The Significance of Access: Students with Mobility Impairments Constructing Geoscience Knowledge Through Field-Based Learning Experiences

Dissertation

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by

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"The cave you most fear to enter contains the greatest treasure."

Joseph Campbell

For Dominic, Kadelyn, Alexandra.

Never be afraid to pursue your dreams.
Abstract

The post-secondary geology curriculum typically requires completion of multiple field-based education components. The importance of field-based learning experiences is well documented in geoscience education literature. However, due to these field requirements, persons with mobility impairments face multiple barriers to obtaining a higher education in the geosciences. Furthermore, the lack of exposure to career opportunities in the geosciences potentially creates a perception that most geoscience careers do not accommodate graduates with mobility impairments. As a result, students might feel discouraged from pursuing undergraduate and graduate level degrees in geology.

An assumption exists that most traditional field environments are inaccessible to students with mobility impairments. A main objective of this study was to first determine how experience in a geologic field environment assists in the overall construction of cave geology content knowledge for students with mobility impairments. An effective evaluation of this field experience required an understanding of how students interact with their environment. Individual case studies of the participants’ lived experience with (and within) a traditional field-site provided an understanding of how geological content knowledge was constructed in the face of field-related barriers. Also assuming that knowledge is independent of one’s physical ability, this study focused on understanding the potential environmental and physical barriers that students with mobility impairments maintain with respect to field-based education. Therefore, participants’ experience in a cave geology field environment was investigated through
their personal perception of the surroundings. This exploration was not intended to differentiate them from the rest of society by what they do or do not know, what they can or cannot do, but to assist them in obtaining the accessibility and content knowledge of a geoscience field-based curriculum. An understanding of these first-hand perceptions provides a valuable foundation for field-based science educators to include, accommodate and provide equal access for students with mobility impairments.

As part of this study, participants with mobility impairments learned about geologic processes in a classroom setting and then participated in a field-based learning experience relative to those processes. Through an assumption that most traditional field environments are inaccessible to students with mobility impairments, a primary objective of the study was to determine how first-hand experience in a geologic field environment assists in the overall construction of content knowledge for students with mobility impairments. An evaluation of this field experience required an understanding of how these students interact with the environment through daily routines, which was accomplished through six individual case studies of the participants’ lived experience.

This dissertation presents both quantitative and qualitative data related to the construction of geoscience content knowledge and how personal, environmental and societal barriers were perceived by the participants and how these barriers could be minimized in the planning of future geologic field experiences.
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The idea for this project began in the spring of 2008. During a walk around Beekman Park on campus, I had an opportunity to discuss my thoughts with my good friend, Jim Bruner. From the introduction of this project, Jim never wavered in his support and dedication. He was supportive not only of the idea and planning, but in the design and development of the several of the graphics presented in this dissertation. I will always be extremely grateful for his encouragement, for being available at a moment’s notice to provide graphical support, and for being an amazing friend.

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content to disability studies. To Dr. Karen Irving, my primary advisor, for her support through my entire doctoral program, and most importantly through the planning and implementation of this dissertation project. Having offered an opportunity to assist in her research project, which would have allowed me to complete the program much more quickly, Karen saw the value and importance of my research ideas and provided a wealth of encouragement and guidance to help me succeed. She was always available to provide firm, often parental, advice when I needed “straightening up” and offered thorough and effective feedback through the modification of my unique writing style. The end result was a collaborative effort that enabled me to transform this document into something I am very proud of. I could not have had a better advisor throughout this program.

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Major Field: Education
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Chapter 1: Introduction

Coursework in a traditional post-secondary geology curriculum typically requires completion of a field-based education component. Students are placed in the natural field environment in order to extend their classroom-based learning experiences and to help them learn to formulate scientific interpretations from what they observe in the field. Studying in the field often requires traversing difficult terrain and working within the unpredictable elements of nature. A mere inconvenience for some, these conditions often present a complete barrier for students with mobility impairments. This study addresses the issues of accessibility for students with mobility impairments participating in an undergraduate geology course with field-based education requirements.

Statement of the Problem

The nature of field-based geoscience education is to place students in a natural learning environment that focuses on the earth’s processes while also assisting in obtaining an understanding and appreciation of scale, rate, and the timing of the natural geologic processes in order to increase and stimulate the acquisition of earth science content knowledge (Garrison & Endsley, 2005). The importance of field-based learning experience in the geoscience curriculum is well documented in geoscience education literature (Thrift, 1975; McKenzie, Utgard, & Lisowski, 1986; Orion, 1993; Garrison & Endsley, 2005; Elkins & Elkins, 2007; Potter, Niemitz, & Sak, 2009; Thomas & Roberts, 2009). However, due to the field requirements in undergraduate geoscience education, persons with mobility impairments face multiple barriers to participating in geoscience field courses and obtaining geoscience degrees in higher education (Cooke, Anderson, &
Forrest, 1997; Hall, Healey, & Harrison, 2002; Healey, Roberts, Jenkins, & Leach, 2002; Locke, 2005; Hall & Healey, 2005; Norman, 2002; Stokes & Boyle, 2009). Geoscience educators are failing to recognize the scientific abilities of all men and woman, regardless of their physical conditions. Furthermore, the lack of exposure to career opportunities in the geosciences potentially creates a perception that most geoscience careers do not accommodate graduates with mobility impairments. As a result of this limited accessibility, students with mobility impairments may be less interested in pursuing undergraduate and graduate-level degrees in the geosciences.

Rationale for site selection.

In selecting a field environment for study of accessibility of students with mobility impairments, several sites and geoscience content topics were considered. Included in potential field sites were: highway road-cuts, bedrock quarries, gravel pits, cave and karst systems, and large natural exposures in river and coastal sites. However, a cave site presents a limited spatial environment that would have a direct impact on participants with mobility impairments. Additionally, this subsurface environment would provide the participants an opportunity to observe and analyze the potential link between cave formation processes and the development of a regional karst landscape, and would include studying a much broader environmental topic. Although the participants in this study might have been familiar with some of the above field site examples, few if any would have had physical access to a cave environment. The incorporation of a cave setting provided a completely unique learning environment to assess the construction of content knowledge and the identification of field-related barriers for participants with mobility impairments.
The content and field site focus of this study was the dissolution-formed, dendritic cave and karst system. Caves are an example of an often studied environment in higher education geoscience courses, even though cave and karst geology is not demonstrated as a state or national content priority in the academic standards for secondary education. As such, the public understanding of the environmental impact of cave and karst systems is very limited (Kastning & Kastning, 1999). Other than post-secondary education opportunities, obtaining an understanding of cave and karst features would not occur unless one participates in informal learning opportunities such as independent study, visiting museums, and cave sites open to the public. Additionally, cave and karst features do not occur in every geographic region, which potentially contributes to the lack of public awareness and the development of misconceptions about the environmental importance of cave systems. Few studies have sought to identify the public understanding of common cave knowledge from either formal or informal educational settings (Kastning & Kastning, 1999). This study adds to the literature on the conceptual understanding of cave and karst systems.

Additionally, due to the underground setting and various natural obstacles, cave environments are commonly physically challenging, regardless of one’s physical ability. Thus, this study focused on determining what is commonly misunderstood about cave geology, assessing the personal, social, and environmental barriers related to field-based learning within caves for persons with mobility impairments, and how field site experiences may relate to a stronger understanding of the content than classroom instruction alone.
Assumptions

Prior to this study, the researcher held several pre-conceived assumptions. Due to limited experience with students with mobility impairments, most of what is known personally had been obtained through the disability studies literature and informal second-hand communication with those most closely associated with students with physical disabilities. Although the issue of bias is explained in further detail in Chapter 3, a listing of brief researcher assumptions follows:

- Most geologic field sites (caves in particular) are not easily accessible to persons with mobility impairments.
- Direct field-based geology experience leads to stronger understanding of the content. A lack of observable evidence allows for the construction of content misconceptions.
- With limited opportunities for accommodated field-learning experiences, students with mobility impairments are less interested in courses that have field-based learning requirements.
- An individual’s cognitive ability is independent of their physical ability.

Research Questions

Due to the assumption that most traditional field environments are inaccessible to mobility impaired students, the rationale for this study was to determine how experience in a geologic field environment assists in the overall construction of knowledge for mobility impaired students. The main themes of this study are to discover common cave geology misconceptions and understand how conceptual development and the
construction of knowledge take place through both direct and indirect experiences of a specific geologic phenomenon.

During the design of the study, an assumption was made that typical classroom instruction is not enough. Direct observation and experience within the field environment must supplement classroom instruction for a student to construct a solid understanding of a geologic phenomenon. As a result, this need for enhanced instruction and direct observation generated three specific research objectives aligned to the aforementioned themes. First, an understanding of common geologic misconceptions regarding cave and karst geology needed to be described. Second, the overall effectiveness of experience within a field environment as a means to construct geologic content knowledge must be documented in terms of learning outcomes and other measures of student achievement. Third, effectively evaluating this field experience required an understanding of how students interact with their environment. To do this, the researcher focused the participants’ perceptions of their surroundings in order to understand their lived experience with (and within) a traditional field-site. Assuming that knowledge is independent of one’s physical ability, this study required an understanding of how students with mobility impairments construct geological knowledge in the face of field-related barriers. This exploration was not intended to differentiate them from the rest of society by what they do or do not know, what they can or cannot do, but to accommodate and include them in a field-based course on cave and karst geology.

Based on these research objectives, the following questions are the guiding framework for the study:

1. What are common misconceptions of caves?
2. How does participation in a field geology experience about caves affect the construction of knowledge in students with no experience and limited content knowledge about caves?

3. What types of barriers do students with mobility impairments perceive regarding access to and studying within cave environments?

