyard for example. …How much more local can it get?" (Interview #2, with Mrs. Hunter, 4/17/09). Throughout the interviews, Mrs. Hunter referenced the lack of awareness of our use of Earth's natural resources. She regarded the role of the outdoors, the schoolyard, and the focus on "us" in the curriculum materials as a strategy for relating science concepts to students' lives.

I asked Mrs. Hunter how she might help students understand the relevance of the rock cycle during upcoming lessons. She expounded upon her acknowledgement of how society treats the environment, and questions the practices of construction companies, as she describes observations she has made outdoors.

Mrs. Hunter: When you look at the phenomenal amount of stuff that we build. Like the road and the potholes. We're so wasteful. …but maybe encourage some students to look at—do we, in the state of Michigan—when they redo the roads, what happens to the stuff that they scoop up and they drop in the back of those dump trucks? I dunno, do they dump them someplace? I've seen piles of that rubbish someplace, but do they reuse them? I couldn't tell you. (Interview #3 with Mrs. Hunter, 4/27/09)

Mrs. Hunter saw one way to make the rock cycle relevant to her students was through a discussion about construction projects and disposal of rock material in Michigan, and to encourage some students to explore such a question for the mini-project at the end of the unit. The activities throughout the unit as well as her personal experience have awakened a curiosity about her local environment.

Mrs. Hunter believed her students were relatively unaware of their immediate surroundings. She describes an outdoor learning experience that focused upon identifying manmade objects around the school grounds.

Mrs. Hunter: I said 'just look around, circle around.' … and they were noticing things not necessarily 10 feet away, like the water tower, and the buildings, and I heard somebody identify the cell phone tower or some sort of communication tower over there. So they were looking past… Also I think they were talking about glass and little discussion about where that comes from. I don't think a lot of them realize, or really thought about it. …Our stuff! And they were like 'the bench, the sidewalk, the lamppost, the building!' (Interview #3 with Mrs. Hunter, 4/27/09)

During a brief activity outdoors, students noticed manmade objects in their immediate surroundings, as if for the first time. The use of Earth's resources for making many of the objects we use daily was a concept Mrs. Hunter believed many students had never considered, and the simple use of this outdoor experience fostered a discussion of the origins of manmade materials later in the classroom, and during the visit to the rock quarry and landfill. After the extended field trip, Mrs. Hunter explained that seeing and discussing Earth's resources had the potential to help students become more aware of their effect on the Earth system.

Mrs. Hunter: You'll hear them distinguish between, 'well you have well water, I have city water.' … I don't think they realize it alllll comes out of the same ground. … I always try to make the connection to, because people put so much junk on their lawns. We put all that stuff on the ground. Where does it go? I don't care how safe they think it is. Look at the chemicals in the warnings. 'No pets, no children.' It's like scary stuff. Do you really think it's that important to not have dandelions in your yard? … Probably not! (laughs). …I'd like to really make that connection to the landfill. We're such a disposable type of people. (Interview #4 with Mrs. Hunter, 5/5/09)

Mrs. Hunter indicated that she tried to make these important connections with students to help them become more aware of the ways that science was relevant to their lives, and also the ways in which humans can impact the environment—a key aspect of Earth systems science. Mrs. Hunter expressed her concern about students' disregard for materials they use in the classroom such as markers and colored pencils, and she has found a way to connect the outdoor learning experiences with students' behavior to increase its relevance.

Another contribution of the outdoor learning experiences in this unit was to provide a window into possible career options for students. "The more you can expose them to different things, the more choices that they're going to realize they have, as far as 'what are you going to do one day?' … career wise." (Interview #4 with Mrs. Hunter, 5/5/09). Mrs. Hunter mentioned construction workers and quarry workers as jobs students may have not considered until the visit to the rock quarry. In addition, this field trip provided an opportunity for students to consider the ethical implications of finding a contaminant in the water from the rock quarry. "The afternoon class, said 'if we find something in the water that shouldn't be there, are we gonna tell them?' ….I said, 'well I guess we'd have to!' They said, 'wouldn't it shut them down?'" (Interview #5 with Mrs. Hunter, 5/19/09). Following was a discussion about quarry workers potentially losing their jobs. This very important conversation among students and Mrs. Hunter provided a good example of the role of science in society, and the potential impact of science for other areas of life. Students first wondered about their responsibilities in the event that contaminants were to be found in the water supply. This led students to consider the impact that such a finding would have on the rock quarry business, and specifically on the people who work at the quarry who might lose their jobs. This was an ideal example that illustrated the importance of helping students develop skills surrounding the interaction of components of Earth's systems, and the connections between science and society.

Summary of Mrs. Hunter's perspective.

Salient findings from interviews regarding the influence of outdoor learning experiences on practice revealed that such activities facilitated Mrs. Hunter in: 1) making coherent connections throughout the unit; 2) providing a variety of firsthand experiences; 3) increasing student involvement throughout the unit; and 4) heightening students' awareness of the relevance of the Earth systems unit to their lives. These key ideas related specifically to the contribution of the outdoor learning experiences on Mrs. Hunter's teaching practice.

Mr. Ford's Perspective of his Role as the School Principal in Relation to Teachers' Practice

The interview with Mr. Ford provided insight into his perceptions of his role as the school principal, and the coding of his expressed ideas throughout the interview revealed certain central dimensions of his perspective. Figure 4.3 illustrates an analysis of the relative frequency of passages coded to each dimension, and Figure 4.4 shows the percent coverage of each dimension within the entire interview. In general, Mr. Ford regarded his role as supporting teachers in their practice by encouraging risk-taking and creativity. Mr. Ford discussed these aspects in relation to Mrs. Hunter's curricular enactment that included integrated outdoor learning experiences. He believed the enactment of the Earth systems science unit demonstrated her willingness to take risks and be creative in her teaching practice. In addition, Mr. Ford acknowledged some aspects of the value of outdoor learning experiences, but communicated the difficult task of balancing the value with the challenges associated with such activities.

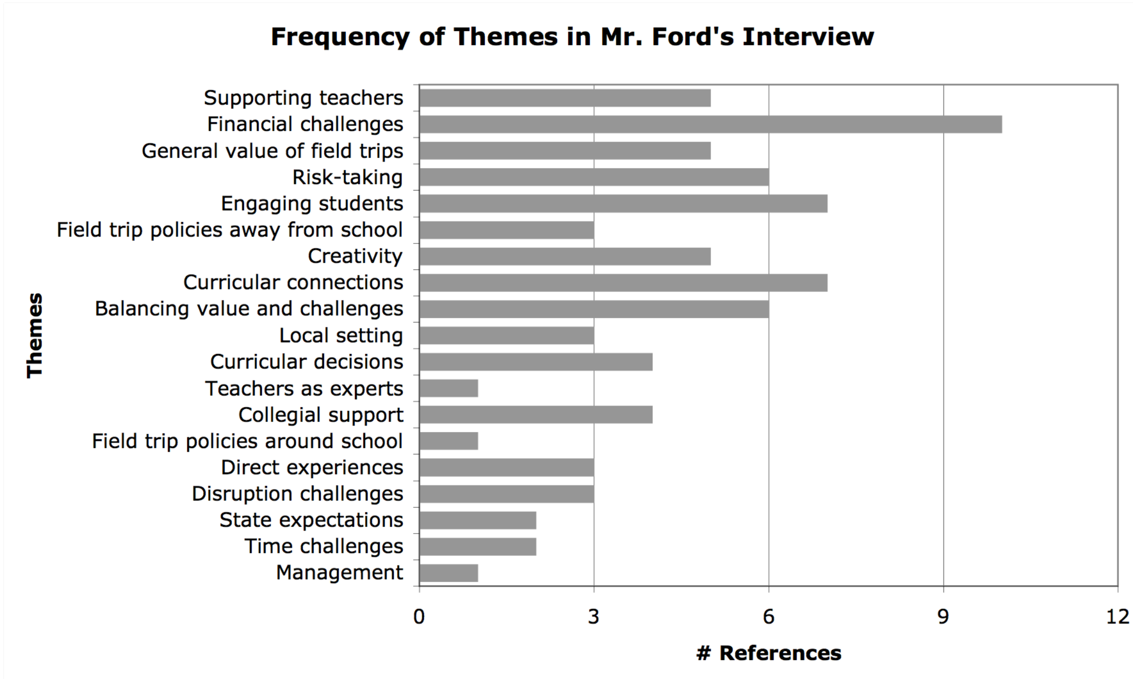


Figure 4.3. Relative frequency of passages coded to each theme.

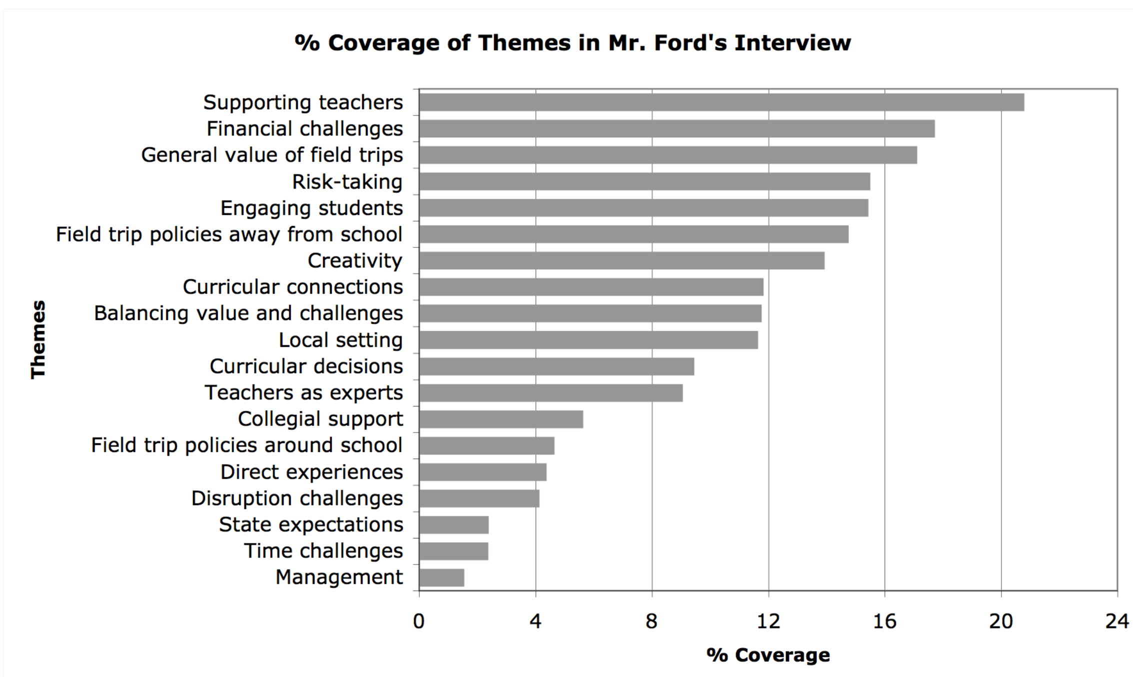


Figure 4.4. Percent coverage of themes for Mr. Ford's interview.

Supporting teachers and encouraging risk-taking.

Mr. Ford believed that although the teaching occupation has some requirements and standards that need to be met, that the actual craft of teaching is completely self-imposed without guidelines from the school administrator. During the interview with Mr. Ford, he described the ways he tries to create a supportive environment in which teachers trust him and are comfortable taking risks and experimenting with new instructional techniques.

Mr. Ford: But you also have to create an environment that people can trust you to know that, because we have an evaluation process here too and if you have teachers that live in fear about taking risks – I've lost and I've not done my job. If I can get teachers to take risks and do things like Mrs. Hunter's doing or anything for that matter that's different, I've won, they've won and ultimately most importantly the kids win. … I think the more opportunities I have to model that support, to say "yeah take a risk and let's talk about it and see how it went. And even if it fails or it doesn't turn out the way it was expected, that's okay. It's not going to show up in an evaluation. You're a risk taker." We're trying to do things for kids. That's part of the game in what we should do. I hope, I mean I'm a strong believer in terms of modeling in that the more experiences I have like this with Mrs. Hunter or anybody else for that matter. (Interview with Mr. Ford, 4/23/09)

Mr. Ford emphasized the importance of an environment in which teachers trust him when he encouraged risk-taking in the classroom. He explained that although there is an evaluation process, he did not want teachers to avoid trying new instructional techniques. He saw Mrs. Hunter's willingness to participate in this research study and take risks as a model of a teacher feeling supported in the school environment. Although, Mr. Ford described the difficulties in creating such an environment in a school setting due to teacher evaluations.

Mr. Ford: That's a tough job in itself to do, to create trust, like I said because there is an evaluation process attached at the end of the year to teachers. ... So only being here since November I'm trying to develop some trusting relationships with people so that they know who I'm about, who I am. It's one thing to say, it's another to model it. So I can say it all I want, but until I model some support for Mrs. Hunter or any other teacher that's doing something, then they won't believe me and I don't blame them. Cause I should be able to model and not just say it. … I hope she spreads a good word because like I said it's not what I say, it's what I do. (Interview with Mr. Ford, 4/23/09)

Mr. Ford suggested that by supporting Mrs. Hunter in her risk-taking, he modeled his values, and guided other teachers to recognize his beliefs as the school principal. He drew attention to the insufficiency of simply saying he encouraged risk-taking. Instead, he modeled his acceptance of risk-taking, as the school principal. He described his hope that Mrs. Hunter would "spread a good word" about her experience taking a risk, and presumably being supported and encouraged by Mr. Ford.

Supporting teachers by recognizing the potential value of outdoor learning experiences.

Mr. Ford discussed his perspective of the ways in which outdoor learning experiences can be valuable. This dimension arose throughout the interview frequently, and covered a substantial percentage of the interview (Figure 4.4). In general, Mr. Ford believed outdoor learning experiences were valuable in that they provided exposure to new and live experiences, opportunities to make connections of various types, opportunities to teach students values and to connect to their community.

The exposure to live experiences was one major role of field trips from Mr. Ford's perspective. Not only were such outdoor learning activities hands-on, allowing students to more actively construct knowledge from their experiences, but they were live. By "live", Mr. Ford indicated the hands-on nature of the entire outdoor context. During an outdoor learning experience, students were surrounded by phenomena, which contributed to the value of such activities. He contrasted such experiences with those that involve technology, both during the school day and at home.

Mr. Ford: I think the value lies in the hands-on experience, the live experience I think. I don't think there's any question we live in a time where we spend a lot of time in front of a screen … and I think that for me, the most important thing we could get out of a field trip is that live experience. Something they wouldn't otherwise do in their regular life and to make a topic come alive. That's powerful. You cannot recreate that in the classroom. You cannot recreate that on the Internet. That's some of the things that you can do, can only get the greatest impact, by seeing things live. (Interview with Mr. Ford, 4/23/09)

Related to live experiences that occur outdoors, is the idea of providing access to concrete and direct experiences with phenomena. This idea is tied into Mr. Ford's view of the opportunity to introduce students to activities they would not participate in otherwise. When I probed Mr. Ford about why they are so valuable, he explained that activities in the outdoor setting can engage students with hands-on, live activities, which ultimately can help them connect to concepts.

> Mr. Ford: But I think, my main point here is the number one benefit is it gets kids engaged in their learning to benefit them in the best possible way so they can connect to a topic or an idea or a concept. … But when you get your hands on it and you live and you talk about it and you engage because you can't recreate some of the conversations that occur in terms of over the curriculum connection kids can make. You can't plan for it, it just happens and then the value of bringing that back in the classroom and then collaboratively coming back together just holds a lot of value and kids like it. (Interview with Mr. Ford, 4/23/09)

The aspect of valuable connections arose throughout the interview in multiple contexts, including the value of engaging with and connecting to topics, as in the example above. Mr. Ford recognized the importance of integration of different learning settings when he described how conversations occur during outdoor activities, which were then taken back into the classroom to enhance curricular connections.

An alternative type of connection Mr. Ford discussed was in the context of encouraging the building of trustworthy connections among students and with their teacher, a type of community building. Mr. Ford described the value of students learning about their local setting. He regarded the development of students' awareness of their surroundings as a valuable contribution of localized learning. Specifically, becoming aware of the surroundings through outdoor learning experiences can help students recognize value within the community.

> Mr. Ford: I think the importance of connecting to your community and your settings around you, is that it becomes more important to you. It becomes more valuable to you. The more you understand what's around you and what's available to you, the more you respect it. … Getting kids connected to the community around them, essential. And I think that gives them a better understanding, a better respect for things in the community [in] which they live. (Interview with Mr. Ford, 4/23/09)

Through a greater awareness of the value of the surroundings, comes a greater sense of respect. Mr. Ford goes on to say, "That's why I'm passionate about being creative about what you do in the classroom because we don't have to do the same thing" (Interview with Mr. Ford, 4/23/09). Thus, Mr. Ford has acknowledged the valuable contribution of outdoor learning experiences, linked these activities to the importance of fostering students' connection with their community, and finally connected these ideas to his support of teachers' creativity in their practice.

Balancing the value of outdoor learning experiences with challenges.

As the school administrator, Mr. Ford cited several major barriers to field trips that occur away from the school grounds. These included restrictions of money, time, schedule disruption, and the potential of isolated experiences. Mr. Ford recognized the value in conducting outdoor learning experiences; yet, he also acknowledged challenges with such activities. The importance of balancing the value with the challenges when making administrative decisions was a frequently cited aspect of Mr. Ford's perspective (Figure 4.3).

One of the central barriers that emerged frequently, and was discussed a large percentage of the time were the financial barrier of extended field trips. As Mr. Ford explained, it can be costly to take students away from school due to the cost of renting buses. "It comes back to money." (Interview with Mr. Ford, 4/23/09). Mr. Ford provided numerous examples that related to the dimension of financial challenges associated with trips away from school, including the limited number of buses owned by the school district, and the limited number of bus drivers, the cost of paying people for additional driving time, and fuel costs. In addition, Mr. Ford explained that he must be sensitive to the financial burden that a field trip may have on a family.

Mr. Ford: And the other thing personally I'm really sensitive to, is cost. We live in a time where jobs are tight and money is tight and if it's an expensive field trip even if it holds a lot of value that weighs heavily on the decision that I would make. I love field trips. I think they're great for kids. I think they can gain a lot out of it. But money does play a big factor and it's unfortunate, but it does. (Interview with Mr. Ford, 4/23/09)

Mr. Ford made it clear that he recognized the value that a field trip can hold, but the financial impact of field trips can be burdensome, not only for the school, but for families as well. "I get really anxious about students flipping the bill for some of these field trips." (Interview with Mr. Ford, 4/23/09). Thus, Mr. Ford explained that he must weigh various aspects of a field trip, including the potential value and cost, when deciding whether a field trip will occur. The school policy was for the student to contribute funds to cover the cost of the field trip, indicating that there was not a school budget to cover these costs.

Another challenge that must be considered when planning a field trip was time. This included time spent away from school, and the potential impact of an extended field trip on other teachers. Mr. Ford described the need to plan field trip experiences that can be completed during the course of a single day. This is in part, due to the need for all buses to be available at the beginning and end of the day for transporting students to and from school. Mr. Ford stated that there were very few extended day field trips across the school district due to the time restrictions.

A related challenge is the potential disruption that an extended field trip could have on teachers outside of the discipline in which the field trip is occurring. “You also have the fact that you see six different teachers in a day. ... If you disrupt six teachers’ schedules because of one subject you can just imagine.” (Interview with Mr. Ford, 4/23/09). Mr. Ford explained that the disruption to teachers’ schedules due to a field trip in one subject can be difficult, noting that he believed teachers were flexible and understanding of the needs of their colleagues, but nevertheless he must be aware of the impact of a field trip on an entire day’s worth of teaching activities across the school. He further explains “But the reality is if you did make a choice to take a field trip, even if it has a strong curricular connection, you impact that day.” (Interview with Mr. Ford, 4/23/09). The impact on other teachers and the disruption of a school day was raised again, as Mr. Ford stated “when you leave a school day, the question is: ‘did it hold the value that you would have if you stayed in school and progressed through this curriculum?’” (Interview with Mr. Ford, 4/23/09). He continued on, to clarify his opinion regarding the need to consider other teachers whose day would be impacted by a field trip away from school. “[The field trip has] got to hold a lot of value in terms of curriculum connection and you need to get the buy-in from your colleagues.” (Interview with Mr. Ford, 4/23/09). The importance of collegial support, and the potential opportunities to make connections across disciplines was raised as a factor that could facilitate a teacher’s decision to take students on a field trip. Mr. Ford continued on to describe the school policy regarding the type of field trip in which students can participate.

Mr. Ford: We have made a commitment that everything that you do outside the school has to have a strong curricular tie. It really truly has to be a unit that you might be in and then the field trip takes place at that point and

> there is no question about how great it is. Similar to what you'll be doing. Next week is it? (Interview with Mr. Ford, 4/23/09)

Thus, a field trip away from school must be tightly aligned to the curriculum, and Mr. Ford provided the upcoming field trip to the rock quarry as an example of an integrated trip with such characteristics. He described the high expectations put forth by the state in terms of standards, and acknowledged the risk that a field trip will not necessarily hold greater value than if students were to remain at school during the day. This requirement was indicative of the strong need for coherence across the curricular unit, and a strong and clear integration of learning environments including the classroom, laboratory, and outdoor settings.

Mr. Ford described the great potential value of outdoor learning experiences and field trips. In addition, he acknowledged his awareness of the disconnect between these values, and administrative needs that must be balanced. "So that's kind of the, I guess the rub between the way we've moved, and yet the value of a field trip because it holds a lot of value. But there are other factors that are [involved] in those decisions." (Interview with Mr. Ford, 4/23/09). The potential value of a field trip was not the only aspect he considered as the school principal; rather there are a system of difficulties he must balance when making curricular decisions regarding whether or not to support a field trip away from school.

I drew Mr. Ford's attention to an alternative type of field trip that occurred throughout the Earth systems unit—outdoor learning experiences that can take place around the school grounds, and asked his opinion of such activities. Although my question focused on the challenges of such activities, Mr. Ford instead discussed the great value they can offer.

Mr. Ford: Those experiences hold tons of value and they should be maximized and we forget about what we have at our fingertips sometimes, particularly in the area of science … we should be looking at doing some of those outdoor learning activities on a regular basis…. We have resources right here on campus and they don't have to be—I mean, the rock quarry is great. That's an awesome experience, but there are some things right here—streams and woods and rocks and all kinds of things. (Interview with Mr. Ford, 4/23/09)

Mr. Ford regarded outdoor learning activities around the schoolyard as having great potential value. He recognized the rich resources surrounding the school and believed they could and should be used more extensively, admitting that it can be easy to overlook such resources. These activities were not coupled with the various barriers associated with activities away from the school, although the curricular connection must still be present.

Summary of Mr. Ford's perspective.

Salient findings from the interview regarding the principal's perspective of the inclusion of outdoor learning experiences in the Earth systems science unit include that such experiences: 1) were an example of a teacher taking risks to try new instructional techniques; 2) were an example of a teacher being creative and trying to improve student outcomes; 3) had the potential to be valuable for student learning, involvement, coherence, and connection to their community; and 4) must be examined for the value they can provide, and balanced with the associated challenges. These key ideas related specifically to the role of the outdoor learning experiences in the Earth systems science unit.

Discussion

I have explored the role and value of outdoor learning experiences integrated with the enactment of the unit from the teacher's perspective. In addition, an interview with the school principal revealed his perspective on supporting teachers in their craft, and the need to balance the value of outdoor learning experiences with the challenges related to their enactment.

The analysis of interviews revealed much alignment between Mrs. Hunter's and Mr. Ford's perceptions of the role of outdoor learning experiences in the Earth systems science unit. While other researchers (Michie, 1998; Mirka, 1970; O'Neal, 2003) have investigated the perceptions and experiences of teachers' tendencies to use the outdoors for teaching, this study contributes to our knowledge by offering an in-depth examination of a single teacher enacting a curriculum with integrated field experiences. In addition, this study contributes an exploration of the commonalities between a teacher's perspective, and that of her school principal to provide a more holistic view of the use of the outdoor setting in curriculum reform efforts. To my knowledge, the alignment or lack thereof in perspective regarding teaching in the outdoor setting, between a teacher and her school principal has not been explored. The vast similarities in their views suggests that curriculum reform efforts are likely to be facilitated when the principal supports a teacher in a new venture such as using outdoor experiences as an integral part of a curriculum. In addition, this study contributes a set of implications for curriculum development that is most likely to be supported by a principal with a perspective like Mr. Ford's in which risk taking and creativity are valued, and in which certain challenges can be attended to with carefully designed materials. While Orion's (1989, 1993) model of novelty space typically refers to the need to reduce the novelty of a setting, or their personal needs, as well as cognitive factors, this model can be extended and applied to Mrs. Hunter. In this study, Mrs. Hunter experienced what it was like to enact a novel type of curriculum that included instructional techniques outside her typical repertoire. This can be seen as a way to reduce Mrs. Hunter's novelty space by exposing her to new settings and experiences to increase her comfort level, and her understanding of how to teach students in the outdoor setting.

Curricular Coherence

One common dimension of their viewpoints is the role of outdoor activities in facilitating curricular coherence. This finding, along with Mrs. Hunter's descriptions of her efforts to make connections to the field trip, indicate the importance of that experience for her teaching practice. The peak (Figure 4.2) coincides with unit activities that synthesize and make sense of phenomena from earlier in the unit, and observations from the rock quarry visit. This finding suggests that this outdoor experience played a key role in the development of coherence across the unit. Other researchers (Hofstein & Rosenfeld, 1996; Orion, 1993; Sharp, 1988; Tal, 2001) have explored the outdoor setting as a learning environment that should get equal consideration compared with the classroom or laboratory. The ways in which these three learning environments might be integrated have also been explored (Ben-zvi-Assaraf & Orion, 2005a; Hofstein & Rosenfeld, 1996; Orion, 1989). However, the particular role of such experiences as a vehicle for fostering curriculum coherence adds to our understanding of the potential value of the outdoor learning environment. During interviews throughout the unit, Mrs. Hunter frequently discussed her observations of the flow of activities, but the percent coverage of this dimension during the interviews following the field trip to the rock quarry have a distinct peak compared to earlier interviews (Figure 4.2). Following the rock quarry field trip, Mrs. Hunter communicated the many content connections she was now able to make. While this finding is not surprising given the design of including integrated learning environments, this has not been discussed as a valuable role of outdoor learning experiences in the literature, except to investigate the intended sequence of activities in Orion's (1993) model of field trip development. Specifically, the value of using outdoor learning activities in addition to classroom and laboratory activities can provide a range of valuable experiences for students, and opportunities to develop a deeper understanding of key concepts through knowledge integration.

In addition, teachers' developing awareness over time of curriculum coherence in the context of the outdoor learning environment has not been explored and provides valuable insight into the potential of including instruction regarding such activities in teacher preparation programs (O'Neal, 2003). O'Neal (2003) found that teachers who participated in outdoor activities in their teacher education program were more capable of developing similar activities for their students. This research suggests that the traditional teacher education program that does not include field-based activities may not adequately prepare teachers to make use of this learning setting. This provides a possible explanation for the limited use of the outdoors by teachers. Lortie (1975) states that many pre-service teachers believe they learn to teach through experience, a sort of "trial and error in the classroom" which is in contrast to the "refinement and application of generally valid principles of instruction" (p. 79-80). Perhaps the success of the preservice teachers in O'Neal's study is due to the focus on exploring the principles of outdoor instruction in the context of teacher education courses, rather than through personal testing of such methods once one is in the classroom. In the current study, some of the principles of outdoor instruction were communicated to Mrs. Hunter through educative features in the curriculum materials (Davis & Krajcik, 2005) that explained the rationale behind, for example, the organization of activities according to Orion's (1993) model of a preparation phase, the field trip experience, and the summary phase. This highlights the important contribution of this study for expanding the variety of experiences that teacher education courses expose preservice teachers to, and for designing curriculum materials that both include integrated learning environments, and that are educative for teachers.

In addition to Mrs. Hunter's awareness of the role of outdoor activities in emphasizing curricular coherence, Mr. Ford also similarly noted the potential role of these experiences for promoting coherence. He communicated his expectation that all activities occurring away from the classroom are connected to the curriculum, and that there must be no question as to the value of such an out-of-school experience at the time the field trip occurs. However, he also focused on the opportunities to foster connections across disciplines, and highlighted the importance of collegial support in the enactment of field trips away from school. This finding indicates that Mr. Ford encourages cross-discipline connections, and would like to see more collaboration between teachers of different subjects in his school. He saw the field trip as one possible vehicle for fostering such connections, when he described his pride that Mrs. Hunter was taking a risk, and being creative in her teaching. Her enactment of the Earth systems science unit was seen as a model for other teachers to also take risks, and as an example of how they might be similarly supported and encouraged by Mr. Ford. "I hope [Mrs. Hunter] is willing to spread the word…. And then also challenging her colleagues. That's pretty powerful when colleagues can challenge colleagues in a positive way; good things come out of that." (Interview with Mr. Ford, 4/23/09). Therefore, Mr. Ford could more strongly justify the inclusion of field trips away from school grounds with a greater teacher buy-in as a result of colleagues working together to develop connections across disciplines. This finding adds to our knowledge of how principals can support teachers, and the specific role that outdoor learning experiences may play in fostering cross-content connections.

Cundell (2006) suggests that an integration of all subjects could provide a more holistic view of science problems and the relevance of science to society. "Instead of merely extending the content of each topic, science classes should incorporate any and all information needed to completely understand how each subject works in real-world terms" (p. 42). The extent to which outdoor learning experiences might play a role as a vehicle or seed for building connections across disciplines has not been explored, and this study can further our understanding of how the principal can support and encourage teachers with such an eventual outcome of a more unified and integrated school curriculum that includes various disciplines. Such a finding has implications for the design of curriculum materials to be cross-disciplinary to a greater extent. This would involve collaboration between teachers of different subjects, curriculum developers, and the support of the principal for this type of curriculum reform.

Scientific Relevance Fostered through Outdoor Learning Experiences

Another common dimension of Mrs. Hunter and Mr. Ford's perspectives was in the value of outdoor learning experiences to provide a greater sense of relevance to students, which also related to students' awareness and respect for their local community. While the value of outdoor learning experiences has been discussed in the literature, the particular emphasis on these activities for promoting awareness of relevance has not been widely investigated, although some researchers have described this as one potential outcome related to learning in the outdoor setting. Specifically, Ben-zvi-Assaraf and Orion (2005b) have explored the potential of students' studying cyclic Earth systems for increasing awareness of their place on Earth. This relevance to students has typically been explored from the students' perspective, yet this study contributes the unique perspectives of the teacher and principal as students gain a greater awareness of the relevance of science to their lives. This relevance was fostered through the outdoor learning experiences, according to Mrs. Hunter and Mr. Ford, providing evidence of the unique contributions of such activities to students' experience.