**Significance of the Study**

Many studies within the sciences have focused first on determining the common misconceptions held by the students and then providing appropriate instruction to modify or deconstruct the incorrect assumptions while reinforcing the scientifically accurate ones (diSessa, 1993; Dykstra, Boyle, & Monarch, 1992; Garnett, Garnett & Hackling, 1995; Kind, 2004; Klymkowsky & Garvin-Doxas, 2008; Trend, 2001; Trundle, Atwood & Christopher, 2007; Vosniadou, 2002). Fewer studies identify misconceptions and focus on the construction of knowledge through direct observation or personal experience of geoscience-specific phenomena (e.g., Bisard, Aron, Francek & Nelson, 1994; Kastning & Kastning, 1999; Lyle-Elkins, 2004; Schoon, 1992; Sibley, 2005). This study adds to the existing body of literature by focusing on direct observational experience and accessibility on cave geology concept attainment and the implications of experience on instruction.

**Accessibility in field-based learning.**

Supported by the National Science Foundation, Opportunities for Enhancing the Diversity in the Geosciences (OEDG) Planning Grant No. 0939645, this investigation identified the effects of geographical, psychological, and societal barriers, and addressed the needs of students with mobility impairments. Also studied was the extent to which
first-hand experience was used as a means to construct an understanding of the environment. This investigation and subsequent discovery informs the geoscience community about the need to promote inclusive and accessible field-based learning opportunities for students from underrepresented groups. This project also continues to broaden the way we currently view inclusive education by enabling students to actively participate in their own learning.

**Definition of Terms**

The following terms are used throughout this dissertation. Definitions for each term have been acquired from a variety of sources and modified to relate to the purposes of this study only.

**Accessibility** – Refers to elements of the environment that allows approach, entrance and use of the facilities and site by persons with physical disabilities (Kennedy, Smith, & Austin, 1991). For the purposes of this study, inaccessibility is the presence of natural and architectural barriers that disallow entrance to or participation in the field site to persons with mobility impairments.

**Barrier** – According to Merriam Webster, a barrier is something immaterial that impedes or separates; an obstacle. Barriers can be physical, economical, environmental, societal and psychological. For persons with physical disabilities, barriers often become amplified.

**Mobility Impairment** – Defined from the participants within this study, a mobility impairment represents any physical condition that prevents an individual from performing a key life activity through movement; conditions that limit one’s ability to use stairs or traverse rough terrain; not due to sensory or psychological impairment. The
movement activity relates to transporting one's body from one place to another. Mobility impairments consist of a non-ambulatory, physical condition requiring the use of a manual or power wheelchair, scooter, walker, cane, crutches or any other mobility device in order to get from one place to another. For individuals with mobility impairments, access may be limited to ramped entrances, elevators, wheelchair lifts, smooth, hard surfaces without sand, gravel, steps, curbs, throw rugs or similar unstable surfaces.

**Personal Assistant** – An individual who assists with personal care and activities of daily living including, but not limited to: attending to the dependent individual’s personal hygiene, dressing, eating, taking medications, laundering clothing and housekeeping needs.

**Usability** – Commonly used interchangeably with accessibility, usability refers to a location or field site that maximizes the opportunity for use by persons with mobility impairments (Kennedy, Smith, & Austin, 1991).

**Summary**

Considerable research has been done regarding the educational importance of geologic field experiences. However, what is lacking in the current literature is the existence of inclusive instruction that accommodates students with physical disabilities participating in field-based learning courses. This study explores the gap between current geologic field-based learning opportunities, accessibility, and inclusion for students with mobility impairments. In the next chapter, a brief review of the literature that aligns to various aspects of this study is presented, as well as a description of the theoretical underpinnings that provide the framework for this current research.
Chapter 2: Review of Literature and Theoretical Framework

This chapter provides a review of the literature related to this dissertation study. Divided into multiple sections, this chapter provides a theoretical overview that develops the framework of the dissertation, drawn from multiple perspectives of constructivism, conceptual change, and experiential education, which are all aligned to the central frame of Transformative Learning Theory (TLT). In addition to the theoretical alignment, the importance of field-based learning is presented along with a discussion of the challenges of access for students with diverse physical abilities. Finally, this chapter concludes with a section describing the content focus of the study: cave and karst systems, while also examining the literature of requirements for making public field sites accessible to visitors.

Centered on the framework of TLT (Mezirow, 1991), this study is also interpreted through the voice of Critical Theory: a study design seeking to establish an emerging theme of emancipation that may be used to affect social or educational change (Mayo, 2007). In this context of change, Critical Theory addresses the social and educational problems of equal access (Freire, 2000) or discrimination (Haymes, 1995; Barton, 1997). In the geosciences, examples of research informed by critical theory are that of Williams and Semken (2011) and Semken and Brandt (2010). The former researchers seek to affect change in educational praxis through challenging the status quo of geoscience teaching. They seek to transform education from static, exclusionary dispensation of facts into a dynamic, inclusive process that connects learners to a specific landscape. The latter study takes on broader societal issues of cultural sustainability. The researchers approach these
problems by calling for the integration of Western science practices with indigenous
culture and knowledge. Semken and Brandt (2010), through applications of place-based
geoscience education, seek to give Native American peoples and their knowledge a voice.

The driving force of the current study was to confront the current constraints of
geoscience field-based accessibility for a commonly marginalized population; a challenge
to the status-quo preconception that some students can perform the traditional
requirements of field geology, while others cannot. Traditional geologic research, such
as the structural history of a region or the evolution of a landscape, rests entirely within
the theoretical framework of scientific empiricism. Quantitative inquiry and scientific
empiricism are both predicated on the notion of a measurable, objective reality and the
ability to replicate experiments and observations. This procedure is commonly referred to
as a scientific method of investigation. Geological research conducted outside of this
theoretical framework of logical empiricism has commonly been rejected by most
practicing geologists, but is beginning to grow in popularity (Feig & Stokes, 2011).

Science investigators have long held a unifying purpose: to discover the truth about a
phenomenon and how it works. Qualitative inquiry also seeks to understand the truth of
a phenomenon, but by contrast, considers problems that are much more detailed,
descriptive and often much less generalizable in nature. Attitudes, perceptions,
individually communicated truths are the data generated by qualitative inquiry (Mason,
2002; Feig, 2011). These data do not lend themselves well to experimental manipulation,
numerical analysis, but offer additional evidence and perspectives of understanding that
quantitative data cannot provide.
The following sections detail the theoretical frame as well as the supplemental paradigms that each plays a role in the development and analysis of this study.

**Construction of Knowledge**

Equilibration, or commonly referred to as self-regulation, is regarded by Piaget as the most fundamental of all four factors of developmental process (Piaget, 1964). Equilibration is the act of knowing. The individual must react intellectually to an external disturbance and cognitively compensate to attain reversibility of the cognitive dissonance (Piaget, 1964). When this new information is introduced, the external experience, or reality, must be integrated, or assimilated into a current structural framework of understanding. Conversely, the theory of accommodation is when the individual is unable to assimilate the experience based on prior knowledge and thus develops a new intellectual framework that will allow cognition to take place. These successions of alternating equilibria and disequilibria are foundational bases of cognitive development (Ginsburg & Opper, 1988). Piaget felt that assimilation and accommodation were a mold and cast of the same cognitive process. “Cognitive adaptation consists of equilibrium between assimilation and accommodation” (Piaget, 1970, p.708). Therefore, during intellectual development, assimilation does not exist without accommodation, and accommodation does not exist without the simultaneous nature of assimilation. Mental equilibrium occurs when information is either assimilated or accommodated according to the learner’s intellectual schema (Ginn, 1995). In order for educational development and understanding to take place, the learner must encounter a sense of cognitive dissonance, or disequilibrium. The new information must then be accommodated to fit current conceptual understandings, or else the new information will
modify the conceptual understanding all together. This equilibration phenomena begins to allow the learner to “make the world make sense” (Block, 1982). Once this structural reorganization takes place, cognition occurs and equilibrium is restored.

Piaget feels that without accommodation, there would be no cognitive change, and assimilation would govern the world. Because of this, one’s own reality would hinder their intellectual development; creating a completely myopic view of the world around them, and the child would not develop any further from the initial stages (Piaget, 1970). In this sense, knowledge development, which can be classified as a derivative of environmental factors, is a social construction of knowledge that advances the intellect through each of the four developmental stages. Thus radical construction of knowledge would only relate to the conservative nature of development, completely subordinate to the constraints of the environment. For accommodation to take place in a social construction of knowledge, equilibrium must occur between external information and internal knowledge structures, defined not by balance between opposing forces, but by self-regulation of these external disturbances (Piaget, 1970).

Regardless of the nature of constructivism (internal or external construction), “[k]nowledge is always the result of a constructive activity, and therefore cannot be transferred to a passive receiver” (von Glasersfeld, 1993). The learner will always develop an understanding for a concept, although they may not have accurate understanding of the content or phenomenon.

[Radical] constructivism drops the requirement that knowledge be ‘true’ in the sense that it should match an objective reality. All it requires of knowledge is that it be viable, in that it fits into the world of the knower’s experience. (von Glasersfeld, 1996)
This is radically constructive in that the material that you are taking in allows you to accommodate your current knowledge in a way that ideally progresses to a more complete understanding of a phenomenon.

Radical constructivism states that knowledge is created individually. Even through a social environment, the end understanding is a direct result of one’s personal experiences and previous knowledge. For students with limited content knowledge about geologic topics or little to no experience of being inside a cave, information is first developed through social interaction and then an understanding is constructed by personally assimilating that information. According to von Glasersfeld, “the function of cognition is adaptive and serves the organization of the experiential world, not the discovery of ontological reality” (1989, p. 182). To the radical constructivist, knowledge is obtained individually, through direct interaction with the world around us. However, radical constructivists believe that there is little truth in the knowledge we construct, and that we cannot possibly know the exact reality of the understanding of a specific constraint. Unfortunately, once developed, this internalized understanding is usually based on incorrect assumptions and solidifies as an incorrect structure of reality which is even more difficult to reverse.