Similarly, Mr. Ford viewed the potential of outdoor activities to help students become more aware of their community, and to increase their respect for their surroundings as a valuable aspect of this curriculum, and one in which he supported. This observation is aligned to one design principle upon which this unit was developed, in which contextualization must be attended to, in order to increase students' sense of relevance, and ability to relate to scientific concepts (Novak & Gleason, 2001; Orion et al., 1996; Rivet & Krajcik, 2004; Singer et al., 2000). The current study contributes a unique perspective of the close alignment between the teacher's and the principal's perceptions of the value of outdoor learning experiences for helping increase the relevance of science to students' lives, which results in a potential reform that is more likely to occur due to the support of various key players in the educational system.

Firsthand Experience with Phenomena through Outdoor Learning Experiences

Another role of the outdoor learning activities identified was to provide firsthand, direct, and live experiences to students. This is directly related to Mrs. Hunter's opinion that, at a young age, it is crucial for students to have concrete experiences with phenomena to help them make sense of the world. Mrs. Hunter's perspective of the centrality of concrete experiences for children is aligned to educational research that suggests the importance of concrete experiences for helping students learn (Birnbaum, 2004; National Research Council, 1996b; O'Neal, 2003; Piaget, 1955). In particular, such direct experiences are necessary for learning about abstract ideas in their potential for later abstraction and generalization (Dewey, 1902; Orion, 1993).

The perspective of the outdoor learning activity as a way to provide firsthand experiences is not a unique finding. Indeed, many researchers have recognized the value of such experiences for student learning (Hammerman et al., 2001; Hofstein & Rosenfeld, 1996; Koran & Baker, 1979; McNamara, 1971). However, a contribution of the current study is the minimal extra effort required by Mrs. Hunter to conduct integrated outdoor activities as part of the Earth systems science unit. This was determined by the limited number of coded passages across all six interviews, devoted to discussions of challenges and barriers associated with teaching outdoors (16 references), and the greater focus on the value and role of such experiences (33 references). Thus, findings from this study indicate that little effort on the part of the teacher is necessary for substantial added value to the students' overall experience. Mr. Ford placed greater emphasis on the various types of challenges associated with outdoor learning experiences (15 references total), but still discussed the value of such experiences for providing firsthand experiences (3 references). In summary, just as laboratory activities can add value to classroom activities, so too can outdoor activities add value to a curriculum that makes use of the more traditional classroom and laboratory settings. However, as Orion (1989) stresses, outdoor activities should only be included in a curriculum when it is appropriate for the concepts being studied. This study does not suggest that field trips are a solution to all educational issues—a viewpoint shared by Nuttall (1940) in his review of Atyeo's (1939) seemingly extreme discussion of the values of field experiences.

Increased Engagement Regarding Outdoor Learning Experiences

Both Mrs. Hunter and Mr. Ford described the valuable role of outdoor learning experiences for increasing students' engagement with their learning. McCormick and Pressley (1997) provide one definition of engagement, used by Hug and colleagues, in which "engagement is the mindful investment and commitment of students as they create a deep understanding of science concepts and processes" (Hug, Krajcik, & Marx, 2005, p. 451). Skinner and Belmont (1993) state "children who are engaged show sustained behavioral involvement in learning activities accompanied by positive emotional tone" (p. 572).

Mrs. Hunter described that the variety—in types of activities, experiences, writing tasks, and learning environments—was valuable for students in promoting engagement. She observed their sustained interest in the unit, indicating engagement and a positive emotional reaction to learning tasks (Chapman, 2003). She repeatedly commented on her belief that students' had positive opinions of the variety, and enjoyed, what she felt they perceived as spontaneity. She saw this aspect as valuable for helping different types of learners succeed. From Mrs. Hunter's perspective, the outdoor learning experiences offered a specific contribution in the added excitement, novelty, and unique experiences, perhaps even motivating students to attend school when they might not have otherwise. These findings of the increased engagement and interest of students, attributed partially to the outdoor learning experiences are supported by prior research (Benz, 1962; Birnbaum, 2004; Brady, 1972; Disinger, 1984; Folkomer, 1981; Harvey, 1951; Hofstein & Rosenfeld, 1996; Kern & Carpenter, 1984; Koran & Baker, 1979; Michie, 1998; Mirka, 1970; Orion & Hofstein, 1991; Smith, 2005). Thus, there is a great deal of evidence that students are positively influenced by the engaging aspects of outdoor learning experiences as part of a curricular unit. While this is a valuable finding that is well-supported in the research literature, the contribution of such experiences with middle school students is a less well-researched phenomenon. For example, Orion and Hofstein's (1991) study of students' attitudes towards field trips was conducted with high school students, and revealed positive outcomes that differed with grade level, but this study revealed similarly positive findings and trends in regard to student attitude for younger students as well. In addition, the use of the attitudes towards field trip questionnaire with middle school students is a unique contribution, suggesting that it is a valid and reliable instrument with a wider range of ages (Chapter III). Mr. Ford's perspective of the role of outdoor learning experiences for increasing student engagement is aligned to that of Mrs. Hunter. He referenced this dimension of outdoor activities seven times, which covered nearly 16% of the total interview, indicating the prevalence of this aspect of outdoor learning in his thinking.

Balancing Values and Challenges

The particular aspects of outdoor learning activities that school administrators deem valuable are largely unexplored. Better understood are the challenges that must be overcome in order for outdoor learning experiences to become more widely used where appropriate (Michie, 1998; Mirka, 1970). A common barrier cited by teachers who desire to conduct outdoor activities is a lack of administrative support. The current study indicates that in a situation in which the school principal supports risk-taking, creativity, and encourages colleagues to work together, curriculum reform can occur with few barriers. In addition, this study can contribute to our understanding of how the school principal has a key role in the development of curriculum materials. By examining Mr. Ford's thinking regarding how he must balance the values of outdoor learning experiences with the challenges inherent in such activities, curriculum developers can more finely adapt materials to fit this balance, increasing their value as a vehicle for curricular reform. In other words, to a certain extent, curriculum materials must conform to the needs of schools in which certain aspects must be met, such as the requirement that all field trips have a strong curricular tie.

While both Mrs. Hunter and Mr. Ford acknowledged the important and valuable role that outdoor learning experiences can play as an integral part of the school curriculum, Mr. Ford was more attuned to the challenges he must face as a school administrator making curricular decisions. Ultimately, the decision to allow a field trip away from the school grounds is left to him. Thus, the challenges he acknowledged regarding the use of field trips as an instructional technique must be initially attended to. Following this, Mr. Ford stated that he supports and encourages teachers to incorporate such experiences due to the value they can hold for students.

However, without an awareness of the potential value of a field trip, Mr. Ford is less likely to approve this activity. This highlights the principal's key role in curriculum decisions. Recognizing value is not necessarily sufficient in overcoming the various challenges the school faces, which fall under the categories of financial barriers, time constraints, and the potential for disruption of the school day. Mr. Ford was enthusiastic about an alternative type of field trip experience—those that occur around the school yard, and do not require financial support, additional time, and would be constrained more readily in the school day so as not to disrupt other teachers' schedules. Mr. Ford saw great potential in the resources available in the school yard, and stated that those resources should be used more frequently.

The role of the school principal seems to be one with inherent contradictions (Duke, 1988), as Mr. Ford struggled to balance what he saw as barriers to students' experiencing valuable field trips. Comparatively, Mrs. Hunter was significantly less concerned with the administrative issues that would need to be dealt with upon the adoption of this type of curriculum, and was more attuned to the value of using a curriculum of this type, and the generally positive experiences of her students. While this is not surprising, given each individual's role in the school, an examination of the perceived and experienced challenges and school policies that can limit teachers' freedom to enact curriculum provide insight into barriers to scaling up with materials of this nature, and have implications for curriculum development in a potentially constrained environment.

The barriers to field trips away from the school as part of the science curriculum cited by Mr. Ford were mostly focused upon logistics, a finding aligned to other studies that explore perceived barriers (Birnbaum, 2004; Mason, 1980b; Mirka, 1970; Sharp, 1988). Because these field trips require bus transportation, the policies regarding extended field trips are almost entirely related to finances (Figure 4.3). In addition, the window during which a field trip might be possible is limited due to bus transportation.

Mr. Ford also describes the potential disruption that can occur when a field trip affects multiple teachers' schedules. This challenge is regarded as specific to middle school students, as elementary students typically have a single teacher all day. Although the field trip in the Earth systems unit was primarily of a scientific nature, the Social

Studies, English, and Mathematics teachers agreed to allow Mrs. Hunter's field trip to take place during their scheduled classes. Each teacher played important roles during the field trip by leading stations while Mrs. Hunter circulated. Although Mr. Ford regarded such a field trip as a potential disruption, during the same interview, he expressed his desire for colleagues to collaborate to develop cross-content connections. "Collegial support comes I think, when you can hold value-- that there's a cross curricular connection going on here and we can both get something out of this and I would love to see that more often. And like I said, it doesn't happen often I don't assume, but it can…" (Interview with Mr. Ford, 4/23/09).

Mrs. Hunter's colleagues participated in this scientific field trip even without explicit cross-content connections. The disruption that Mr. Ford regarded as a potential barrier also provides an opportunity for teachers to collaboratively develop field trips that could be mutually beneficial. Such a field trip would be aligned to the research goals regarding integration of the school disciplines through a unified curriculum (Cundell, 2006), an educational change that would require substantial creativity, risk-taking, collegial collaboration and mutual support—aspects of his role that Mr. Ford described as ways he can facilitate teachers in their practice. Ultimately, such a field trip would lessen the challenges put forth by Mr. Ford while increasing coherence across the school curriculum. Additionally, an integrated and unified curriculum may be well suited and aligned to the primary goal of science education, to develop a scientifically literate citizenry, as socially relevant phenomena can often be drawn out of conversations that cut across traditional divisions. The result may be well-rounded students, able to discuss phenomena in an intellectual way, while drawing connections between scientific disciplines (McComas & Wang, 1998) and across content areas.

Conclusion

This study provided valuable insights into aspects of the implementation of reform-based curriculum materials. Specifically, the environment for this experimental curricular enactment could be considered ideal, as there was a high degree of alignment between Mr. Ford and Mrs. Hunter's opinions of the value and role of outdoor learning experiences. Not only was Mr. Ford supportive of Mrs. Hunter's agreement to enact a different type of curriculum, he encouraged this behavior. Further, he applauded her risk-taking and indicated that it was important that other teachers in the school were aware of her experiences working with a new type of instructional technique. This administrative support allowed Mrs. Hunter to carry out the enactment with few barriers. A different work setting would have greatly impacted the curricular enactment, and perhaps Mrs. Hunter's perceptions of the experience. Instead, Mrs. Hunter's teaching in a supportive environment allowed her to enact the curriculum without many of the challenges that might face a teacher working in a less supportive setting.

Mr. Ford saw one aspect of his role was in supporting teachers in their practice. One way in which this could foster teacher professional development is in encouraging teachers to work with one another to draw cross-disciplinary connections in relation to a field trip. Such collaboration has the potential to lessen the challenges and increase the value of such an experience. Specifically, one challenge Mr. Ford discussed was in the potential disruption of many teachers' schedules as the result of an extended field trip away from school. However, teachers who can draw on a field trip experience through connections to the curriculum can increase the coherence, not only within their class, but across the entire school curriculum, thus promoting a more unified learning experience. Mr. Ford raised this aspect as a potentially valuable exercise for teachers and reveals valuable aspects and novel roles of the field trip experience not yet explored.

Using the data gathered throughout this study, and discussed in Chapters II, III, and IV, the following chapter describes the final aspect of the systemic approach used in this study. Chapter V describes the findings from an external evaluation of the Earth systems science curricular unit as the last contribution to the systemic perspective of the introduction of this unit to a single school system. The data sources previously discussed will be integrated in order to highlight aspects of the unit that could be improved to further teacher and student learning as they align to the design principles described in Chapter II.

Appendices

Appendix 4A: Teacher Interview Protocols

Teacher Interview Protocol #1 (3/30/09) - pre-enactment

This is Molly talking with Mrs. Hunter-the participating teacher for this upcoming curricular enactment.

- Can you describe your experiences teaching Earth science in the past? What has it been like? What topics have you taught? What methods do you typically use?
  What do you like about teaching Earth science? What do you dislike?
  What do you see as the teaching challenges specific to this field?
  What do you think students can gain as a result of learning about Earth science concepts?

- Have you had a chance to look over the curriculum yet?
  YES: What are your thoughts on the unit as you get ready to begin in a few days?
  NO: From what we've discussed, what are your thoughts as you get ready to begin in a few days?
- Is there anything that you are particularly excited or nervous about?

- You know that this unit will use the outdoors for teaching concepts related to rocks, water, their impact on the Earth's systems (biosphere, atmosphere, geosphere, hydrosphere), developing environmental awareness, use of natural resources, etc. What do you see as the affordances of using the outdoors for teaching these concepts?

- What do you see as the challenges or barriers of using the outdoors for teaching those concepts?

- How do you expect students to react to this curricular unit, in which they will be going on several school-ground field trips, and to a rock quarry? For the most part, will this be a novelty for many students?

- How do you think using this unit might impact your daily teaching practice?

- Do you feel like you have the support of the administration for using this curricular unit? What have been the reactions (positive and negative) of other teachers and the principal?

- Do you think it is important for students to learn about their local setting? Why or why not?

Thank you!

Teacher Interview Protocol #2 (4/17/09)

This is Molly talking with Mrs. Hunter-the participating teacher for this curricular enactment.

- In general, can you tell me how the unit is going so far?

- What do you like or dislike about the format of the printed materials? (teacher notes)

- What is your opinion of the unit up to this point?
  - What do you think students' opinions are up to this point?
  - Are you able to make this unit relevant to students' lives? How/what connections can you make?

- Can you describe the first outdoor learning experience? (the nature walk)
  - Can you describe the second, shorter outdoor learning experience? (collecting geosphere materials)
  - You mentioned a scary field trip experience you had one year. Can you tell me again what happened?
  - How did that experience affect your teaching, or your willingness to use the outdoors as a learning environment?

- You've just completed activity 7 today.
  - What big ideas do you think students have learned in the first 7 activities of the unit?
  - What (if anything) do you think has gone well up to this point?
  - What (if anything) has not gone well?

- What do you think about the flow of the unit thus far? (are you able to make connections from day to day?)

- Are there any students (specifically, or groups/types of Ss) who you notice are more or less engaged than they typically are? (or you notice them participating more in the daily activities/raising their hand, more actively engaged in the unit, etc?)

- The activities so far have been focused on collecting and classifying components of the Earth's spheres. What role do you see the outdoor learning experiences playing in these activities? Were they necessary? Helpful? Could you have done the curriculum without them?

- Are there any ways that this unit has impacted your daily teaching practice? Can you explain?

- Do you think it is important for students to learn about their local setting? Why or why not?

Thank you!

Teacher Interview Protocol #3 (4/27/09)

This is Molly talking with Mrs. Hunter-the participating teacher for this curricular enactment.

- In general, can you tell me how the unit is going so far?