**Modifying Conceptual Understanding**

**Conceptual change theory.**

Conceptual change theory has become a term for learning and instruction from constructivist perspectives (Duit, 1999) in a number of content domains (science, mathematics, etc.) (Vosniadou, 1994), and is also commonly referred to as “weak knowledge restructuring, assimilation or conceptual capture and strong/radical
knowledge restructuring, accommodation or conceptual exchange” (Duit & Treagust, 2003). This theoretical understanding closely corresponds to that of Piaget in which the students strive to reach cognitive equilibrium. Both radical and social constructivist aspects are at play here, forming a weak, or trivial construction of knowledge through social means of informational presentation followed by an internal restructuring of knowledge through assimilation and accommodation.

Conceptual change theory requires an understanding of the student’s perspective of a misaligned concept and then describes a technique to systematically alter this conception to a way that makes the student comfortable with the redirection of this knowledge. The conceptual change approach examines specific areas of cognition and attempts to relate and align processes of learning and development with misaligned content knowledge. These domain-specific approaches should be considered similar rather than opposing to the more general aspects of social constructivist theories of Piaget. The basic understanding of conceptual change is the assumption that domain-specific content knowledge is organized into a relative theoretical structure in which the student can relate. When unfamiliar information or problems are presented, knowledge is structured in the form of naïve theories through weak explanations and predictions. These newly formed explanations enable the student to make sense of everyday phenomena (Hatano & Inagaki, 1994). However, these explanations are usually created and supported through inaccurate understandings. Students, who have minimal exposure to geoscience concepts may have developed internal understandings for this material, through misaligned discussions or personal experiences. Therefore, teachers need to make students’ ideas an explicit part of the instruction. Students need to be assured that
they *can* have a view that is dissimilar to that of the teacher and that their ideas are an important aspect of the community discussion (Hewson, Beeth, & Thorley, 1998). When value is placed on the students’ ideas, conceptions and misconceptions are realized more easily. However, von Glasersfeld (1996) suggests that when a student has struggled to establish an understanding of a topic and provide an initial response, dismissing it as *wrong* is counterproductive, even if the teacher then provides the *correct* rationale. He goes on to state that disregarding the student’s effort will demolish their motivation.

**Transformative Learning Theory**

Transformative Learning Theory (TLT) seeks to examine how individuals learn and make meaning of their experiences (Mezirow, 2000). The major concept of TLT targets understanding an individual’s viewpoint, defined as “the structures of assumptions through which we understand our experiences” (Mezirow, 1997, p. 5). Having primary application in adult cognition, TLT has become the most often researched and discussed theory in adult education (Taylor, 2007).

Primarily a reconstructive theory, TLT focuses on establishing a model to explain the structure, dimensions, and dynamics of the learning process for adult learners (Mezirow, 1991; 1997). Learning takes place through dissonance in prior interpretation to develop a new or revised interpretation of the meaning. TLT proposes that adults learn through engagement and examination of existing beliefs and perspectives. Utilizing critical self-reflection in an attempt to change an individual’s frame of reference, the process of transforming one’s knowledge includes interpreting an experience through its effect on our prior understandings (Mezirow, 2000). Grounded in the nature of human
communication, this theoretical process is considered developmental (Taylor, 2007), aligning to some of the earliest constructive learning theorists.

The following three propositions of TLT, developed by Mezirow (1996, pp.162-163) best align the theory according to the objectives and methodologies of this study (see Mezirow (1996) for a discussion of the nine additional propositions of TLT):

1. Learning is known as a process of using a prior knowledge to create a new or revised interpretation of an experience to guide future understanding.

2. A transformative learning experience involves a transformation of knowledge structures and requires the learner to make an informed and reflective decision to accommodate new experiences.

3. Development in adulthood is a learning process. Competence includes managing the social world as well as the world of personal subjectivity. Learners must develop the ability to negotiate their own purposes, values, and understandings rather than accepting those of society. “This competence can be achieved through becoming more aware and critically reflective of assumptions, and more able to freely and fully participate in discourse and to overcome constraints to taking reflection action.” (Mezirow, 1996, p. 163)

Transformative learning is more than a prescription or plan, and more than an implementation of a series of instructional strategies. It involves an awareness of perspectives over a course of time. Transformative learning means developing a sense of trust in the process, allowing for participants to live with some comfort while on the edge of knowing, in the process of gaining new insight and understanding (Taylor, 2008).

However, the researcher’s role is to help the participants find their edge of meaning. With
this responsibility the researcher must be able to determine the readiness for transformative learning through the engagement in the various data collection methods.

**Reflection.**

Through critical self-reflection, TLT is meant to be comprehensive, transforming problematic frames of reference, sets of fixed expectations, to make individuals more open, reflective, and emotionally capable to change their understanding (Mezirow, 2003). Thus, a primary factor for transformation is providing participants with learning experiences that are direct and personally engaging that stimulate a desire to reflect upon the experience. Reflective dialogue between participants should be a priority in order to transform prior perspectives. Articulating critical reflection is a primary skill in reflecting. Individuals must be able to recall critical thought.

The other factor is how to recognize when the participant is susceptible to a transformative experience (Taylor, 2007). Fostering transformative learning includes paying close attention to participant responses to personal questions. Through questioning, the researcher must be able to identify if the participant has reached a crossroads in their perspective (Taylor, 2007). Fostering transformative learning has happened in a variety of disciplines that help to explain the change in perspective. Most of these studies have been done in formal instructional settings, leaving a need to explore other settings, particularly where instruction occurs more informally, in student-centered environments that are more susceptible to external influences, similar to that of geologic field-based learning.
**Socio-cultural context.**

More recent understandings of research using transformative learning include the use of critical reflection as a catalyst of contextual change (Taylor, 2008). The learning process needs to give more attention to context and the mechanism to make change, importance of relationships in the learning context(s), and broadening the definitional outcome of a perspective transformation.

Context has been identified as an overlooked area of transformative learning. Included in the context is persona and socio-cultural experiences, such as prior life experiences and historical events that hold potential significant in transformative learning. More empirical studies will offer a clearer understanding of context relative to transformative learning experiences. Analyzing the characteristics of transformative outcomes may provide an understanding to what degree the participants in each study were products of the context. Taylor (2007) suggests the following questions to drive such an analysis: how is the influence of context effectively recognized? How might educators foster transformative learning through context? How are transformative experiences affected by historical events in society?

**Interaction and group dynamics.**

A study published by Taylor (1998) emphasizes the importance of participant relationships as an essential factor in a transformative experience. Relationships allow critical discussion and the open sharing of information. Relational qualities include a non-hierarchical group dynamic that includes trust, participation, feedback, shared goals, and authenticity. In a study of peer-based professional development, Eisen (2001) identifies this dynamic as effectively providing support in a non-confrontational, open
environment, where equal ownership of power is perceived, allowing for trust and autonomy between colleagues (Eisen, 2001). Baumgartner (2002) targeted the relationship between transformation and action through the study of individuals identified as HIV positive as they engaged in community service projects. The learning experiences offered a reciprocal benefit for participants, and a perspective transformation of self-worth, community value, and collegiality (Baumgartner, 2002).

**Experiential Education**

Authentic, relevant and meaningful learning occurs through experience (Bell, 1995). However, a major difference exists between experience and learning. To some, experience is an activity with the potential for cognitive, affective, or psychomotor domain outcomes. For others, experience is merely living one’s life (Mezirow, 1991). The views of learning by John Dewey and Kurt Hahn provide the theoretical basis of Experiential Education (Frank, 2004). Dewey and Hahn both felt that learning is in isolation unless the learner takes time to reflect upon the experience in order to gain insight and transfer the insight into one’s life. Experience is a relationship between the individual and their environment, a replicable interaction in which meanings are found (Dewey, 1938). To some, Dewey is regarded as the father of experiential education, viewing education as a process of teaching students how to solve problems (Frank, 2004). Dewey introduced the link between experience and learning and believed that learning and understanding consists of developmental experiences. His view of education is a continual development of experience, interaction with the environment, and application of the present to the future (Brown, 2006). The experience must be useful to the learner.
As discussed previously, transformative learning as a result of an experience is triggered by critical reflection (Mezirow, 1990). Reflection, or cognitive processing, that occurs during or after an experience is the embodiment of experiential learning. This processing, which can be done through individual or group debriefing, offers the opportunity to transfer and apply the learning from the experience, and facilitate change in attitudes and behaviors (Luckner & Nadler, 1995). Debriefing also enhances the experience (Frank, 2004) by providing an opportunity for students to share their different perspectives of an experience with peers in an emotionally safe learning environment. Without the opportunity to debrief and reflect on the experience, the learning potential of an individual’s experience can be lost.

**Field-based learning experience.**

Geospatial awareness in the geologic curriculum with objects, structures and features, events and processes in their natural setting is taught through geologic field experience. The study of geology has developed through the labors of field researchers collecting samples, traversing terrain, taking measurements and drawing maps that many of us have relied upon during our own education. The field has been the home of the “expert practitioner” that encounters and deals with these phenomena (Lonergan & Andresen, 1988).

There is a definite advantage of observing geologic phenomenon in its natural setting as opposed to seeing it as a picture in a textbook or on a screen. The real classroom for an earth science student is outside, hiking over a volcano, chipping rocks, or measuring strike and dip. Then and only then can the student get a real ‘feel’ for the subject. (Thrift, 1975)

Traditional field-based experiences should not be passive, conservative template-style activities. Learning in the field should be process-centered rather than content-
centered to be an effective tool for improving student knowledge and the ability of transfer (Elkins & Elkins, 2007). “The nature of the field trip is a factor in retention, with an active excursion being superior to a passive one” (McKenzie, et al., 1986).

Some skills cannot be taught in the classroom: geologic field techniques, familiarity with regional geomorphology and the nature of field evidence. “The main drawback of field projects is that they are generally very time consuming, but in most cases the value outweighs the shortcomings” (Garrison & Endsley, 2005). Garrison and Endsley (2005) state that the factors of physical activity, synergy and group work in the outdoor setting set the stage for strong team-building and peer mentoring skills as well as overall group trust. Additionally, the effectiveness is boosted because of the enjoyment and meaningful experiences students receive from a well designed field trip (Orion, 1993; Elkins & Elkins, 2007).