- What is your opinion of the unit up to this point?
    - What do you think students' opinions are up to this point?
    - Are you able to make this unit relevant to students' lives? How/what connections can you make (or do you think Ss are making)?

- Can you describe the third outdoor learning experience? (the line of boulders from yesterday)
    - What do you think Ss gained from that outdoor learning experience?

- You've just completed activity 11 today.
    - What big ideas do you think students have learned in the past week (since we last talked: Act. 8-11)?
    - What (if anything) do you think has gone well up to this point?
    - What (if anything) has not gone well?

- What do you think about the flow of the unit thus far? (are you able to make connections from day to day? Do you think Ss are making these connections too?)

- Are there any students (specifically, or groups/types of Ss) who you notice are more or less engaged than they typically are? (or you notice them participating more in the daily activities/raising their hand, more actively engaged in the unit, etc?)

- What role do you see the outdoor learning experiences playing in this curriculum? Were they necessary? Helpful? Could you have done the curriculum without them?
    - What value are these experiences adding to the curriculum?

- Are there any ways that this unit has impacted your daily teaching practice or preparation? (i.e. are you more/less engaged in teaching than usual/do you look forward to teaching this unit daily?) Can you explain?

- Can you explain your current comfort level with the science content you have been teaching?
    - Do you feel like you are becoming more comfortable with the ideas you are teaching?
    - And what is your current comfort level with using the outdoors for teaching various concepts?

Thank you!

Teacher Interview Protocol #4 (5/5/09)

This is Molly talking with Mrs. Hunter-the participating teacher for this curricular enactment.

- In general, can you tell me how the unit is going so far?
- What is your opinion of the unit and activities up to this point?
  - What do you think students' opinions are up to this point?
  - Are you able to make this unit relevant to students' lives? How/what connections can you make (or do you think Ss are making)?

- Can you describe the fourth outdoor learning experience? (searching for manmade materials around the schoolyard)
  - What do you think Ss gained from that outdoor learning experience?

- You've just completed activity 20 today.
  - What big ideas do you think students have learned in the past week or so (since we last talked: Act. 12-20)?
  - What (if anything) do you think has gone well up to this point?
  - What (if anything) has not gone well?

- What do you think about the flow of the unit thus far? (are you able to make connections from day to day? Do you think Ss are making these connections too?)

- Last Friday, you took all four classes to the rock quarry. Can you tell me about the field trip?
  - Did the field trip meet your expectations?
  - What were you concerned about before taking the field trip?
  - What went well? What didn't go well?
  - What changes/modifications would you make if you were to take Ss on this field trip again next year?
  - What do you think Ss gained from this field trip?
  - What did you gain from this field trip?
  - How do you plan to connect the field trip experiences with the upcoming lessons?
  - What do you think Ss will remember about the field trip?
  - Why do you think the field trip helped Ss learn about their environment?

- What role do you see the outdoor learning experiences playing in this curriculum? Were they necessary? Helpful? Could you have done the curriculum without them?
  - What value are these experiences adding to the curriculum?

- Now that you've taken Ss on several small outdoor learning experiences, and the quarry field trip, what do you see as the barriers/challenges to using the outdoors for teaching science?

- Why do you think it's important for Ss to learn about their local environment?

Thank you!

Teacher Interview Protocol #5 (5/19/09)

This is Molly talking with Mrs. Hunter-the participating teacher for this curricular enactment.

- In general, can you tell me how the unit is going so far?
- What is your opinion of the unit and activities up to this point?
    - What do you think students' opinions are up to this point?
    - Are you able to make this unit relevant to students' lives? How/what connections can you make (or do you think Ss are making)?

- Can you describe the fifth outdoor learning experience? (Characterizing the nearby stream)
    - What do you think Ss gained from that outdoor learning experience?

- You've just completed activity #26 today.
    - What big ideas do you think students have learned in the past week or so (since we last talked: Act. 20-26)?
    - What (if anything) do you think has gone well up to this point?
    - What (if anything) has not gone well?

- What do you think about the flow of the unit thus far? (are you able to make connections from day to day? Do you think Ss are making these connections too?)

- What experiences have you been able to draw on in class related to the rock quarry field trip?
    - How do you think the field trip helped Ss learn about their environment and the concepts they are now dealing with in class?

- It's important for me to understand how you see this unit differing from other units or your typical teaching techniques—obviously, I'm interesting in how you are using the outdoor experiences—both around the school and at the rock quarry—in your teaching. (i.e. How is this unit impacting your teaching practice?)
    - What role do you see the outdoor learning experiences playing in this curriculum? Were they necessary? Helpful? Could you have done the curriculum without them?
    - Is it worth your extra time and effort to take Ss outdoors? Why?
    - Would this unit be progressing differently if you were unable to take Ss outdoors and on the quarry field trip? How?

- Can you explain your current comfort level with the science content you have been teaching?
    - Do you feel like you are becoming more comfortable with the ideas you are teaching?
    - And what is your current comfort level with using and connecting to the outdoors for teaching various concepts?

Thank you!

Teacher Interview Protocol #6 (6/8/09)

This is Molly talking with Mrs. Hunter-the participating teacher for this curricular enactment.

- In general, can you tell me how the end of the unit went?
- What do you think students' opinions of the unit were?
- Were you able to make this unit relevant to students' lives? How/what connections were you able to make (or do you think Ss made)?
- What (if anything) do you think went well during this unit?
- What (if anything) did not go well during this unit?

- What did you think about the flow of the unit? (were you able to make connections from day to day? Do you think Ss are making these connections too?)

- How do you think the field trip helped Ss learn? Why—really, why, do you think the field trip was useful in this unit?

- It's important for me to understand how you see this unit differing from other units or your typical teaching techniques—obviously, I'm interested in how you used the outdoor experiences—both around the school and at the rock quarry—in your teaching.
    - What role did you see the outdoor learning experiences playing in this curriculum? Were they necessary? Helpful? Could you have done the curriculum without them?
    - Is it worth your extra time and effort to take Ss outdoors? Why?
    - Would this unit have turned out differently if you had been unable to take Ss outdoors and on the quarry field trip? How?

- Can you explain your comfort level with the science content you taught in this unit?
    - Do you feel like you have more/less/or the same comfort level with the concepts you taught?
    - And what is your comfort level with using and connecting to the outdoors for teaching these concepts?

- What were some of the strengths of this unit?
- What were some of the weaknesses of this unit?

- Tell me about the final mini-projects that Ss completed. (How do you think they turned out? Did Ss seem engaged in these projects? How did Ss choose the topic for their projects? Did this affect their level of engagement?)

- Imagine that a fellow teacher, say Mrs. Klesky, was considering using this unit. What would you say to her about your experiences teaching this unit? (Please be honest!)
- What do you think Ss took away from this unit?
- What will they remember a year from now-both about their experiences, and the content?

Thank you!

Appendix 4B: Principal Interview Protocol

Principal Interview Protocol #1 (4/23/09)

This is Molly talking with Mr. Ford, the school principal on 4/23/09. Thank you for taking the time to talk with me!

As you know, Mrs. Hunter has been enacting a curriculum that I developed as part of my dissertation research. I am interested in exploring how the outdoors can be used in teaching science. The curriculum that Mrs. Hunter is enacting is grounded in short field trips around the school grounds that can be completed within a class period. As you know, a field trip to a nearby rock quarry is also planned for the end of next week. I'd like to ask you some questions about your perspective of these types of field trips and outdoor learning experiences in science.

- Who in the school or district chooses the science curriculum to be used by your teachers?

First I'd like to talk a little about field trips away from school grounds.

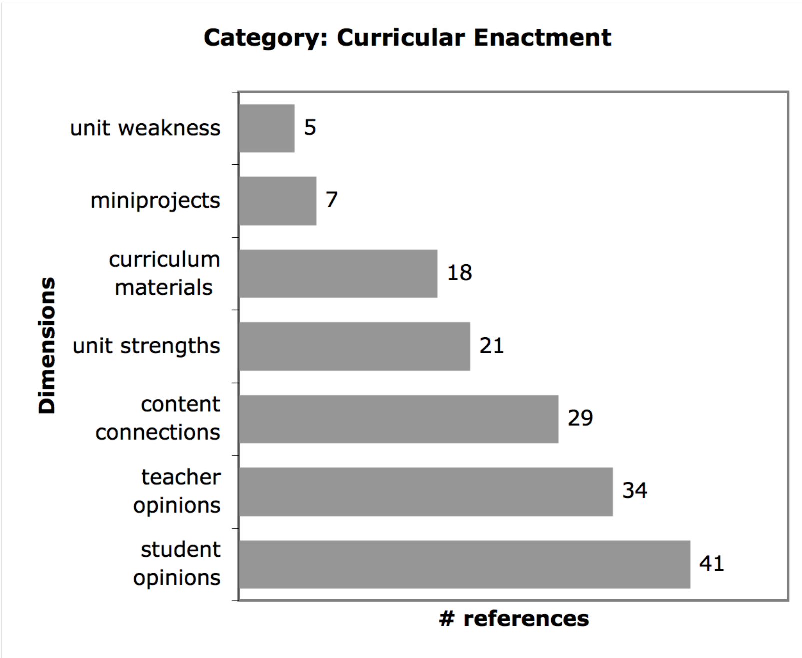
- Does your school have any policies in regard to field trips (away from school grounds)?
- What do you see as the barriers, limitations, or concerns associated with taking students on field trips?
- In what ways if any, do you see field trips as being valuable for students?

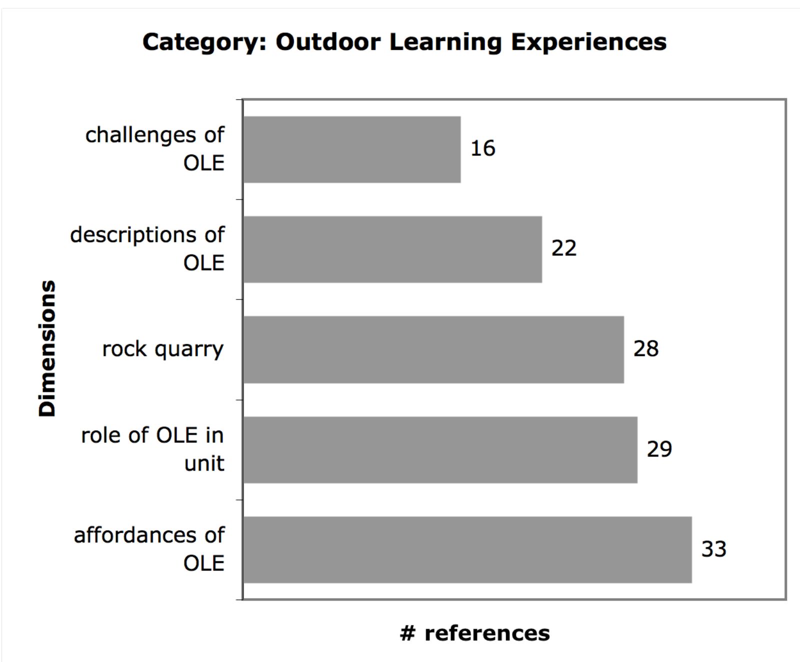
Now I'd like to talk about outdoor learning experiences that can take place around the school grounds.

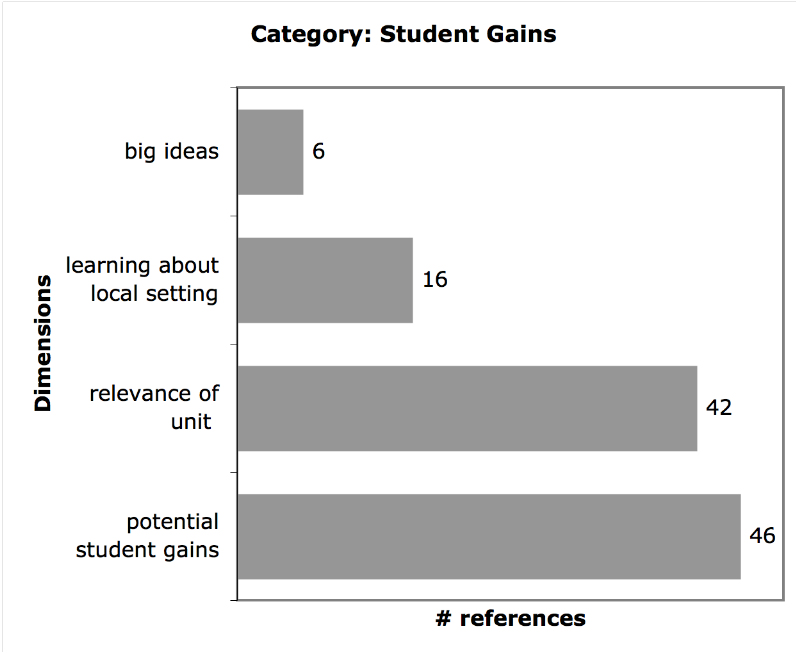
- What do you see as the possible barriers, limitations, or concerns associated with taking students outdoors to investigate their school yard?
- How might outdoor learning experiences be valuable for students?
- Hypothetically, what types of support could the school offer teachers who want to plan and implement field trips or outdoor learning experiences? (financial, planning time, other resources, etc.)
- This year, I am financially supporting Mrs. Hunter in the curriculum enactment, as far as purchasing supplies, paying for the buses, etc. Of course, this isn't sustainable. If teachers wanted to enact a curriculum such as this one in the future, would the school be able to support that? Can you explain?
- Do you believe it is important for students to learn about their local environment? Can you explain?

Thank you!

Appendix 4C: Expression of Themes Across Mrs. Hunter's Six Interviews



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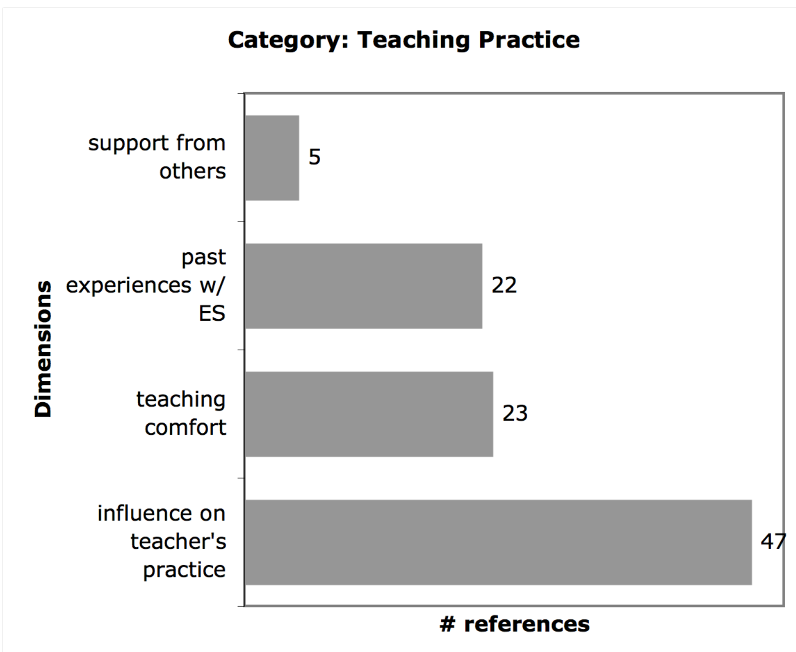
big ideas
6
learning about local setting
16
relevance of unit
42
potential student gains
46
Dimensions
references


Category: Teaching Practice
support from others
5
past experiences w/ ES
22
teaching comfort
23
influence on teacher's practice
47
Dimensions
references

CHAPTER V

Indicated Improvements to the Earth Systems Science Curriculum Unit

Abstract

Carefully developed educational materials are one vehicle for curricular reform. Materials should go through several rounds of revisions in order to improve their educative nature. The revisions should be based on pilot enactments and observations of their usage in the classroom context. In addition, external sources can evaluate materials to highlight potential revisions. In this paper, I explore the potential revisions of the Earth systems science unit, based on a single teacher's enactment with four classes of students. The potential revisions are based on several sources, including: 1) an external evaluation based on the AAAS middle grades textbook criteria, 2) feedback from students and student data, 3) feedback from the teacher, 4) and observations of the daily enactment. The indicated revisions are discussed in relation to the design principles that guided the development of the unit, and suggest that a greater emphasis needs to be placed on supporting the teacher with embedded educative supports. Specifically, these supports should focus on conducting outdoor learning activities that are integrated with indoor experiences, making use of formative assessment items, and taking account of students' developing ideas.

CHAPTER V

Indicated Improvements to the Earth Systems Science Curriculum Unit

In this chapter, I discuss the findings of an external evaluation of the unit, and the revisions that are indicated from the previous chapters, which include feedback from students, the participating teacher, classroom observations, and the external evaluation. In addition, I relate the indicated revisions to the design principles discussed in Chapter II.

The Earth systems science curriculum was developed as the first iteration of a unit, thus there are a number of revisions that could improve the educative nature of the unit for both students and teachers. The external evaluation based upon the Project 2061 criteria, as well as student learning and feedback, teacher feedback, and observations made during the curricular enactment, indicate the types of revisions that could contribute to the overall improvement of the unit. Each of the revision ideas will be discussed in terms of the source of evidence supporting their need, aligned to relevant design principles, and will focus on large grain-size changes influencing a substantial portion of the unit, as opposed to smaller changes to individual activities.

The systemic approach of this study comes full circle in this chapter, as I return to the curriculum and examine its use from various perspectives, as a basis for future revisions (Figure 5.1). The data on student learning and their perspectives of the value and role of the outdoor learning experiences that were integrated into the unit (Chapter III) were explored in relation to revision. Conversations with the teacher also provided evidence as to how the unit could be improved (Chapter IV). Each of these data sources was related to the design principles that guided the development of the unit (Chapter II). The result is a plan for revision that is in alignment to the systemic approach of this study.

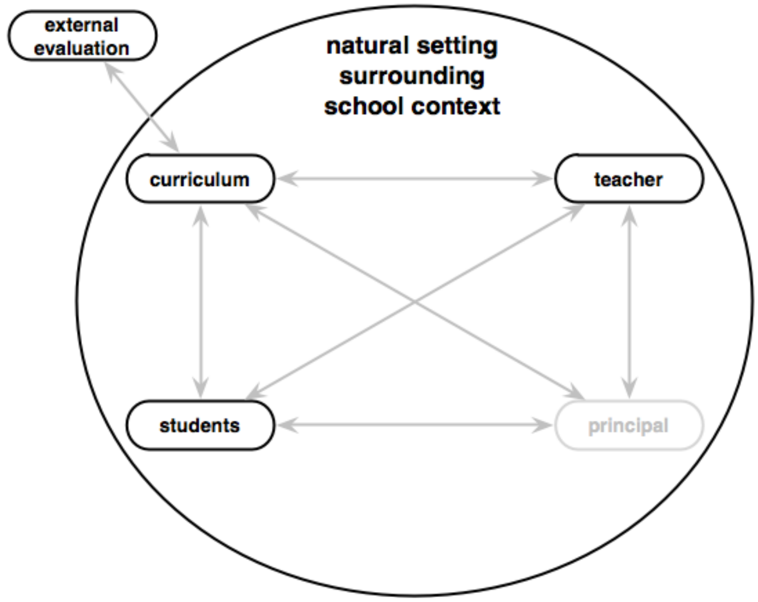


Figure 5.1. Systemic approach to revision of the Earth system science unit

Planned Revision of the Earth Systems Science Unit

External Evaluation of the Earth Systems Science Unit

Due to the nature of this project as a developing curriculum, it was necessary to conduct an evaluation of the materials based on criteria meant to explore the aspects of quality learning materials. Therefore, an external individual (Ph.D. and Assistant Professor in Science Education with curriculum materials development experience) conducted an evaluation of the Earth systems science unit using Project 2061's Middle Grades Science Textbooks Evaluation Criteria (American Association for the Advancement of Science, 2002; Kesidou & Roseman, 2002) after the curricular enactment. The evaluation criteria are organized into seven categories, each covering a different aspect of instructional support embedded in the curriculum materials. Each category includes criteria to guide a reviewer in evaluating and assigning an overall rating. The quality of instructional support of this curricular unit can be determined based upon this external evaluation, and can guide future revision cycles to focus on problematic or weak areas. The seven categories used to evaluate the Earth systems science curriculum materials are provided along with the criteria used to rate each category, and the assigned rating. The full evaluation procedure, and complete details about the indicators of meeting each criterion are available on the Project 2061 website: http://www.project2061.org/publications/textbook/mgsci/report/crit-used.htm#2

The evaluation of the Earth systems science unit is summarized in Table 5.1, followed by a more detailed description of each category, and the findings of the evaluator for each criterion. The evaluation has been expanded slightly to provide important contextual information. For example, the evaluator may have recorded “Criterion #2 is met in nearly every lesson.” I have modified this phrase to read “Nearly every lesson provides the teacher with sufficiently detailed answers to questions that students are expected to answer.” This expansion eliminates the need for the reader to determine the meaning of “Criterion #2” to which the evaluator refers.

Table 5.1 *Overview of Project 2061 Curriculum Evaluation Categories, Criteria, and Rating (American Association for the Advancement of Science, 2002)*

#	Category	Criteria	Rating
I	Providing a Sense of Purpose	Conveying unit purpose	Very good
		Conveying lesson purpose	Excellent
		Justifying activity sequence	Excellent
II	Taking Account of Student Ideas	Attending to prerequisite knowledge and skills	Fair
		Alerting teacher to commonly held student ideas	Poor
		Assisting teacher in identifying their own students' ideas	Very good
		Addressing commonly held ideas	Satisfactory
III	Engaging Students with Relevant Phenomena	Providing a variety of phenomena	Excellent
		Providing vivid experiences	Excellent
IV	Developing and Using Scientific Ideas	Introducing terms meaningfully	Excellent
		Representing ideas effectively	Excellent
		Demonstrating use of knowledge	Excellent
		Providing practice	Excellent
V	Promoting Students' Thinking about Phenomena, Experiences, and Knowledge	Encouraging students to explain their ideas	Very good
		Guiding student interpretation and reasoning	Excellent
		Encouraging students to think about what they've learned	Excellent
VI	Assessing Progress	Aligning assessment to goals	Very good
		Testing for understanding	Very good
		Using assessment to inform instruction	Poor
VII	Enhancing the Science Learning Environment	Providing teacher content support	No rating scheme
		Encouraging curiosity and questioning	No rating scheme
		Supporting all students	No rating scheme

Category I: Providing a Sense of Purpose

> "This category consists of criteria for determining whether the curriculum material attempts to make its purposes explicit and meaningful to students, either in the student text itself or through suggestions made to the teacher. The sequence of lessons or activities is also important in accomplishing the stated purpose, since ideas often build on each other" (American Association for the Advancement of Science, 2002).

Findings

- *Conveying unit purpose:* Overall, the unit has a clear sense of purpose in that it examines connections between Earth systems. Students are frequently asked to make connections back to previous material in the unit, thus supporting the unit purpose and lesson sequence. The purpose of the unit is made explicit in the first lesson but not as much in subsequent lessons; students do not clearly return to the driving question at the end of the unit (*rating: very good*).
- *Conveying lesson purpose:* All lessons convey a comprehensible purpose for the subsequent activities. Most lessons engage students in thinking about the purpose of the activity and the connections between the activities. Students often stop and reflect on what they have learned and are encouraged to ask new questions throughout (*rating: excellent*).
- *Justifying activity sequence:* The material follows a logical sequence where lessons almost always build directly on previous lessons (except in a few cases where the topic shifts, but then returns to make connections after a few lessons). Connections are necessary which justifies the "rationale" for the sequence (*rating: excellent*).

Category II: Taking Account of Student Ideas

> "Fostering understanding in students requires taking time to attend to the ideas they already have, both ideas that are incorrect and ideas that can serve as a foundation for subsequent learning. This category consists of criteria for determining whether the curriculum material contains specific suggestions for identifying and addressing students' ideas" (American Association for the Advancement of Science, 2002).

Findings

- *Attending to prerequisite knowledge and skills:* The structure builds prerequisite knowledge throughout, though does not specifically identify existing prerequisite knowledge for the teacher. The materials are not explicit in this regard. However, based on the design of the unit, the prerequisite knowledge and skills for later lessons are implicitly woven into previous lessons (*rating: fair*).
- *Alerting teacher to commonly held student ideas:* The design of the materials help support teachers in identifying commonly held ideas, although this is not made explicit in the text (*rating: poor*).

- *Assisting teacher in identifying their own students' ideas:* While such tasks do not always explicitly state the purpose as identifying students' ideas, this is implicit in the construction of the material. The materials do not often include suggestions for how the teacher can probe and interpret students' responses, thereby reducing this rating (*rating: very good*).
- *Addressing commonly held ideas:* There is little evidence that the materials address students' commonly held ideas, yet most of the activity designs are likely to help students progress from their prior ideas through challenges, comparisons, and extensions (*rating: satisfactory*).

Category III: Engaging Students with Relevant Phenomena

"Much of the point of science is to explain phenomena in terms of a small number of principles or ideas. For students to appreciate this explanatory power, they need to have a sense of the range of phenomena that science can explain. The criteria in this category examine whether the curriculum material relates important scientific ideas to a range of relevant phenomena and provides either firsthand experiences with the phenomena or a vicarious sense of phenomena that are not presented firsthand" (American Association for the Advancement of Science, 2002).

Findings

- *Providing a variety of phenomena:* Phenomena are varied, and include short and long field trips, models, firsthand investigations of rocks, water tests, etc. Experiences are directly tied to Key Ideas. This is a very strong part of the curriculum. Students are clearly engaged in a variety of phenomena (*rating: excellent).*
- *Providing vivid experiences:* The phenomena included in the unit provide efficient and sufficient vivid experiences. Moreover, these experiences lead students through building up their understanding of most of the Key Ideas. This happens across most of the days of the curriculum as students typically engage with phenomena firsthand. Most of the experiences are efficient, meaning that they are relatively inexpensive, yet are highly relevant to the concepts, thereby they have high value to the unit (*rating: excellent).*

Category IV: Developing and Using Scientific Ideas

"Science literacy requires that students understand the link between scientific ideas and the phenomena that they can explain. Furthermore, they should see the ideas as useful and become skillful at applying them. This category consists of criteria for determining whether the curriculum material expresses and develops the Key Ideas in ways that are accessible and intelligible to students, and that demonstrate the usefulness of the Key Ideas and provide practice in varied contexts" (American Association for the Advancement of Science, 2002).

Findings

- *Introducing terms meaningfully*: Terms appear to be carefully introduced in a way that is often in conjunction with, or following an in-depth experience with a related phenomenon (*rating: excellent)*.
- *Representing ideas effectively*: Representations are few, but are always (or nearly always) used in conjunction with firsthand experiences. Representations appear to be accurate and are only used when they are clearly integrated into an activity (*rating: excellent)*.
- *Demonstrating use of knowledge*: Key Ideas are introduced through well-crafted experiences and students demonstrate their understanding in contextual scenarios. Students often carry out activities, writing assignments, or discussions in which they are demonstrating knowledge that goes beyond facts. The supports help the teacher judge quality (*rating: excellent)*.
- *Providing practice*: Students practice with the phenomena. The materials include a wide variety of tasks that are often novel. Thus, complexity increases throughout the unit. As initial concepts are mastered, new ones are introduced (*rating: excellent)*.

Category V: Promoting Students' Thinking about Phenomena, Experiences, and Knowledge

"Engaging students in experiences with phenomena (category III) and presenting them with scientific ideas (category IV) will not lead to effective learning unless students are given time, opportunities, and guidance to make sense of the experiences and ideas. This category consists of criteria for determining whether the curriculum material provides students with opportunities to express, think about, and reshape their ideas, as well as guidance on developing an understanding of what they experience" (American Association for the Advancement of Science, 2002).

Findings

- *Encouraging students to explain their ideas*: The materials regularly encourage students to express, as well as clarify, justify, and represent their ideas. This opportunity is provided for each student in the written materials. The materials do not often include explicit suggestions to the teacher for how to diagnose errors with students' ideas *(rating: very good).*

- *Guiding student interpretation and reasoning*: Students' development of understanding is often scaffolded and supported through working with questions and specific tasks in sequence. These opportunities are provided relatively consistently throughout the curriculum materials, and guide students to make connections between their ideas and the phenomena observed *(rating: excellent)*.
- *Encouraging students to think about what they have learned*: Students often express their ideas and stop periodically to think about what they have learned. Students often pause to reflect on, or build upon their ideas *(rating: excellent).*

Category VI: Assessing Progress

"This category consists of criteria for evaluating whether the curriculum material includes a variety of aligned assessments that apply the Key Ideas taught in the material" (American Association for the Advancement of Science, 2002).

Findings

- *Aligning assessment to goals:* Assessments are designed primarily as formative rather than summative, in that they are part of activities that are meant to build towards an understanding of the Benchmarks/Key Ideas, rather than assessing those concepts directly. In other words, the assessment items use portions of a Key Idea but not the entire idea. It is not clear that assessments are covering all the Key Ideas, as the evaluation scheme states that the assessment items should adequately assess the Key Ideas. This indicates that the materials do not include a sufficient number of assessment items *(rating: very good).*
- *Testing for understanding:* Assessment are often based upon understanding rather than trivial information or memorized facts, and provide a variety of assessment formats for students' to express their thinking. Again, it is not clear that all Key Ideas are being assessed in the materials *(rating: very good).*
- *Using assessment to inform instruction*: The materials use embedded assessment as a routine strategy, but do not guide the teacher in interpreting students' responses to diagnose learning difficulties, nor do they provide specific

suggestions to teachers about how to use the information from the assessments to make instructional decisions for further learning activities *(rating: poor).*

Category VII: Enhancing the Science Learning Environment

"The criteria in this category provide analysts with the opportunity to comment on features that enhance the use and implementation of the curriculum material by all students. For this category, the reviewers used criterion-specific ratings in lieu of the general ratings used for categories I through VI" (American Association for the Advancement of Science, 2002).