Due to the lack of instrumentation techniques available to assess students’ conceptual understanding of basic geoscience knowledge gained through field-based learning, Libarkin and Anderson (2005) developed the Geoscience Concept Inventory (GCI). This study determined that introductory geology classes (n=29) were found to be ineffective at improving conceptual understanding of geoscience content without the use of a field-based component (Libarkin & Anderson, 2005, 2008). Meanwhile, Elkins and Elkins (2007) attempted to study the gains of students’ pre and post-field trip content understanding using the GCI. Assessing the Interdisciplinary Field Program (IFP) at the University of Georgia as well as the GeoJourney program at Bowling Green State University, they found a statistically significant increase in student performance and conceptual understanding as a result of the students’ field experiences (Elkins & Elkins,
Clearly, a need for field study exists, not only for graduate and professional level students, but also for novice learners who will be tomorrow’s professionals.

**Challenges of accessibility in experiential education.**

Traditionally performed outside of laboratory walls, geology studies the interrelationships between natural processes that have shaped the Earth over billions of years. Although there are many sub-disciplines within the geosciences that promote varying levels of accessibility, this science does not lend itself well to those who are physically unable to study beyond a controlled, laboratory or classroom environment. Additionally, students in Ohio coming out of secondary education have less exposure to the geosciences than other disciplines, as a result of graduation requirements in Ohio, large class sizes or teachers unqualified to teach the earth sciences. For students with disabilities, this lack of prior exposure to the earth sciences may be magnified due to not having equal access to field studies within these courses (Locke, 2005).

Substantial evidence exists regarding the importance of student learning in the field (Elkins & Elkins, 2007; Garrison & Endsley, 2005; McKenzie, et al., 1986; Orion, 1993; Potter, et al., 2009; Thomas & Roberts, 2009; Thrift, 1975). According to the academic benchmark statement from the Quality Assurance Agency for Higher Education (QAA) in the United Kingdom, a student obtaining an education in the geosciences must be actively involved in the external world, that “it is impossible for students to develop a satisfactory understanding… without a significant exposure to field based learning and teaching, and the related assessment” (QAA, 2007, an earlier version also found in Hall, Healey, & Harrison, 2002). The benchmark goes on to state that “[d]eveloping field-related practical and research skills is, therefore, essential for students wishing to pursue
careers in [the earth and environmental sciences] (QAA, 2007, paragraph 4.3). Fieldwork discourse develops a student’s team-work, self-management and interpersonal skills; the skills of a professional (QAA, 2007).

However, much less work has been conducted on students with disabilities attempting to learn in the field (Cooke, et al., 1997; Hall, et al., 2002; Hall & Healey, 2005; Healey, et al., 2002; Locke, 2005), and even fewer on field-based education with students with mobility impairments (Norman, 2002; Stokes & Boyle, 2009). In the presence of such challenges of field-based learning, Orion and Hofstein (1994) articulated the concept of Novelty Space: geographic, cognitive and psychological barriers that field students negotiate in the field-based learning process. All students face various aspects of novelty space with respect to their own experiences within field-based learning environments. However, many studies that discuss planning and development of field-based courses present suggestions for preparation under an assumption that all learners are physically able-bodied to perform un-accommodated field-based tasks (Elkins & Elkins, 2007; Garrison & Endsley, 2005; McKenzie, et al., 1986; Orion, 1993; Potter, et al., 2009; Thomas & Roberts, 2009; Thrift, 1975). As a result, the documentation of knowledge construction, that is evident in Orion’s concept of Novelty Space, did not take into account the physical and psychological barriers that are significant to learners with mobility impairments.

Students with disabilities encounter unique challenges in any scientific discipline, yet geoscience remains one of the sciences with the lowest participation levels for persons with disabilities (Locke, 2005). With the emphasis placed on field research at the undergraduate level, persons with various physical ability impairments face profound
barriers to obtaining a higher education in the geosciences. Geologic field study is considered a key component of a well-rounded understanding in geology and earth sciences (e.g., Elkins & Elkins, 2007; Maskall & Stokes, 2008; Riggs, Lieder, & Balliet, 2009). The basic method of classroom instruction is not enough; no analog exists for traversing a landscape (Riggs, et al., 2009).

The first-hand observation and construction of field knowledge is associated with the aspect of *embodied fieldwork* (Nairn, 1999), and is especially important for a novice geology student with limited field knowledge and experience, regardless of their physical ability (Elkins & Elkins, 2007). The embodiment of the fieldwork experience is often represented by the effect that the field experience has on the student, both cognitively and physically. This embodiment is depicted by how the student begins to understand the content and operate as a field practitioner rather than just a student. This requires a physical interaction with the field environment as well as the learning experience. Professional geoscientists maintain that “field competence is an essential skill” for undergraduate geoscience students and should be emphasized as a primary part of the geoscience curriculum (Whitmeyer & Mogk, 2009, p.385). Additionally, geoscience field-based coursework offerings in most geology and earth science departments are reappearing nationwide (American Geologic Institute, 2009; Whitmeyer & Mogk, 2009). The potential revitalization of the importance of field instruction in the geoscience curriculum that had been on a slight decline in recent years, suggests an increased need for accessibility.

A student’s identity within the geosciences may also be profoundly shaped by field study, therefore marginalizing those students who do not fit the able-bodied,
fieldwork identity (Hall, Healey, & Harrison, 2002). Locke (2005) identified a traditional conceptualization of fieldwork that ultimately suggests that “geoscience careers are only for the strong and able-bodied” (Locke, 2005, p. 2). Those students who do not fit this able-bodied profile are therefore marginalized, excluded from traditional geoscience fieldwork (Hall et al., 2002; Hall & Healey, 2005; Nairn, 1999). “Unfortunately, the traditional focus on fieldwork has led to the perception among some faculty and many students that geoscience [field-based education is] only for the strong and able-bodied” (Locke, 2005, p. 2). In order to be fully integrated in the field-learning experiences, all students’ needs must be addressed.

Based on the findings of Hall et al. (2002), an assertion can be made that students with physical disabilities should not be treated as fragile learners, but as collaborative learning partners who can offer an alternative view of reality based on their own perspective. All students have needs, and in order to improve access and opportunities, as well as to increase diversity in the geosciences, all needs must be taken into consideration when preparing inclusive, educational field excursions (Cooke et al., 1997; Healey et al., 2002). Increasing the awareness of barriers to participation by all students will limit the difficulties to overcoming these barriers through the course design process (Healey et al., 2002).

By the year 2000, total college enrollment in the United States approached 15.3 million persons (NCES, 2008). Of that total, 10.6%, or approximately 1.4 million students, reported having a disability of some kind (NCES, 1999; Locke, 2005). The most recent and thorough study documenting the enrollment of geoscience students with disabilities stated that during the 1995-96 school year, the
total U.S. undergraduate enrollment in the geosciences was estimated at 32,932; of this group, only 59 students (0.17%) were identified as disabled (AGI, 2006; Locke, 2005). In 2006, AGI also reported that of all science, technology, engineering and mathematics (STEM) bachelor degree recipients, only 6.45% were individuals documenting some kind of a physical disability (AGI, 2006). Furthermore, as of 2004, only 7% of the science and engineering workforce was composed of persons with disabilities (NSF, 2004). The downside of these figures is that they combine all physical disabilities into one category, and do not categorize a disability that may be a hindrance to one’s mobility. Despite the fact that science education reform is widely accepted (McCarthy, 2005), little research has been conducted to determine how the practice of field-based geologic education can also address the needs of individuals with disabilities. This determination would begin to satisfy the non-discriminatory provisions of the Americans with Disabilities Act of 1990 (P.L. 101-336) and of Section 504 of the Rehabilitation Act of 1973 (P.L. 93-112) (Cooke et al., 1997).

A comparison of the proportions of students with disabilities in the geosciences to the overall college population suggests that students with disabilities are poorly represented in geosciences. This discrepancy represents opportunities to (1) diversify the geoscience student population, (2) improve the inclusiveness of geoscience curricula and (3) explore instructional innovations, particularly with respect to field-based education, which will potentially improve field-based education to all student populations (Cooke et al., 1997; Norman, 2002).
Cave and Karst Systems

Caves are an often forgotten aspect of the natural environment. Few well-known caves are open for public viewing, thus rendering opportunities to learn about such attractions limited. Because of the geophysical and lithological requirements necessary for formation, caves are not equally dispersed throughout all geographic regions. Although some instances of cave formation in central Ohio exist, few locations are open for public access. The significance of the environmental impact that cave and karst systems have on the adjacent regions provide rationale for raising public awareness and promoting the instruction of content presented in this study.

Public standards for access.

To experience such geologic environments, participants are required to travel to locations that are not easily accessed. This experience thus resembles the field-based learning environments of a geologic program in higher education. In most geology curricula, fieldwork is primarily designed as an active, physical experience; students go into the field, traverse the landscape, take measurements, collect rock samples and, while navigating the terrain, make first-hand observations of their surroundings. This experience engages multiple senses, yet the overall experience relies heavily on the physical abilities of the student (Hall, et al., 2002). The traditional field-based learning experience is often predicated on a given level of personal mobility and therefore may negatively impact a field learning experience for students with mobility impairments if no modifications of the field instruction exist.
Although work progresses towards providing equal access to all public facilities for persons with physical disabilities, limitations in experience-based educational access still exist for many individuals. According to the Americans with Disabilities Act (ADA) of 1990, Title III states that public facilities that are historic in nature, are only obligated to comply with the provisions of providing accommodations to the "maximum extent feasible" but if compliance to the established standards would "threaten to destroy the historic significance of a feature of the building" then expected provisions could be alternated for lesser standards (ADA, Title III: 42 U.S.C.§ 12181–12189).