Findings

- *Providing teacher content support:* Teachers are provided detailed answers that could help them understand the content. Nearly every lesson provides the teacher with sufficiently detailed answers to questions that students are expected to answer. However, the materials do not alert the teacher to how ideas have been simplified to help students make sense of the content, nor do the materials recommend additional resources for improving teachers' own understanding of the Key Ideas *(no rating scheme).*
- *Encouraging curiosity and questioning:* Throughout the materials, students are encouraged to ask questions and respond using evidence. Examples of classroom interactions are infrequently provided for illustrating examples of ways to respond to students' questions and ideas *(no rating scheme).*
- *Supporting all students:* The text does not use stereotypes or offensive language. However, the materials do not illustrate the specific contributions of women and minorities to science, nor do they provide suggestions for modifying activities for students with special needs. The materials do occasionally provide strategies to help teachers validate students' personal experiences with relevant scientific ideas *(no rating scheme).*

The external evaluation revealed certain aspects of the curriculum materials that were relatively weak. Specifically, the materials should better support the teacher in taking account of students' ideas which is a key aspect of the construction of ideas based on prior knowledge. The ways in which both formative and summative assessments can be used to inform instruction could be more explicit, and were rated relatively low by the external evaluator. The findings of this evaluation provide one basis for the next iteration of the materials, and focus the revisions on the relatively weak areas of the curriculum that were revealed to be lacking in quality, according to the criteria set forth by AAAS (2002).

Potential Revisions

Several improvements could be made to the curriculum materials based upon the external evaluation. For example, more support is needed in guiding the teacher and students in recognizing the purpose of an activity. In a future iteration of these materials, the purpose of the unit—to be able to answer the driving question about why students' city looks a certain way—needs to be made more explicit. While the entire sequence of lessons can eventually help students answer this question, they did not explicitly return to it at the end of the unit. Instead, students answered a more general question about why places have different appearances on Earth, and specifically, why other locations might look different from their own city. This question was implicitly related to the driving question, "Why does my city look the way it does?" The students and teacher could benefit from a more explicit connection to the driving question. In addition, the external evaluator suggested that the necessity of connections from lesson to lesson was the justification for sequence, however, a more explicit rationale behind the sequence of lessons could guide the teacher in helping students make stronger connections from lesson to lesson, thereby strengthening the continuity and coherence of the unit as a whole, and in solidifying the purpose of the unit.

The next iteration of this unit should better facilitate the teachers' attention to students' ideas. Specifically, the materials should guide the teacher in the identification of commonly held ideas as found in the research literature on student learning regarding this content. Once these ideas are identified, more educative supports need to be included to help the teacher address commonly held ideas that may be non-normative. The materials should include suggestions for how the teacher can probe deeper into students' responses in order to gain a better understanding of what and how they are thinking. The structure of the unit built upon students' earlier knowledge, which is implicit in the materials. This could be communicated more explicitly by describing precisely the knowledge that is prerequisite at the beginning of each new lesson or group of lessons. A related change that could improve the unit is to provide suggestions to the teacher regarding how to diagnose errors in students' ideas, or challenges they are facing in their thinking. These suggestions should be provided explicitly in educative supports, along with rationales as to why it is important to identify difficulties students may be having.

Many of the questions embedded throughout the curriculum materials could be used as formative assessments, but there were no summative assessments included in the unit itself. Assessments should be aligned to the Key Ideas explicitly, and should cover all ideas that guided the development of this unit, so as to be sufficient for the assessment of students' knowledge. The materials also need to better guide the teacher in interpreting students' responses to formative assessments in order to facilitate making appropriate instructional decisions for deepening students' understanding. In other words, assessments should be used to inform instruction in a more substantive way than was done in the first iteration of the materials.

In order to further enhance the science learning environment, the materials should alert the teacher as to how ideas have been simplified to help students make sense of the science content. Additional resources should also be included in the materials to help the teacher in improving her own understanding of the scientific content. In addition, the curriculum materials would benefit from examples of classroom interactions that could facilitate teachers' discussions with students, and provide ideas for ways to respond to common student ideas and questions. Finally, the contribution of scientists, and of minorities and women were not acknowledged in the materials, and should be included in a future iteration, as well as suggestions for how to modify certain activities for students with special needs—a concern that some teachers might have specifically when taking students outdoors.

The indicated revisions based on the external evaluation are presented in Table 5.2.

Table 5.2 *Revisions Indicated Based on the External Evaluation and Linked to Design Principles*

Indicated Revisions	Relevant Design Principles
More explicitly link the purpose of the unit to the activities and key ideas to increase coherence, and provide justification for the structure of the unit	Learning cycles and coherence
Support the teacher in taking account of students' ideas, and being aware of prerequisite knowledge	Embedded educative teacher supports
Include formative and summative assessments that examine students' understanding and inform instruction	Curriculum artifacts, assessments, and projects
Reference external resources to guide the teachers' development of content and pedagogical content knowledge	Embedded educative teacher supports
Include references to the contribution of minorities, scientists, and women	Personal relevance
Include modifications to activities for students with special needs	Embedded educative teacher supports

In addition to the external evaluation, other sources of data also inform future revisions, including data gathered from the participating students.

Student Feedback and Collected Data

The source of the indicated revisions is the data regarding students' experiences and perceptions of the Earth systems science unit, presented in Chapter III. I conducted in-depth interviews with twelve students covering a range of ability levels at the conclusion of the unit. Specific questions that probed students' opinions and suggestions for how to improve the unit included:

- Please be honest: What is your opinion of the Earth systems science unit you just finished?
- What did you like about the unit? What did you dislike about the unit?
- If you could provide feedback to the people who wrote this unit, what would you say?

In addition, the quantitative survey data indicated potential changes that could improve the educative nature of the Earth systems science unit. As discussed in Chapter III, all students achieved learning gains, although the very low ability students did not have a significant change from pre to post enactment. I have not included data related to student learning to highlight potential revisions because of the inability to identify the contributions of various activities to the outcomes measured by the pre and post content knowledge assessment due to the integrated nature of the curriculum. Therefore, the design of the content knowledge assessment used in this study will not provide a clear indication of needed revisions.

Potential Revisions

Overall, students had positive opinions of the Earth systems science curriculum unit. Students provided feedback about several changes they would like to see made to the unit. This feedback is on a small-scale due to the limited number of in-depth interviews conducted. The student feedback can be summarized as a desire for additional learning experiences in the form of more depth of coverage, additional field trips and research projects, and reading assignments. Several examples of students' perspective are provided.

Two out of twelve students felt that concepts related to the rock cycle were not explained thoroughly, and that they wanted to learn more about rocks in the unit. A different student expressed a desire to test the water that is present around the school. During the unit, students tested the water from the rock quarry, and discussed the quality of the water in relation to possible contamination from the nearby landfill. Extending this investigation to include the water around the school would make a more relevant addition to the unit in a future iteration. Water testing of the local water, compared with other water sources was one suggested option for a mini-project, although no students chose this topic.

One student stated that he wanted to participate in field trips to other locations in addition to the ones that he experienced around the school grounds and to the rock quarry. He felt that field trips to more places would allow him to see a greater range of phenomena. Based on this suggestion, and Orion's (1993) learning cycle model, an additional follow-up field trip back to the rock quarry would allow students to conduct their own investigation of a question that they raised during the initial excursion. Another student expressed a desire to conduct a greater number of research projects throughout the unit. This was an aspect of the curriculum that she enjoyed, and additional projects would have improved her opinion of the unit.

One student suggested that due to the hands-on nature of many of the class periods, missing a day of class resulted in difficulty. He felt he had to rely on the data of his classmates in order to catch up, and explained that a reading assignment would have helped him after a missed day of school. The inclusion of readings would help all students, including those that were absent. This is a crucial revision for the next iteration of the unit, as such readings would help synthesize and summarize concepts at appropriate times throughout the unit. Discussions and written exercises were the main methods by which students synthesized information, but including reading syntheses is another way to reach even more students including those with alternate learning styles.

The SOLEI and attitude surveys students completed indicated that lower ability students could benefit from greater attention to the coherence promoted by the unit. The teacher can promote coherence through discussions and activities in which students are encouraged to make explicit connections between indoor and outdoor activities. In addition, an awareness of the interconnectedness of components of the Earth system can be facilitated through class discussions, reading materials, and perhaps activities that deal with the science and society link. One example of a discussion that students raised during the unit was in relation to testing the quality of the water from the quarry, and what would have to be done if students had found a contaminant in the water. Specifically, students raised the question of whether telling the rock quarry about the poor water quality would have an affect on the quarry workers, who might lose their jobs. This type of conversation is an ideal context for making connections between systems on Earth, and they should be more explicitly supported in the curriculum materials.

The indicated revisions based on students' feedback and data are presented in Table 5.3.

Table 5.3 *Revisions Indicated Based on Students' Data and Feedback*

Indicated Revisions	Relevant Design Principles
Provide greater depth into how rocks are formed	Progression from concrete to abstract concepts
Include an activity in which students test the water quality of their school environment, and compare data with water collected from the rock quarry lake	Contextualization, personal relevance, and the local setting
Include a follow-up field trip back to the rock quarry to answer student-driven questions, and conduct investigations designed by students	Learning cycles and coherence
Add additional field trips to various locations to provide more diverse experiences with phenomena	Blending formal and informal learning contexts
Integrate relevant and synthesizing readings throughout	Coherence

the unit	
Make explicit connections between learning settings to help all students recognize the coherence of the unit	Blending formal and informal learning contexts, and coherence
Explicitly support development of the principle of conservation of matter as it relates to direct experiences with phenomena	Direct experiences with phenomena, and progression from concrete to abstract concepts
Increase support in materials for development of systems thinking skills and the interconnectedness of components of the Earth	Earth systems science approach, and coherence

In addition to the data and feedback collected from students, other sources of data also inform future revisions, including data gathered from the Mrs. Hunter.

Teacher Feedback and Collected Data

The source of the indicated revisions is the data regarding the teacher's experiences gathered through a series of six interviews over the course of the curricular enactment, presented in Chapter IV. Several interview questions probed her opinion of the unit, the physical materials, and the progress of the enactment, thereby providing suggestions as to how the unit could be improved in a future iteration. Some examples of relevant questions include:

- In general, can you tell me how the unit is going so far?
- What do you like or dislike about the format of the printed materials?
- What (if anything) has not gone well so far?
- What changes/modifications would you make if you were to take Ss on this field trip again next year?
- What (if anything) did not go well during this unit?
- What were some of the weaknesses of this unit?

Potential Revisions

During formal and informal conversations with Mrs. Hunter over the course of the curricular enactment, several ideas about revising the unit were discussed. One concern that Mrs. Hunter had before the unit began was that she would move through the unit too quickly because at the end of the school year, she found it difficult to lead extended discussions with students, whom she described as "done discussing" after about three questions. During the second interview, Mrs. Hunter felt that the lessons seemed to be an appropriate length. She describes the written materials as “user-friendly” on several occasions. This indicates that the apparent user-friendliness of the materials was being mistaken for simple, and not in need of discussion. In the next iteration of these materials, I will provide a better sense of how long each activity is expected to take, and provide educative teacher supports that can help the teacher gauge how much discussion may be important at various points throughout the unit. The concepts that may require a more extended discussion will be chosen based on the limited literature regarding students’ commonly held ideas, and concepts that are likely to give them difficulty. Most importantly, the rationale behind these development decisions should be communicated to the teacher. These changes could be more easily incorporated into a teachers’ guide that follows a more formal format.

Mrs. Hunter liked the format of the teacher supports in the printed materials. She explains the importance of being on the same page as her students. “I like to be able to see what they see, and I like to know, ‘okay, I’m on 17, so they’re on 17.’ That is very helpful in the day to day running” (Interview with Mrs. Hunter, 4/17/09). She did suggest that the font size for the teacher supports could be larger and therefore easier to read.

One aspect about the curriculum materials that Mrs. Hunter commented on was the lack of prompts for the students, meaning that it would be difficult for them to complete an activity if they were not in class.

Mrs. Hunter: They really need to be here in class to get the full benefit of it, vs. ‘here’s a worksheet, here’s the book. If you’re here or not doesn’t matter.’ It really matters that they’re here. Which is a good thing… I think. (Interview with Mrs. Hunter, 4/17/09)

Mrs. Hunter believes that while the design of the curriculum materials make it difficult for a student to complete the work alone, she sees the lack of prompts as a positive aspect of the materials, because it encourages students to be in school. She felt that the prompts that she provided in class helped students move along with an investigation, but that a student who had missed class would not be able to complete an assignment alone. The frequency of student prompts throughout the materials should be increased during revisions, as this would facilitate the completion of the unit by a larger number of students who may have missed school.

Similarly, Mrs. Hunter commented on the lack of substantial reading assignments in the unit, as compared with what she had previously been using. She felt that having a reading assignment as homework was one way in which to introduce real world applications of the ideas they were learning in class, as well as to provide background knowledge or prerequisite information to help guide classroom activities. The reading assignments could additionally serve the purpose of summarizing and synthesizing ideas, particularly for students who had missed school and needed to fill in missing pieces of the curriculum for a coherent storyline. The relevance and applications to the real world provide an important rationale for why reading assignments should be included in the next iteration of the curriculum materials. Mrs. Hunter points out that because she does not feel confident in her personal content knowledge (Smith & Neale, 1989), that readings would help her in this regard. "Whatever they can get from here would be better because I'm not really the expert" (Interview with Mrs. Hunter, 4/27/09). A student echoed this need for readings during his interview.

Another aspect of the curriculum that Mrs. Hunter discussed was her feelings of preparation and apprehension about the field trip to the rock quarry. She was mostly concerned with logistical issues surrounding the field trips (i.e., leaving a student behind). She described herself as a "follower," explaining that she had been content helping other teachers. Thus, this was Mrs. Hunter's first experience leading a field trip, and it is likely that many teachers have never had full responsibility for leading a field trip, highlighting the importance of educative supports for the teacher surrounding the logistics of leading a field trip. These supports should ideally be included at the beginning of the unit but also just before the trip, in order to guide the teacher in organization and planning. Teachers need to develop skills that will help them lead successful field trips for students. Much of the knowledge regarding the orchestration of field trips can be provided in the materials, including logistical suggestions such as keeping track of students, and collecting permission slips. In addition, the teacher needs support in preparing students for the cognitive, emotional, and logistical aspects of the experience.

The indicated revisions based on Mrs. Hunter's feedback are presented in Table 5.4.

Table 5.4 *Revisions Indicated Based on the Teacher's Feedback*

Indicated Revisions	Relevant Design Principles
Provide a suggested timeline and indicate depth of discussion for important aspects of the unit	Embedded educative teacher supports, and Learning goals based on benchmarks
Include prompts for students to facilitate their individual work	Embedded educative teacher supports
Integrate real-world applications and synthesizing readings throughout the unit	Contextualization, personal relevance, and the local setting
Provide additional support regarding logistical aspects of the field trip in addition to the rationale for including the field trip to a specific location	Embedded educative teacher supports, and Blending formal and informal learning contexts

In addition to the data and feedback collected from Mrs. Hunter, other sources of data inform future revisions, including classroom observations of the enactment of the Earth systems science unit.

Classroom Observations of the Daily Enactment

I observed and videotaped each day of the curricular enactment. During the lesson, I recorded field notes, as well as notes on a Daily Classroom Observation Sheet (Appendix 5A). This Observation Sheet was adapted from those used by the Scoop Notebook (Borko & Stecher, 2006) and the ROLE project (Kempler, 2006; Kempler, Blumenfeld, Geier, & Krajcik, 2008). The field notes included a general summary of what was happening in the classroom each day, and a brief description of ways that I supported the teacher before, during, and after the enactment, often during informal conversations or during a lunch break. Following each daily enactment, I recorded a narrative summary of the classroom activities. The purpose of these data sources was to provide an overview of the daily enactment, rather than for quantitative analysis. Several readings of the Observation sheets, as well as the field notes indicated general themes that emerged, and that contribute to this section regarding potential improvements, additional teacher support features, and general changes that could improve the quality of the curriculum materials in a future iteration. For example, when I noted that I had supported Mrs. Hunter in the setup for most laboratory activities during several days of the enactment, it became clear that additional support was needed in the printed curriculum materials, especially for a future enactment that would almost certainly include less one-on-one, daily support.

Potential Revisions

Based upon my observations of the curricular enactment, there are several revisions that could improve the curricular unit so as to be more educative for both students and teachers. Many of the field notes I recorded about the ways in which I supported Mrs. Hunter before, during, and after each daily enactment, fall into several categories: taking account of students' ideas, formative assessments, and preparation for daily lessons.

At times during the enactment, Mrs. Hunter could have used more support in taking account of her students' ideas. Before beginning the unit, Mrs. Hunter stated that she is not an "expert", mentioning that she was less comfortable teaching Earth science compared with other science disciplines such as biology. This is not uncommon for middle school teachers, who have often specialized in one field of science, yet are expected to teach a variety of fields (McComas & Wang, 1998; McDiarmid et al., 1989). Due to this common concern and lack of confidence that many teachers have regarding their content knowledge in certain areas, it is important that curriculum materials be educative for the teacher—to facilitate her teaching, and more importantly to provide guidelines, rationales, and opportunities for her to deepen her own learning of the content, and how to teach that content to middle school students. Therefore, identifying common student misconceptions or ideas surrounding a specific phenomenon could be useful as she leads discussions and helps students make sense of science content. These educative supports should be more frequent in the printed materials, and sample discussions should be provided to help the teacher in questioning students' ideas and enhancing conversations. An alternative way to probe and further explore students' ideas would be to use the public area where students post their questions, in a more substantial way. While this feature was written into the materials, the particular ways in which this area could be used were not made explicit, nor well supported. Specifically, suggestions for ways to incorporate the use of the public display during class should be included in the next iteration of the materials.

During conversations with Mrs. Hunter, she occasionally wondered about what students were thinking or taking away from the unit, regarding specific ideas. The curriculum materials should include, and identify those items in the materials that could be used as formative assessments. The unit included a number of such items, yet they were not clearly identified as such, leaving Mrs. Hunter to be unsure as to whether students were learning what she intended for them to learn. For example, towards the end of the unit, Mrs. Hunter explained to me that she believed some students were still unsure about the nature of groundwater. She presented a simple assessment task as she discussed this with me, when she predicts what would happen if she asked students to draw and label groundwater. Classroom observations indicated that formative assessment tasks could be included in the curriculum materials, and identified as such, along with a rationale and common student ideas to seek out. Mrs. Hunter conducted activities as suggested in the printed materials, yet did not frequently return to student artifacts that could be used as formative assessments to guide her understanding regarding students' progress, thus promoting curricular coherence.

Finally, another area that could be improved in the next iteration of the materials is in regards to logistics and teacher preparation. Much of the teacher support provided to Mrs. Hunter concerned laboratory equipment and setups. This support often occurred just before Mrs. Hunter's first science class of the day. Mrs. Hunter sought out support in planning out how quickly to move through the sequence of lessons in the unit on several occasions. A suggested timeline should be included in the next iteration of the materials in order to guide teachers in enacting the unit. The printed materials should include enough information so that a teacher is comfortable with laboratory materials and logistics. Details on extensive preparation needed should be included in the materials several days before an activity to provide enough warning for the teacher to carryout any necessary preparation. For example, one activity involved making a large number of plaster "rocks" using ice cube trays. For this study, I prepared these rocks for Mrs. Hunter, however, scaling up this project would require details about this necessary preparatory step. Another example concerns the small tank that is used to model groundwater flow, contamination, and pumping of wells. Due to my presence in the classroom, I was able to provide a hands-on demonstration of this physical model, and help Mrs. Hunter make sense of the model. However, the printed curriculum materials should include instructions and photographs that demonstrate how this model works. In general, the types of logistical support and preparation necessary on the part of the teacher need to be included, as a future enactment using this curriculum would not include a daily support person, as occurred during this study.

Specific to a unit of this type, there is a need for preparation in teaching outdoors. Teachers should have opportunities to visit field sites before taking students outdoors. The curriculum materials should include suggestions for places to visit, and tips to facilitate teaching in the outdoors. During this preparatory phase, the teacher would have an opportunity to forecast the types of questions and ideas that students may have. In addition, the ways to integrate activities that take place in different learning environments should be discussed in the materials to improve the overall curricular coherence of the unit. The indicated revisions based on my classroom observations are presented in Table 5.5.

Alignment of Indicated Revisions to Design Principles

Many of the revisions indicated by the various data sources (Chapters III, IV, V) suggest a greater emphasis and attention to the design principles that guided the development of the unit, specifically in regards to the inclusion of embedded educative teacher supports. For example, the aspects of the unit that Mrs. Hunter struggled with, such as logistics of laboratory activities, or the details of preparing students for the rock quarry field trip could be dealt with through improved teacher supports. The depth of support offered in the printed curriculum materials was likely not sufficient for a teacher who did not have daily one-on-one support as professional development. Therefore, a future iteration of this unit should include a more traditional teacher guide to accompany the student workbook. This format would allow for more depth into other aspects of the design principles, such as supporting formative assessment opportunities throughout the unit, and facilitating the development of coherence between indoor and outdoor learning contexts for all students. In addition, supporting the teacher in identifying students' ideas, as well as helping all students become more aware of their own ideas would improve the unit while emphasizing the importance of personal relevance, and coherently drawing connections between science concepts and students' lives.

Table 5.5 *Revisions Indicated Based on Classroom Observations*

Indicated Revisions	Relevant Design Principles
Increase the frequency and types of educative teacher supports to include common student ideas, sample discussions, and suggestions for using the public classroom space for student artifacts and ideas	Embedded educative teacher supports, learning cycles and coherence
Provide support for which questions or tasks could be used as a formative assessment	Curriculum artifacts, assessments, and projects, embedded educative teacher supports
Include suggestions for ways to use student artifacts as formative assessments, and to encourage curricular coherence	Curriculum artifacts, assessments, and projects, embedded educative teacher supports, coherence
Include support for teaching outdoors, including teacher preparation to become familiarized with the field site, and detailed suggestions for integrating outdoor activities with classroom and laboratory activities to improve coherence	Blending formal and informal learning contexts, coherence, embedded educative teacher supports

Conclusion

The curriculum materials were evaluated externally using Project 2061's evaluation criteria. Findings indicate that certain aspects of the curriculum are more strongly supported than others, and are in alignment to the perspectives of students, their teacher, and observations of the enactment. For example, the evaluation revealed a paucity of built-in support of the teacher taking account of students' ideas. The evaluation also revealed room for improvement in the inclusion of both formative and summative assessments that target key ideas in the unit. Classroom observations also revealed that Mrs. Hunter did not often use assessment items for making sense of what students were learning, although this was discussed as an aspect she felt was important. According to the evaluation, the strengths of the unit are in its ability to engage students in thinking about phenomena they explore through a variety of experiences, and to provide opportunities for practice with the terms, ideas, and knowledge they encounter. These strengths are related to the integration of the outdoor setting as a key learning environment, while the structure of the unit fosters coherence. This is a novel contribution to the field of curriculum development, and suggests the need to further explore the role of the outdoor setting in the context of an Earth systems science approach for promoting coherence.

As the resulting curriculum is only the first iteration of a development process, the potential revisions that could improve the unit to be more fully educative and coherent for students and teachers are discussed. The potential revisions were described based on a variety of data sources, including the external evaluation findings, feedback from student interviews, student data, informal discussions and formal interviews with the participating teacher, and classroom observations of the enactment. Each of these sources focused on various aspects of the printed curriculum materials, the enacted curriculum, and the experienced curriculum, providing a well-rounded analysis of potential changes linked to design principles.

Appendix 5A: Daily Classroom Observation Sheet

Date _________ Hour ______ Activity # ________ Day ________ Observer _______

Activity Description:

Special Circumstances:

Outdoors cited:

Time S/T Description

Student Grouping **1 2 3 4 5**

(Are Ss working independently/pairs/small groups? Is this effective for the activity? Are all Ss participating?)

Hands-on **1 2 3 4 5**

(Are Ss working directly with materials and physically engaging with scientific phenomena?)

Inquiry **1 2 3 4 5**

(Are Ss posing questions, designing investigations, collecting evidence, analyzing data, and answering questions? Are Ss synthesizing knowledge and constructing understanding?)

Cognitive Depth **1 2 3 4 5**

(Are Ss focusing on big ideas? Are Ss generalizing from specific instances to general principles? Are Ss constructing meaning from activities? Does T emphasize purpose of activity?)

Teacher Questioning and Discussions **1 2 3 4 5**

(Are Ss given the opportunity to express their ideas? Does the T's questioning promote understanding? Does T interact with one S for an extended period of questioning? Are discussions brief? Are Ss conversing with other Ss?)

Explanation/Justification **1 2 3 4 5**

(Are Ss expected to provide justification for their ideas, orally and in writing?)

Assessment/Feedback **1 2 3 4 5**

(Are Ss being assessed on a regular basis? Is this being used to inform instructional decision-making? Does the T provide feedback to Ss regularly? Extended or brief?)

Connections/Applications **1 2 3 4 5**

(Are Ss being guided to connect science to their own experiences and their world? Is science being made relevant to real world contexts? T/S generated? Are activities being related to driving question?)

Curriculum Congruence **1 2 3 4 5**

(Did the T follow the intended curriculum? Did the T modify/omit parts of the curriculum? How?)

Content Accuracy **1 2 3 4 5**

(Did the T present scientific content accurately? What alternative conceptions do Ss have?)

Scaffolding and Direction **1 2 3 4 5**

(Did the T break down complex tasks to help Ss do the activity? Was this scaffolding effective and appropriate?)

On-Task **1 2 3 4 5**

(Are most Ss on-task throughout the activity? Are Ss engaged/sleeping?)

CHAPTER VI

Conclusion

This study was designed to explore the outdoor learning environment in a systemic way by attending to various perspectives to gain a deeper understanding of the contribution of this setting within the school context. Until we have a better understanding of the system of related factors that have historically limited the usage of the outdoor setting as a legitimate learning environment, this setting will continue to be under-utilized. Therefore, this study explored:

1) the practical aspects of integrating outdoor learning experiences in curriculum materials (Chapter II)

2) students' perceptions of the role of outdoor learning activities in the context of their learning experience, and students' learning outcomes (Chapter III)

3) the teacher's view of the role of outdoor activities within an Earth systems unit, and the school principal's perspective of the value and challenges related to the incorporation of outdoor learning experiences within the school curriculum (Chapter IV)

4) the revisions indicated from an external evaluation of the curriculum unit, along with student data, teacher interviews, and classroom observations (Chapter V).

Through this in-depth exploration of outdoor learning experiences from a variety of perspectives using a systemic approach (Figure 6.1), this study provides a valuable contribution to our understanding of the ways in which the outdoors can enhance teaching and learning. This final section ties together each of the five preceding chapters by exploring the implications of salient findings of this research.

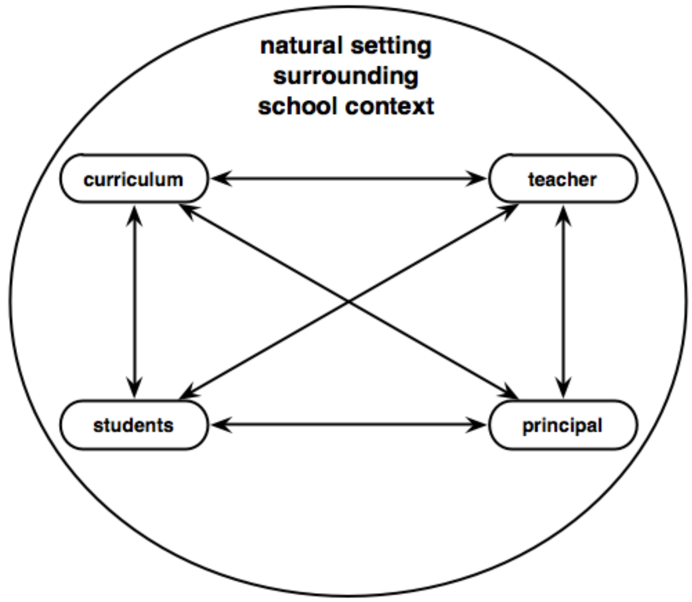


Figure 6.1. Systemic approach to exploring the introduction of a curriculum that includes outdoor learning experiences from various perspectives.

Chapter II described the development of the Earth systems science curriculum unit based on a set of design principles. This type of curriculum was unique in and of itself, as there are few examples of curricula based on the Earth systems approach, and even fewer that explore the integration of outdoor learning experiences as an integral component. Therefore, this unit can serve as a model for how to incorporate research-based design principles including blending of learning environments (Hofstein & Rosenfeld, 1996), into an Earth systems unit (Orion, 2007; Orion & Fortner, 2003). This study contributes to the limited number of examples of blended curriculum units. The resulting unit was also designed with a goal of intraunit coherence, in which the connections between scientific ideas are promoted (Roseman et al., 2008; Shwartz et al., 2008), and students are encouraged to apply these ideas to relevant aspects of their lives (Kali et al., 2008b).

Chapter III explored students' perspectives of the role and value of the outdoor learning experiences integrated into the Earth systems unit, and their learning gains in the context of this enactment. Findings indicated that overall, students recognized the value of outdoor learning experiences along various dimensions, including their role in promoting concrete interactions with phenomena (Dewey, 1902), and the perspective that such experiences combine cognitive and affective aspects of learning; mainly, students reported that outdoor activities allow them to learn while they feel engaged in that learning, which aligns to the findings of Orion and Hofstein's (1991) study with high school students. These researchers found no significant changes along these aspects of students' attitudes for the younger students in their populations, thus highlighting a unique finding and implication of the use of the Attitude survey as a sensitive instrument for exploring middle school students' perceptions. Survey and interview data indicated that students were aware of the integration of outdoor experiences with indoor activities, and cited the outdoor learning experiences as one vehicle for promoting connections between learning settings. This is an extension of the literature regarding coherence, in that the outdoors have not yet been identified as a vehicle for facilitating coherence. This study provided evidence that many students and the teacher recognized the important role that the outdoor experiences played in the ways that they bridged activities, learning settings, and scientific concepts.

However, a closer examination of this aspect of students' perceptions, corroborated by interviews with a subset of students revealed that the awareness of integration was characteristic of average and higher ability students. Lower ability students were less likely to raise the idea of connections between learning activities and concepts, and also were less likely to regard the field trip as a tool for learning. This finding has implications for teacher education (Richardson, 1996), the development of educative curriculum materials (Ball & Cohen, 1996; Davis & Krajcik, 2005), and professional development activities (Putnam & Borko, 2000) to explore the ways in which teachers can better facilitate and promote the development of coherence through the use of integrated outdoor learning experiences. This finding regarding the students' perspective is therefore clearly connected to the role and work of the teacher, emphasizing the systemic approach used in this study (Senge et al., 2000), and its value as an approach to researching complex educational systems. In addition, all students achieved learning gains, although there remain difficulties in students' understanding of key ideas such as the principle of conservation of matter. Other researchers suggest that systems and cyclic thinking skills must be dealt with more readily in curriculum materials (Ben-zvi-Assaraf & Orion, 2005a; Ben-zvi-Assaraf & Orion, 2005b; Kali, 2003; Kali et al., 2003; Raia, 2005). The specific contribution of outdoor learning experiences to the development of systems and cyclic thinking skills still requires additional exploration.