In the case of the National Park Service (NPS), a park that was officially established in 1941 would fall within the historical exception of this statute. The historical significance of Mammoth Cave National Park (MCNP) alone would prevent any destruction of the cave structure for the construction of provisions that comply with ADA mandates. The historical and environmental significance of the park’s natural features would be destroyed by the construction necessary to provide such accommodations. Additionally, the financial strain placed on the NPS as a result of compliance to accommodation standards would also fall under the Americans with Disabilities Act Standards for Accessible Design (ADA, 1990; DoJ, 2010). One might reasonably assume that the effort required to bring a facility as large as an entire national park into compliance with these standards may not be "easily accomplished without much difficulty or expense" (42 U.S.C. § 12182(b)(2)(A)(iv)). Because of this, persons with mobility impairments do not have the opportunity to experience all that MCNP has to offer.
Summary

This chapter presented the three primary areas of the design of this study. Graphically illustrated in Figure 2.1, these areas include the participants (students with mobility impairments), the geoscience content (cave and karst systems), and Transformative Learning Theory (TLT). These areas are bound together by the secondary aspects of experiential education and the theories of constructivism and conceptual change. The participants are tied to TLT through constructivism, the ideology that transformative learning occurs through socially constructed experience and reflection. Geoscience content is bound to the participants by the aspect of experiential education; rich, field-based learning best occurs through experience. TLT and content are aligned through the need to conceptually change, or modify prior knowledge structures through the aspect of transformative experiences.

This study contributes to the current body of literature of geoscience education by combining work in experiential, field-based learning with participants not commonly associated with such courses: students with mobility impairments. Additionally, nothing found within the previous literature of Transformative Learning Theory included the study of physically disabled participants.
Chapter 3, of this dissertation, lays out the context as well as important logistical planning involved in the design of this study. An outline of the methods used to obtain the data to support the assertions made in reference to the research questions posed are presented along with a timeline for implementation and data collection. A detailed description of the instruments used accompanied with attention to the validity, reliability and trustworthiness for each is discussed. Additionally, an outline is introduced for preliminary data analysis. Finally, researcher background and bias as it relates to the work of this study is presented.
Chapter 3: Research Methodology

This chapter details the methodologies used to answer three separate research questions. As discussed in the previous chapters, this study documents the lived experiences of six participants with mobility impairments through an undergraduate geology course on cave geology and their perspective of taking part in a field-based learning environment for the first time. The methods described in this chapter were used to illustrate a holistic picture of these participants’ individual perspectives of knowledge construction in the face of physical, psychological and societal barriers, as well as their emerging understanding of the issues of accessibility in field geology.

A reciprocal relationship of knowledge construction was developed between the researcher and the participants throughout this study. The researcher provided in-depth content instruction and an opportunity to experience a field environment previously inaccessible to the general public. The participants provided a glimpse into their reality of barriers and social stigma.

The design of the study was completed by interconnecting theories of constructivism and conceptual change to the framework of Transformative Learning Theory (TLT) and aspects of experiential education. This study was primarily qualitative, but also utilized several quantitative measures in support of the research questions. The quantitative instruments were used primarily to provide evidence for questions one and two of the study by attempting to ascertain common misconceptions regarding cave geology and the construction of content knowledge through the utilized instructional methods. However, the qualitative methods of the study related to all three
of the research questions. The researcher worked with the participants collectively through the entire process of the content instruction, but also took time to discuss more personal issues with them individually, allowing them to describe their experience with accessibility barriers in field-based education. This evidence was used to create rich, detailed case studies related to each of the participants.

The data collected for both of these study segments were analyzed through the paradigms of positivism (testable knowledge), interpretivism (evaluation through researcher perspective), deconstructivism (challenging perspective through new experiences) and hints of both grounded and critical theories (establishing an emerging theme and providing an emancipatory perspective between populations of mixed physical abilities). Utilizing these multiple paradigms of analysis provided the freedom to let emerging themes appear within the data. According to Lather (1996), rich data analysis can be limited by settling on a specific paradigm. In order to appropriately answer each specific question, the use of any one paradigm should be temporary.

This chapter describes and provides rationale for the selection of the sample population and details the context, and instructional setting of the study. Quantitative instruments and measures used are listed and annotated, followed by a description of their validity and reliability. Qualitative measures are also listed and accompanied by a discussion of their trustworthiness and credibility. The chapter concludes with a brief overview of the expected data analysis techniques and the role, background and potential biases of the researcher.
Participants

Sample characteristics.

As with most qualitative studies, the population size of the present investigation was small (n=6). With a mobility-impaired requirement to take part in this study, obtaining a large sample is difficult. However, several reasons suggest the value of selecting students with mobility impairments to participate in this study. First, it may be possible that students with mobility impairments are not likely to pursue a higher education in the geosciences because of the field-based learning requirements in most undergraduate geology courses. Second, in Ohio, earth science is not a core requirement for high school graduation; most earth science content knowledge is acquired in the eighth grade curriculum. Finally, because of the lack of wheelchair accessibility, the potential for any of these participants having prior experience inside of a cave was unlikely. Due to limited accessibility that will potentially prevent first-hand experiences and the perception that most students possess minimal prior content knowledge, individuals with mobility impairments produce an ideal sample population when assessing content knowledge acquisition over the term of the study. Therefore, visiting this field site was a novel experience for these participants, yielding authentic, richly descriptive qualitative data about the value of field-based learning. The following is a demographic breakdown of the six participants involved in the current study.

- Six participants with mobility impairments
  - 5 congenital, 1 acquired
  - 3 female, 3 male
  - Ages 19-44 (average of 21 without outlier)
  - 5 undergraduate, 1 graduate
  - 3 white, 2 African American, 1 Asian
  - No science majors
Obtaining access and consent.

Initial contact regarding the project was made between the researcher and the staff from the Office of Disability Services (ODS) at WSU in the autumn of 2009. As a result of this meeting, and subsequent meetings with the Project Coordinator for the Ohio STEM Ability Alliance (OSAA), details about the participant characteristics and eligibility to participate were defined. After nearly four months of study and course design as well as the logistical planning of the field experience with the ODS and OSAA staff, participants were then identified through this collaboration. All participants in this study were enrolled in Earth and Environmental Sciences (EES) 199: Introduction to Cave and Karst Systems, which for the purposes of this study, was only offered to students registered with ODS and their personal assistants. The researcher obtained access to these students as a result of being a co-instructor for the geology course. Recruitment for the study was conducted and consent was obtained with the forms found in Appendices A, B and C.

The process that determined participant eligibility included the following:

- Mobility impaired, registered with the University Office of Disability Services (ODS) OR a personal assistant to a student registered with ODS
- Must be in good academic standing
- Enrollment in EES 199

Maintaining anonymity.

For the qualitative data collection, participants agreed to have portions of the study audio-taped, and thus trusted the use of these materials solely to the research project. To protect the identity and anonymity of the participants and those involved in
the study, pseudonyms have been used for the narrative sections of the data analysis which include focus group discussions, individual interview data as well as researcher observations and reflections. Often, current events or unanticipated changes in the personal lives of the participants interfere with the validity of the research study. Therefore, without revealing personally degrading information about the participants, the researcher must include aspects of any such occurrences that would potentially affect the outcome of the study. Thus, peer and participant review of researcher interpretations and observations were conducted to ensure both interpretive authenticity as well as ethical consideration of personal and private information.

**Context and Setting of the Study**

The study was conducted within Earth and Environmental Science (EES) 199, a 2-credit hour, pass/fail course, with an instructor-of-record from the EES department at Wright State University (WSU). The EES 199 course schedule, which included three 3-hour classroom sessions at WSU and a 3-day, 2-night field trip to Mammoth Cave National Park (MCNP) is found in Appendix D. Two options for completing the course included: participants could choose to attend the field-trip to Kentucky, or to complete a research project of a similar time requirement. However, none of the participants chose to complete a research project versus the field trip. The following sections detail the field site and logistical planning of the case study portion of the study.

**The field site.**

Throughout the instructional portion of the study, participants learned about cave and karst systems. During the field site visit, participants were taken to three primary locations, labeled in Figure 3.1, also included in Appendix E, in and around the MCNP
region to observe the cave and karst system first-hand. These stops included the sinkhole plain overlook from Park Mammoth Hotel (Stop #1), River Styx Spring at the Green River (Stop #2), and Cleveland Pass, level C of the Mammoth Cave system. From these three locations, the participants were able to observe how water travels through the three primary variables of the formation of a terrestrial cave and karst system: the recharge area of the sinkhole plain where the water enters the system; the cave passageways through which the water flows and carves the sediment as it travels, driven by gravity to the water table; and the discharge area where the water flows into the river, the lowest point in the system.

![Image credit: Cave Research Foundation](image)

Figure 3.1. Field trip stop locations within the regional cross section of the field site.

MCNP can be described as one of the world’s most fascinating places for both detailing a component of Earth’s history as well as recent human history. This cave system, which is considered the longest in the world, contains well-preserved evidence from past civilizations as well as the early history of the United States. This location is utilized by many research and educational institutions for the vast learning opportunities it possesses. In fact, MCNP, and the surrounding region are the primary foci for one of the field courses at OSU in cave and karst processes within the School of Earth Sciences
This region is also commonly used by the EES department at WSU. However, as with many field intensive courses, accessibility issues with this excursion excludes many mobility impaired students from taking part in the course. These students face challenges of descending stairs, negotiating very narrow passages, and traversing rough terrain that covers a significant portion of the cave floor that ultimately prevents them from taking part in all that this environment has to offer. Because of this, the likelihood that the current participants would consider taking part in this field course was low.

**Logistical planning.**

When planning a geologic field trip, detailed contingency plans and safety procedures should be in place ahead of departure. Due to the various physical abilities of the sample population, every precaution was taken to ensure their safety and psychological well-being. The planning for this research study began one and one-half years prior to selection of the participants. An annotated timeline detailing the thorough communication between the researcher and the field site is provided in Appendix F. This section discusses the logistical planning and safety considerations appropriate for the field site instruction.