Chapter IV explored Mrs. Hunter and Mr. Ford's perspectives of the value and challenges of implementation of outdoor learning experiences in the science curriculum through interviews with both individuals. Mrs. Hunter became increasingly aware of the coherence and integration of ideas promoted by the design principles of the curriculum (Orion, 1993) as she moved through the unit, which peaked shortly after the extended field trip to the local rock quarry. It was at this point that Mrs. Hunter began to focus on the value of the outdoor experiences for fostering connections across activities and concepts. Awareness of the value of these experiences is an important factor in their use in the school context (Michie, 1998; Mirka, 1970; O'Neal, 2003). In addition, outdoor learning experiences provided opportunities for students to interact directly with phenomena (Birnbaum, 2004), an important goal of science education described by researchers (Hammerman et al., 2001; Hofstein & Rosenfeld, 1996; Koran & Baker, 1979; McNamara, 1971). Mrs. Hunter believed the outdoor activities, specifically, helped students' become aware of the relevance of science to their lives (Novak & Gleason, 2001; Orion et al., 1996; Rivet & Krajcik, 2004; Singer et al., 2000), and to increase their engagement (Benz, 1962; Birnbaum, 2004; Disinger, 1984; Hofstein & Rosenfeld, 1996; Kern & Carpenter, 1984; Koran & Baker, 1979; Michie, 1998; Orion & Hofstein, 1991) in the context of the unit. Mr. Ford also recognized the potential of outdoor learning experiences for increasing engagement and coherence, but discussed these valuable aspects in the context of needing to balance them with challenges of field trips away from the school grounds (Birnbaum, 2004; Mason, 1980b; Mirka, 1970; Sharp, 1988). He described the great potential in engaging students with outdoor learning activities on the school grounds that have fewer barriers regarding finances and time. Mr. Ford also described his perspective that his role as the school principal was to support teachers and encourage risk-taking through experimentation with different instructional techniques without fearing negative evaluation.

Chapter V used the data sources from Chapters III and IV, in order to identify potential revisions that could improve the quality of the curriculum materials described in Chapter II. An additional data source was an external evaluation of the unit based on criteria put forth by Project 2061 (American Association for the Advancement of Science, 2002; Kesidou & Roseman, 2002). This evaluation, along with feedback from participating students, the teacher, and classroom observations of the enactment highlighted potential revisions to improve the educative nature of the unit for both students and their teacher. For example, one finding based upon several sources indicated the need to support the teacher in taking account of students' ideas, including their prior knowledge and conceptions, as well as to tend to their developing knowledge through the use of more explicit formative assessments. This would increase the coherence of the unit, and foster the development of connections (diSessa, 2006), an ultimate objective of educational materials and more broadly, a goal of education (Kali et al., 2008a; Kali et al., 2008b).

The most salient theme that emerged from this study was in the recognition of the role of outdoor learning experiences in fostering coherence throughout the unit from all participants' perspectives. Coherence has recently been recognized as a new wave of educational reform to move us closer to the goal of science literacy for all individuals (Kali et al., 2008b). This study highlighted the contributions of the outdoor learning environment to this reform effort. The findings are significant, relevant, and largely unexplored. Mr. Ford greatly valued connections of all types. He discussed the necessity of connections between the curriculum and field trips, as well as the potential of local field trips in fostering students' community connections. As an extension, he believed there was great potential in collegial collaboration to further coherence across disciplinary subjects, as well as for increasing the chances for teacher buy-in to take time for an extended field experience. Mrs. Hunter described the coherence of the unit as a whole, specifically following the rock quarry field trip in which the connections between ideas began to become clearer to both her and her students. However, an exploration of students' perspective revealed that higher ability students were more aware of these connections than lower ability students. This finding suggests that while Mrs. Hunter was aware of curricular coherence, and some students expressed awareness of the interconnectedness of concepts, not all students were benefiting from this aspect of the curriculum. This finding has implications for the development of curriculum materials, specifically in the ways printed materials can foster coherence for all students. The need for educative supports to guide the teacher in communicating coherence and relationships among ideas are indicated. Such supports would additionally help the teacher develop the pedagogical knowledge that may be specific to the outdoor learning environment. For example, the materials could include educative supports for the teacher to guide her in leading discussions with students that make connections between activities explicit. In addition, supports could guide the teacher in identifying difficulties students are having through the analysis of formative assessments.

Further, Mr. Ford acknowledged the rich resources in the outdoor setting that surround the school. He expressed that such resources were not often used, but that he believed they offered potential. Student interviews indicated that students were not necessarily aware of their immediate surroundings, and that the Earth systems unit helped increase this awareness of the local setting. This relates to students developing connections to their local community—a theme throughout Mr. Ford's interview. However, in order to make use of such resources, teachers need guidance in the form of educative curriculum materials and professional development, as outdoor instruction requires a different set of teaching strategies compared to the more traditional classroom and laboratory settings. Mrs. Hunter echoed this idea during interviews in which she described her desire to use the outdoors in her teaching, but felt she needed materials to guide instruction. Thus curriculum developers have an important role in the recognition of the outdoor setting as a valuable and legitimate learning and environment. More research is needed to explore the best ways in which to include this learning setting to get the most out of the valuable role it can play.

Although teaching in the outdoor setting was somewhat novel for Mrs. Hunter, the demands upon her and students were not excessive. Over the course of approximately eight weeks, students ventured outdoors on a total of five occasions, including the extended 2-hour field trip to the local rock quarry. Thus, only about 13% of the total instructional time was spent in the outdoor setting, yet the impact it had upon students' experience was substantial. This study provided valuable insight into this impact and has furthered our understanding of the contributions of the outdoor setting as an environment for both teaching and learning when it is tightly integrated with other instructional activities that occur in the more traditional learning setting of the classroom and laboratory.

Future Research

While this study offers valuable contributions to the field of education, future research would need to extend and add to what we know regarding teaching and learning that integrates outdoor learning experiences into a formal education system. The study population was relatively small, thus an extension of this study would need to examine a greater number of teachers enacting a curriculum of this type in order to generalize these findings more widely. Specifically, an exploration into the ways different teachers foster coherence through outdoor learning experiences could expand our knowledge of this learning environment and the potential value of its inclusion. In addition, trends across school principals would need to be explored to generalize these findings more widely. Further, due to the importance of the local setting for developing outdoor learning experiences, the Earth systems unit was customized to the participating school's location. Scaling up would require a more general curricular template that teachers would modify to adapt to their surroundings, while furthering their professional development regarding expertise of teaching (Brown, 2009) in the outdoor learning environment. Davis and Varma (2008) describe the importance of teachers being given the opportunity to adapt and modify curriculum materials to align to their needs, and the needs of their students. However, the particular ways in which teachers modify existing materials that include outdoor learning experiences has not yet been explored. Sherin (2002) states that teachers who engage with novel instructional techniques develop new knowledge regarding content.

Other studies conducted in a similarly systemic way, but with different age groups ranging from elementary students to university students could provide an important contribution to our understanding of the role and value of outdoor learning experiences in the formal school context. Specifically, the ways in which younger students perceive learning in the outdoors, how this could be measured, and the ways in which teachers of different groups of students can promote coherence could guide curriculum designers and educational researchers. Further, the age at which students become aware of coherence within the school curriculum could provide valuable insight into how to maximize the effectiveness of outdoor learning experiences. While learning outdoors is a more common activity in higher education, typically in geoscience and biology departments, an extension of the findings from this study regarding one role of such activities as promoting coherence, could be tested with an undergraduate population. Attempting to determine whether higher ability students are more aware of coherence and connectedness between activities and concepts should be explored, or perhaps there is an age at which most students are aware of coherence, regardless of ability level. In addition, identifying a possible direction of causality as to whether higher ability students are identified as high ability *due to* their ability to make such connections, or whether these students are more capable of making connections would be an interesting extension of the findings of this study.

Another valuable direction for future research deals with teacher education programs. A question worth investigating is whether preservice teachers who experience learning in the outdoor setting as a legitimate component of teacher education courses are more capable of integrating this setting as a learning environment during their teaching practice. Mirka (1970) promoted the idea that experiences outdoors should be a component of professional education for teachers, yet the limited use of this environment in the formal education system suggests that teachers still have a great deal of discomfort using this setting. Further, Michie's (1998) findings regarding the importance of past positive experiences outdoors, both as a teacher, and as a student play a key role in teachers' decisions to make use of the outdoor setting. Findings such as these provide further evidence that the inclusion of outdoor experiences during teacher education and professional development opportunities may play a key role in the inclusion of such experiences when a teacher is in his or her own classroom. Due to the salient role of the outdoors in promoting coherence, the current study indicates that there is value to this addition to teacher education programs.

This study explored the teacher's perspectives of the role and value of outdoor learning experiences. However, another question that could contribute to our understanding along this line is how the teacher perceives her own personal role in the integration of outdoor and indoor experiences. This would be aligned to the exploration of the principal's perspective of his role in promoting the use of the outdoors in the current study. Specifically, the ways in which the teacher sees her role in using the outdoor learning environment could impact the way teacher education programs might include development in this area. For example, Mrs. Hunter described herself as a "follower" during an interview for this study, in relation to her tendency to not be the planner for a field trip. As this study placed new types of demands on Mrs. Hunter to take the lead in the planning for this curricular unit, she may have developed professionally, and personally in her awareness that she was capable of planning and leading a field trip with a large group of students. Her experiences teaching this unit may have promoted her self-confidence, and her willingness to take risks in the future. This future research could advance our understanding and contribute to the teacher identity literature (Brown & Campione, 1994; Lave & Wenger, 1991).

This study focused on four key sets of players (curriculum, students, the teacher, and the school principal) in the educational system in an effort to provide a systemic perspective of the introduction of a curriculum that includes the outdoors as an integral component. However, the system of key sets of players could easily be expanded to include other entities that almost certainly play important roles in this system, and are intimately intertwined with those included in the current conceptualization of the educational system (Senge et al., 2000). For example, an extension of this study to include perspectives of higher education would be a valuable contribution to the current study. More specifically, the interactions of college and university students (Geology majors, for example) who shift to teacher education programs, but who have experienced learning outdoors during their coursework, may play an important role in increasing the recognition of the outdoors as a valuable and legitimate environment for teaching and learning. This could have implications for the promotion, and increased use of outdoor learning experiences at the higher education level (Kean & Enochs, 2001). In addition, the inclusion of an exploration of the role of family members on this system (Ellenbogen, Luke, & Dierking, 2004) could provide an increasingly complex and deeper understanding of how various individuals can impact the use of the outdoors in the formal school setting. This investigation could be tied to the role of informal institutions such as state parks (Smith, 2005), national parks, and museums (Falk, 2002; Kowal, 1995), as future research could explore the role of these entities as increasing exposure to outdoor learning experiences, which may be furthered in the formal school context. For instance, parents who take family vacations to national parks may place a higher value on the importance of students learning in the outdoors during the school year, and thus could play an integral role in changing school policy related to field trips in their child's school. With such an example, it becomes clear that the interrelationships between the components of a system are numerous, many of which provide potential foci for future research.

The potential for outdoor learning experiences to further the agenda of coherence, not only within a unit, or a single discipline, but across disciplines, also needs exploration. Mr. Ford described these cross-content connections as one way to enhance the potential of outdoor learning experiences, and this concept needs to be investigated to determine the feasibility of such connections, and the ways in which teachers collaborate to promote coherence across the school curriculum. Such a study would involve curriculum development with the promotion of cross-discipline connections (Kimmel, 1996) as a design principle to further coherence. For example, the Earth systems science unit included an extended field trip to the local rock quarry and landfill. The ways in which such a trip could be made relevant, not only to science, but to English, Social Studies, Mathematics, and the Visual Arts could be explored, and would require collaboration and input from teachers of each of these subjects. Through the development of interconnectedness across the entire school curriculum, we can attempt to guide students towards the goal of coherence in a more complete and comprehensive way.

Finally, the role of the principal in supporting teachers' use of the outdoor setting for teaching needs further explanation. This study provided an ideal context for Mrs. Hunter to take a risk with full support and encouragement from her school principal. However, the challenges facing a teacher in an environment in which taking a risk, such as teaching outdoors, is less supported should also be explored. It is likely that the school environment, and the level of administrative support will play a crucial role in the outcomes related to a teacher's perceptions of the role and value of the outdoor learning setting. The relationships between the teacher and school principal under various conditions of support would be a valuable contribution to the literature regarding the integration of outdoor and indoor learning experiences in the formal school context.

Conclusion

This work began with an introduction to a system-wide problem. Our limited understanding of the outdoor learning environment is combined with a limited body of literature regarding the integration of the outdoors with the indoor learning environment within the traditional school context. In addition, few examples of curricula that include the outdoors as a legitimate component exist and thus few teachers employ such instructional techniques. This is likely at least partly due to the lack of exposure to teaching or learning outdoors as a component of teachers' prior experiences and education. This research study was designed using a systemic approach in order to explore various aspects of the introduction of a curriculum that integrates outdoor learning experiences to a single school system. The school system is complex with numerous components (people and organizations) and a seemingly endless set of interrelationships, interdependencies, and connections. Further, the school system is dynamic. The constant state of change to various components and connections within this system makes it inherently difficult to study. While the use of a systemic approach to educational studies is not common due to the complexity of designing research using this approach, the goal of this research was to make a substantial, and system-wide contribution to what is known about the development and use of curriculum materials that include outdoor learning experiences. By exploring the perspectives of those using (students and teachers) or choosing (the principal) the curriculum materials, we can gain a deeper understanding of ways curriculum developers can improve upon the design of such materials.

The introduction of an innovative, reform-based curriculum to one teacher and her students in one school system provided insight into the ability of this particular school system to adjust to this change. The principal not only approved the use of this curriculum, but encouraged such risk-taking, which he described as an important part of the complex work that teachers do. The teacher was forced to adapt her teaching practice to enact this curriculum, and throughout the adaptation process, she provided valuable insight into her perspective of the outdoor learning experiences as an integral part of the curriculum. Finally, the students were exposed to a novel type of field trip, one in which those activities were no isolated and separate from the school curriculum, but instead were highly integrated and connected to the concepts they were learning in science. The findings of this study have salient implications for many areas of education, including curriculum development, teacher education, professional development, teaching, and ultimately, student learning. In addition, this study provides insight into ways in which to blend informal and formal learning contexts. By exploring the introduction of an innovative unit to a single school system, and holistically investigating its use from a variety of perspectives, I have gained insight into the value and role that a curriculum that coherently integrates indoor and outdoor learning environments can have on key sets of players within the educational system.

Specifically, this study provides evidence to extend the models of the integration of formal and informal learning settings described by Hofstein and Rosenfeld (1996), as well as Orion et al. (1997) and Ben-zvi-Assaraf and Orion (2005b) with an example of an Earth systems science curricular unit. This study extends the findings of the way the SOLEI can be used (Orion et al., 1997) to include younger students, and for identifying changing perspectives of connectedness amongst learning experiences. Generally, the value of outdoor learning experiences for promoting intraunit coherence (Shwartz et al., 2008) has not yet been explored, and this finding was supported by the evidence gathered in this study. Further, the SOLEI and interviews with students revealed differences in the ways that students of varying ability levels perceived coherence between activities, lessons, and learning settings, which is a unique and important contribution of this study.

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