Before soliciting participation from the sample population, an initial planning trip to MCNP was necessary. Participating in this overnight trip were the researcher, the Project Coordinator of OSAA, who served as the Ability Advisor during the entire study, the Director of Disability Services at WSU, and two personal assistants for participants with mobility impairments. The purpose of this trip was to solicit professional advice regarding the accessibility of the field locations and lodging during the field-based instruction. This trip was designed with three primary objectives. The first objective was
to identify and reduce many potential physical barriers that would limit the participants’ access to the field site. Next, alternative sites needed to be located to substitute for inaccessible areas which were unable to be appropriately accommodated due to environmental barriers. Finally, the initial planning trip was meant to assure the participants that preliminary investigation of the field site’s accessibility was conducted by articulating to them the potential barriers they would encounter. The major success of this preliminary excursion came as a result of the Director of ODS being mobility impaired. Through his personal experiences and perspective on this trip, participants were assured of the researcher’s credibility in planning the field-based instruction. The Recruitment Flyer, previously mentioned in this chapter and found in Appendix A, as well as the Pre-Trip Logistics Checklist (Appendix G) and the Suggested Participant Packing List (Appendix H) were all developed following this preliminary planning trip. Prior to departing for the field site visit, the participants were also required to complete and submit the Participant Information form (Appendix I), which provides the individual’s emergency contact and medical provider information.

**Instruction and Data Collection**

The study was conducted during the winter, spring and summer quarters of the 2009-2010 academic school-year. According to the Data Planning Matrix (Table 3.1), the process of data collection was broken down into three basic informational gathering questions. This graphic organizer was used to locate the multiple data sources needed to respond to the three research questions of this study. These sources included quantitative assessments of content knowledge, motivational and attitudinal measures to respond to the first research question. Questions two and three were answered through
focus group and individual, semi-structured and open-ended interviews, reflective and reflexive journals, observations and documents from course activities, as well as portions of the previous quantitative measures. Additional follow-up interview, member checks and delayed post-assessment data were collected following the main instructional segment of the study to provide a level of trustworthiness and additional comparative information.

Table 3.1. Data Planning Matrix

<table>
<thead>
<tr>
<th>What do I need to know?</th>
<th>Why do I need to know this?</th>
<th>What kind of data will answer the questions?</th>
<th>Where to find these data?</th>
<th>Timeline for acquisition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Determining the common misconceptions of cave and karst geology</td>
<td>· Design of geology course delivery</td>
<td>· Quantitative · Qualitative</td>
<td>· GCI* · Pilot CKAA** · Interviews · Observations</td>
<td>· April - May · August for post-assessments</td>
</tr>
<tr>
<td></td>
<td>· Modification of the Cave Knowledge and Attitude Assessment (CKAA) Survey</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The construction of knowledge through a first-hand geologic field experience</td>
<td>· Relates the discovery of common misconceptions to varying instructional strategies</td>
<td>· Quantitative · Qualitative</td>
<td>· GCI* · Pilot CKAA** · Interviews · Observations</td>
<td>· May</td>
</tr>
<tr>
<td>The perception of field-related barriers among mobility-impaired students</td>
<td>· To develop a thick descriptive case study narrative</td>
<td>· Quantitative · Qualitative</td>
<td>· Interviews · Observations · SMQ***</td>
<td>· April - May · August for post-assessments/ interviews</td>
</tr>
</tbody>
</table>

*Geoscience Concept Inventory  
**Cave Knowledge and Attitude Assessment  
***Science Motivation Questionnaire

**Timeline.**

The planning phase of this study began in late summer, 2009, with conferences being set between researchers and staff of the Ohio STEM Ability Alliance (OSAA): a National Science Foundation supported Research in Disability Education (RDE) project
between OSU and WSU. As a result of this early collaboration, relationships were forged between projects that strengthened the foundational development of the EES 199 course as well as the rationale for the identification of potential participants within the course and research study. Found in Appendix J, the syllabus for the EES 199 course was approved in late February, 2010, and the participants were identified through OSAA in mid March, 2010. The primary collection of data occurred during the course of five weeks between April and May, 2010, in association with the EES 199 course. The course met on three consecutive Friday evenings for three hours each, and concluded during a three-day, two-night field site visit to MCNP in the second weekend of May, 2010.

Additional data collection after the conclusion of the course was conducted for follow-up interviews, clarifying member checks, delayed post-assessments and surveys. Table 3.2 details the data that relates to each specific research question as well as the time frame for collection.

### Table 3.2. Timeline of Data Collection

<table>
<thead>
<tr>
<th>Day</th>
<th>Topic</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.7.2010</td>
<td>Personal Demographic Form</td>
<td>WSU</td>
</tr>
<tr>
<td></td>
<td>SMQ pre-assessment</td>
<td></td>
</tr>
<tr>
<td>4.9.2010</td>
<td>GCI pre-assessment</td>
<td>WSU</td>
</tr>
<tr>
<td></td>
<td>Student Journal Entry #1</td>
<td></td>
</tr>
<tr>
<td>4.16.2010</td>
<td>CKAA pre-assessment</td>
<td>WSU</td>
</tr>
<tr>
<td></td>
<td>Student Journal Entry #2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Individual interview: (Participants 1, 2, 3)</td>
<td></td>
</tr>
<tr>
<td>4.23.2010</td>
<td>GCI post-assessment</td>
<td>WSU</td>
</tr>
<tr>
<td></td>
<td>Student Journal Entry #3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Individual interview: (Participant 4)</td>
<td></td>
</tr>
<tr>
<td>4.26.2010</td>
<td>Individual interview: (Participants 5, 6)</td>
<td>WSU</td>
</tr>
<tr>
<td>4.30.2010</td>
<td>Individual interview: (Participants 1, 2, 3)</td>
<td>WSU</td>
</tr>
<tr>
<td>5.3.2010</td>
<td>Individual interview: (Participants 5, 6, 4)</td>
<td>WSU</td>
</tr>
</tbody>
</table>

Continued
Table 3.2 Continued

<table>
<thead>
<tr>
<th>Day</th>
<th>Topic</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>EES 199 Field Site Portion</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.7.2010</td>
<td>Student Journal Entry #4</td>
<td>MCNP</td>
</tr>
<tr>
<td>5.8.2010</td>
<td>Focus Group Interview #1</td>
<td>MCNP</td>
</tr>
<tr>
<td></td>
<td>Cave mapping exercise</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Student Journal Entry #5</td>
<td></td>
</tr>
<tr>
<td>5.9.2010</td>
<td>Focus Group Interview #2</td>
<td>MCNP</td>
</tr>
<tr>
<td><strong>Post Course Data Collection</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.11.2010</td>
<td>Student Journal Entry #6</td>
<td>WSU</td>
</tr>
<tr>
<td></td>
<td>SMQ post-assessment</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CKAA post-assessment</td>
<td></td>
</tr>
<tr>
<td>5.21.2010</td>
<td>Focus group Interview #3</td>
<td>WSU</td>
</tr>
<tr>
<td>6.10.2010</td>
<td>GCI delayed post-assessment</td>
<td>WSU</td>
</tr>
</tbody>
</table>

**Quantitative instruments.**

The following instruments were used primarily to obtain a quantifiable data set for the purpose of comparison between pre, post and delayed-post assessment measures. Below are descriptions of each instrument. This study’s strength and credibility can be addressed through the use of a mixed-method design that involves triangulating data sources. Validity of the quantitative measures included using two previously validated instruments, the Geoscience Concept Inventory (Libarkin and Anderson 2005) and the Science Motivation Questionnaire (Glynn & Koballa, 2006; Glynn, Taasoobshirazi, & Brickman, 2009) that have both undergone rigorous examination through separate research designs in previous studies. An additional third measure was developed for this study and continues to be assessed for validity through multiple iterations of content legitimacy and contextual understanding through pilot testing over a diverse control group population of undergraduate psychology students. A detailed discussion of each instrument’s validity is included with the following descriptions of each.
Modified Geoscience Concept Inventory (mGCI).

The GCI is a 73-question earth science content assessment tool, currently in its second generation of modifications, grounded in alternative conceptions research from Libarkin and Anderson (2005; 2008). For this study, the modified version of the GCI, located in Appendix K, is a 25-question subset of the full GCI. This assessment consists of text and diagram-based multiple-choice questions used to evaluate student conceptions of topics relative to the content presented during the instructional segments of the study: plate tectonics, rock cycle, hydrologic cycle, geologic time scale. An additional five Likert-type response questions were added to the mGCI by the researcher to elicit a level of participant knowledge specific to cave and karst features. This assessment was administered three times during the study: once at the beginning, again after the classroom instruction and then one month following the field site visit.

Instrument validity and reliability.

The GCI instrument has been subjected to several assessments of validity and reliability. Table 3.3, provided with credit to Libarkin and Anderson (2008), details the most recent version of the instrument validity and reliability testing of the GCI.

Table 3.3. Validity and Reliability Measures Used in GCI Development

<table>
<thead>
<tr>
<th>Validity/Reliability</th>
<th>Exemplar Question</th>
<th>Example of method used for GCI development</th>
</tr>
</thead>
</table>
| Construct Validity   | Is there strong support for content of items? | 1) Multi-method: GCI stems and items are based upon large interview data set (n=75) and questionnaires (n=1000); items developed naturally from data (grounded); Think-Aloud interviews with students  
2) Multi-trait: Each concept covered by multiple questions |

Continued
Table 3.3 Continued

<table>
<thead>
<tr>
<th>Validity/Reliability</th>
<th>Exemplar Question</th>
<th>Example of method used for GCI development</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content (Face) Validity</td>
<td>Do items actually measure conceptions related to “geoscience”?</td>
<td>1) Review of each question by 3-10 geologists/science educators</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2) Review of revised items by 10 to 21 faculty for content and correctness of responses</td>
</tr>
<tr>
<td>Criterion Validity</td>
<td>Correlation between GCI and other measures?</td>
<td>1) Trends in quantitative GCI data correlate strongly with conceptions revealed in qualitative data</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2) Preliminary GCI 15-item sub-test results show correlation between sub-tests</td>
</tr>
<tr>
<td>External Validity</td>
<td>Are results generalizable to other populations?</td>
<td>1) Piloting with wide range of students from 49 institutions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2) Calculation of bias relative to gender and/or ethnicity of subjects via differential item functioning (DIF); caution with 4 items suggested by Mantel-Haenszel DIF approximation.</td>
</tr>
<tr>
<td>Internal Validity</td>
<td>Random sample? Do researcher expectations or actions bias results?</td>
<td>1) Items were reviewed by experts in both geology and education</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2) GCI administered by participating faculty; no administration bias on part of GCI developers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3) Rasch scales are very similar for pre- and post-tests, suggesting that student attrition and changes made to items during revision do not affect stability of questions on Rasch scale.</td>
</tr>
<tr>
<td>Reliability (repeatability)</td>
<td>One example: Are test results repeatable?</td>
<td>1) Administration to multiple populations yielded similar results</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2) Classical reliability and Rasch scale stability</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3) Internal consistency of items (KR-20) = 0.69</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4) The item separation reliability of Rasch scale = 0.99</td>
</tr>
</tbody>
</table>

(Table 3.3 credit: Libarkin and Anderson, 2008)

*Modified Science Motivation Questionnaire (mSMQ).*

The Science Motivation Questionnaire (SMQ) is used to analyze the aspects of participants’ motivation of learning science (Glynn & Koballa, 2006; Glynn, Taasoobshirazi, & Brickman, 2009). A modified version of the SMQ, located in Appendix L, was used in an attempt to correlate the participants’ motivation to learn science to their personal perspective data obtained throughout the study. The slight modifications of the original SMQ were within the text of several questions; substituting the words “science test” with “science,” and then modifying the grammar of each
changed text accordingly. This 30-question Likert-scale survey was administered to the participants through an online survey tool before the course began and once again after the field site visit to also determine if a change in their science-based motivation occurred as a result of the content instruction.

**Instrument validity and reliability.**

Following the parameters of DeVellis (2003) and Bradburn, Sudman, and Wansink (2004), the 30-item SMQ (Glynn & Koballa, 2006) was developed based on five constructs selected from a potential inventory of 87 items that most represented each of the six motivational components. These items were developed according to several factors, including (1) the literature based on six motivational components that influence self-regulatory learning, (2) interviews and focus groups with both science and nonscience majors, and (3) an item selection committee of four science educators. The instrument was initially tested with both science and nonscience majors and found to be reliable and valid. Additional evidence of the reliability of the SMQ items conducted on a sample of nono-science majors indicated a Cronbach coefficient alpha of 0.93 (Glynn et al., 2009).

**Cave Knowledge and Attitude Assessment (CKAA).**

Through examination of the literature surrounding geoscience education involving cave and karst content, little was found regarding preconceived content knowledge and public understanding. To approach the study of this question, conversations were held with the Educational Outreach coordinator of the National Cave and Karst Research Institute (NCKRI) in Carlsbad, NM. With the assistance of the Educational Outreach coordinator at NCKRI, a *frequently asked questions* document was obtained from a
prominent national cave and karst site in South Dakota, which was developed over many years of visitors’ questions during public cave tours. This document provided a starting point in obtaining evidence for this research objective in that it guided the initial development of the Cave Knowledge and Attitude Assessment (CKAA).

The CKAA was designed to enhance the investigation regarding the impact of experience on the construction of knowledge. This researcher-designed survey defined and quantified a difference between experience, content knowledge, and attitude regarding cave geology exploration. The purpose of this survey was to assess experience, attitude, and content knowledge of individuals who have never had a direct field experience in a cave geology environment. The original survey, found in Appendix M, was presented in four distinct sections: demographics (that allowed the participants to remain anonymous), experience, attitude, and content questions regarding cave geology. Before deployment, the questions were presented to a validation committee of 12 individuals to evaluate the accuracy of the content. This committee was composed of geoscience and education professionals as well as graduate students in geology, science, and mathematics education.

The survey was divided into the two different question styles: Likert-scale and multiple choice response questions. There were 25 Likert-scale questions and five multiple choice/true-false hybrid questions. The five multiple choice hybrid questions were very specific in content assessment. However, the way in which these items were coded in Differential Item Functioning (DIF) analysis did not provide a reliable measure. The hybrid questions were rewritten using the Likert-scale response design for future use of the piloted instrument. The Likert questions measured attitude (fear of caves) as well
as basic content of cave geology. Based on demographic data available, the initial pilot also investigated the significance of any potential relationships between gender and content knowledge.

Once developed, this early survey was piloted with 37 participants, referred to as Validation Group 1 in Table 3.4, as part of a quantitative instrumentation course at OSU. As a result of the Validation Group 1 pilot, an updated version of the CKAA, provided in Appendix N, was revised and redeployed for a second round of reliability and validity testing. Two separate sample groups were included in the redeployment of the instrument: the Experimental Group and Validation Group 2. The Experimental Group consisted of the six participants who consented to this dissertation study. The Validation Group 2 sample consisted of students enrolled in an undergraduate psychology course at WSU. A more detailed description of this sample is provided in the Sample Population section below.

Timeline.

The entire time frame for the instrument development and validation was during the entire 2009-2010 school year, as shown in Table 3.4. Planning and development occurred early during the autumn of 2009, followed by an initial pilot administration of the instrument to Validation Group 1. Revisions to the instrument occurred during the winter of 2010, to be administered to the Experimental Group during the spring of 2010. The instrument was again deployed during the summer quarter of 2010 to Validation Group 2.
Table 3.4. CKAA Validation Deployment Timeline

<table>
<thead>
<tr>
<th>Group</th>
<th>Location</th>
<th>Timeline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Validation Group 1</td>
<td>Online</td>
<td>October 2009</td>
</tr>
<tr>
<td>Experimental Group - Pre-test</td>
<td>Classroom</td>
<td>April 2010</td>
</tr>
<tr>
<td>Experimental Group - Post-test</td>
<td>Field Site</td>
<td>May 2010</td>
</tr>
<tr>
<td>Validation Group 2</td>
<td>Classroom</td>
<td>August 2010</td>
</tr>
</tbody>
</table>

Sample population.

For the development of the content knowledge assessment used in this study, multiple samples were used along with multiple test iterations. The Validation Group 2 sample (n=163) of students were enrolled in a first year Psychology course at WSU. The rationale for utilizing this validation group included multiple reasons. One reason for employing this sample was that it would have been difficult to find a single sample with enough participants of the same demographic population (mobility impairments) needed for appropriate validation of the instrument. In addition, selecting a sample group from a general education required course increased the overall diversity of the total respondents, strengthening the validation of the instrument by generalizing to a representative population of college students.

Obtaining access to sample.

The process to gain access and obtain consent for the Validation Group was quite different than the Experimental Group. Participant eligibility was based solely on their enrollment in coursework at WSU. Access was obtained with the assistance of their course instructor. Consent was obtained by asking the participants to complete the
assessment. A completed assessment constituted informed consent for this portion of the study. These participants were not utilized in any other aspect of the research study.

Maintaining anonymity.

Participants completing the content knowledge assessment were not requested to provide any identifiable information. Therefore, anonymity was easily maintained for this sample group.

Context and setting.

The context was the completion of the CKAA survey instrument. The setting of this portion of the study was the classroom where each participant completed the survey.

Instrument validity and reliability.

An objective of this study was to respond to the participants’ cave knowledge and personal attitude regarding cave exploration. However, no instrument was available that measured such a narrow topic. Therefore, a secondary focus of this dissertation centered on the development of an instrument to collect data for this objective. Once developed, the instrument needed to be validated. The six participants involved in the study would not provide enough data to begin validating the instrument. More respondents were needed.

A request was made through the Psychology department at Wright State University to obtain a generalized sample population, to be used solely for instrument validation, with similar demographics to the experimental group participants. As a result, permission was granted to administer the CKAA to a group of 163 first-year Psychology students. As a university-wide general education requirement, administering the instrument to this class provided a widely generalized audience: a diverse academic
population with the potential of wide-ranging personal experiences. While this was still significantly lower than the necessary number of respondents needed to validate a 45-question instrument, these data were useful for the beginning stages of the validation process.

In order to collect and analyze responses quickly, Scantron answer sheets were used. However, many forms were completed with missing demographic information, skipped questions or ineligible responses. For example, if a question only had four choices, A-D, some respondents answered choice E on the Scantron sheet. Or, if no response was provided for question #22, it could not be assumed that the response provided for question #23 was meant for that question, and not the actual response for #22. Any skipped or incorrectly answered questions caused a potential misalignment in all of the following responses provided. In order to maintain statistical reliability, assumptions could not be made to place data in a useable format. Therefore, not all collected data were reliable. As a result, 90 of the 163 completed surveys were removed from the analysis due to potentially unreliable data. In total, 73 complete surveys with no obvious flaws provided the data to validate the instrument.

The CKAA instrument was divided into four sections, the first of which contained four demographic questions. The demographic section responses were tallied and averaged to provide a solid understanding of the validation group population. The total respondents in the control group were 69% female with an average age of 19.6 years. Ethnicity within the group included 7% Asian, 29% Black, 1% Hispanic, 57% White, and 4% classified as Other. Of the respondents, 13% self-reported having a hearing
impairment and 3% indicated being visually impaired. None of the respondents indicated having any type of mobility impairment.

Part B was composed of five questions that measured each individual’s level of experience and understanding with respect to caves. This section queried respondents about first-hand personal experience of caves, second-hand experience through communication with relatives or friends, or indirect experience through the media (books, articles, videos, documentaries, movies, etc.). Each of the five questions was coded for positive and negative response: a one (1) was scored for a “no” response and a two (2) was given to a “yes” response. Once scored, all question responses were tallied and averaged. Thus, on average, the lowest possible experience level is one (1) which would indicate no experience relative to the questions posed. The highest level of experience is a two (2). The overall level of experience for the entire the control group is detailed in Figure 3.2. With an average numerical value of 1.8, the figure is negatively skewed, providing an asymmetric distribution indicative of a high level of overall cave experience within the instrument validation group population.
The next two sections (Parts C & D) of the CKAA were composed of 10 and 25 questions respectively. Part C assessed the individual’s attitude about caves; specifically going into and exploring caves, regardless of experience. However, an assertion can be made that personal experience would also have an impact on one’s attitude about caves and cave exploration. Discussion of this assertion can be found in Chapter 5. Finally, geology content knowledge relative to caves was assessed in Part D. Each section was based on a four-point Likert scale; ranging from strongly agree to strongly disagree.

Each of these two sections were analyzed using the PASW 18™ software. Once the data were organized and placed into the software, an exploratory factor analysis was conducted. Using the Varimax Factor Rotation Method with a Kaiser Normalization, each section was analyzed through multiple factor iterations. Part C was analyzed
through two factors while Part D was analyzed through one, two, three, five and ten factor iterations. According to results found in Table 3.5, the analysis of Part C provided strong evidence for two factors, as expected. The questions in Part C were written to evoke either positive or negative attitude responses to being in and around cave environments, and two factors emerged that reflected this effort. According to the internal consistency measure on the 73 respondents in each of the 10 questions, the Cronbach’s Alpha (α) coefficient (Cronbach, 1951; Zinbarg, Revelle, Yovel, & Li, 2005) indicates that factor #1 (α₁ = enjoy) and factor #2 (α₂ = fear) both appear to be within an acceptable range of measurement reliability (α₁ = .742; α₂ = .780) for participant attitude.

However, upon completion of the analysis for Part D, a determination was made that this section would be best described with one factor. By viewing this section through multiple factors iterations, a variety of statistical themes occurred throughout the section that resulted in no discernable patterns in each of the possible factors. Again looking at Table 3.5, the Cronbach’s Alpha was calculated using both the original participant population (163) and the final population (73) once the usable data were separated from the entire collected data set. Regardless of the number of respondents, the coefficient was calculated to be within acceptable range of measurement reliability (α=.833 for n=163; α=.764 for n=73) for this single factor for all 30 questions.

<table>
<thead>
<tr>
<th>Table 3.5. Factor Analysis Internal Validity for CKAA Parts C and D</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Part C</strong></td>
</tr>
<tr>
<td># of Factors</td>
</tr>
<tr>
<td># of Question Items</td>
</tr>
<tr>
<td># of Participants</td>
</tr>
<tr>
<td>Coefficient Value</td>
</tr>
</tbody>
</table>
Qualitative instruments.

Data trustworthiness was established through inter-rater agreement among multiple dialogue decoders, cross-checks of discourse interpretation with research colleagues, and participant member-checks of thoughts, perceptions and ideas expressed during interviews and journal activities as well as researcher interpretation of these items. A detailed discussion of the credibility and trustworthiness of the qualitative data collection and analysis methods is included with the following descriptions of each.

Demographic information survey.

To obtain initial background information for each participant, a demographic survey (Appendix O) was presented to the participants prior to the start of the first classroom session. This survey was used to provide baseline introductory information about each of the six participants and assist in the development of the case profiles provided in Chapter 4.

Interviews.

Semi-structured, open-ended interviews were conducted at various times during the course of the study. Three individual and three focus group interviews occurred throughout the study. Appendix P details the protocol for all individual and focus group interviews. Interviews were conducted based on topics relating to science learning, perceptions of science, geology content, and science careers. Additionally, many questions that were posed during the field site visit were grounded (Strauss & Corbin, 1998) in the data collected from the participants prior to the field site visit. The focus group interviews were largely grounded in the collected evidence of the study and conducted for the purpose of obtaining an understanding of the group dynamic for the
activities and experiences during the trip as well as the general overview of the EES 199 course experience.

**Journals.**

In addition to the interviews, participants were required to complete weekly journal entries. Journal prompts (Appendix Q) were provided to serve as a starting point and to narrow the focus of their writing. Participants were encouraged to extend their thinking about topics presented in class while relating their personal experiences and knowledge about these topics to what they experienced during the study.

**Observations.**

During the classroom and field-site instruction, the researcher anticipated several opportunities to observe the group dynamic. Through researcher field notes, field debriefs with personal assistants and instructional staff, observations provided an additional opportunity for data triangulation. The participants worked together throughout many in-class activities and completed a geologic mapping exercise while inside the cave. The following are three types of participant interactions that were observed, along with the data that were obtained from the observations:

- Student-Student interactions – observations of researcher (researcher reflection, journal entries, focus group interviews)
- Student-Instructor interactions – observation of researcher (researcher reflection)
- Student-Personal Assistant interaction – observation of researcher (Personal Assistant focus group discussion)

**Document analysis.**

Documents such as demographic information sheets, participant journals, researcher field notes, and coursework activity samples were analyzed for themes that
align to other data evidence as well as any disconfirming evidence against the themes found in those data sources.

**Data Analysis**

As a result of this mixed-methods study, both quantitative and qualitative data were collected to provide rich evidence to support the research objectives. Three quantitative instruments were used to obtain content knowledge, attitude and motivational information from the participants. The qualitative instruments consisted of participant demographic information, individual and focus group interviews, participant journals and activity documents, and researcher field and observation notes, and peer debriefing data. In the following sections, a description of quantitative and qualitative analysis methods as well a discussion of the measures to ensure credibility and trustworthiness for each instrument and data collection method are presented.

**Quantitative analysis.**

This study utilized three quantitative instruments to measure content knowledge, motivation, and attitudes of the participants. However, the main concern with using quantitative methods on a sample of six participants is that data obtained is not generalizable for larger populations. Although this study deals with a specialized sample population, a sample of six participants does not satisfy the randomization and large participant sampling requirements necessary for generalization. Therefore, unless indicated, all measures were analyzed through comparative analysis and descriptive statistics.

For the mGCI and mSMQ quantitative measures, the experimental group (n= 6) consisted of the study participants, and did not include their personal assistants. No other
comparison measures were conducted for the GCI and SMQ. These assessments were administered to determine if any significant difference was observed within the participant sample. However, the CKAA was also administered to, and compared with a validation group that consisted of a sample population (n≈163) of undergraduate psychology students.

Due to the small experimental group sample size, descriptive statistics were used to analyze the data found in the mGCI assessment and mSMQ survey instruments. These two instruments, which were validated through previous studies (Libarkin & Anderson 2005; Glynn & Koballa, 2006; Glynn et al., 2009), underwent a comparative analysis within the sample to test for significant differences of content knowledge and motivation to learn science between pre, post and delayed-post assessment deployment. Utilizing both the experimental and validation group samples, the CKAA underwent item analysis based on gender, age, race and physical ability. This continued the content and context validation procedures that began during the preliminary pilot deployment of the instrument.

**Qualitative analysis.**

The qualitative data for the study included semi-structured, individual and focus group interviews, participant journals, and researcher observations. All of the interviews and researcher debriefs were audio-recorded, transcribed verbatim and verified for content accuracy before analysis. Data collected were first analyzed through the themes of participant attitude, content knowledge, and experience. Using the NVivo 8™ software, these initial codes were then refined to include axial codes (Strauss & Corbin, 1998), themes that emerged through the combined data sets to include a more defined
meaning of the primary codes. The Coding Scheme, shown in Table 3.6, is divided into three levels to include primary, secondary and tertiary coding themes. Second and third level codes were used to provide a deeper understanding of the qualitative data collected. For example, participant attitude was a primary, a priori coded theme. This theme was broken down into several secondary codes and included aspects of fear, efficacy, contentment, personal reflection, and interest. A third level included a deeper explanation of the fear code, and included aspects of implicit or innate fears experienced by the participant.

Table 3.6. Three Levels of the Qualitative Coding Scheme

| Attitude          | Ability
<table>
<thead>
<tr>
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<tbody>
<tr>
<td></td>
<td>Dependence</td>
</tr>
<tr>
<td>Fear</td>
<td></td>
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<tr>
<td>Implicit</td>
<td>Perceived</td>
</tr>
<tr>
<td>Innate</td>
<td></td>
</tr>
<tr>
<td>Efficacy</td>
<td></td>
</tr>
<tr>
<td>High</td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td></td>
</tr>
<tr>
<td>Contentment</td>
<td>Inter-Relationship/Engagement</td>
</tr>
<tr>
<td>Enjoyment</td>
<td>Peer</td>
</tr>
<tr>
<td>Frustration</td>
<td>Instructor/Research</td>
</tr>
<tr>
<td>Personal Reflection</td>
<td>Environmental</td>
</tr>
<tr>
<td>Past Experiences</td>
<td>Experience</td>
</tr>
<tr>
<td>Present Experiences</td>
<td>Education</td>
</tr>
<tr>
<td>Interest</td>
<td>Knowledge</td>
</tr>
<tr>
<td></td>
<td>Prior</td>
</tr>
<tr>
<td>Prior</td>
<td>Current Study Impact</td>
</tr>
<tr>
<td>Accurate</td>
<td>Family/Friends</td>
</tr>
<tr>
<td>Misconception</td>
<td>Indirect (Media)</td>
</tr>
</tbody>
</table>

The initial qualitative coding scheme was developed from aspects of the research questions. These preliminary codes provided initial evidence from the data sources. Once analysis of the data began, and through discussions with peer coders, initial codes
were redefined and additional codes were implemented to account for new information emerging from the data sources. This strategy provides validity of the coding scheme and minimizes interpretive bias between independent reviewers (reference). The mutually agreed upon Coding Scheme also enhances the trustworthiness for transferability (Lincoln & Guba, 1995) and replication in similar future studies. Descriptions of these codes, found in the final Coding Scheme (Appendix R) were developed through consensus between the researcher and three peer reviewers.

During the qualitative analysis of interview and journal data sources, multiple raters independently reviewed each of the data sources. While not all of the qualitative data were assessed entirely by every reviewer, each data source was overlapped with more than one reviewer. Once the independent coding was completed, the researcher gathered the coded data and calculated a percent agreement of inter-rater reliability for each of the codes in the qualitative data.

Once the coding scheme was modified according to inter-rater agreement, there were 877 codes labeled to as many observations. While not all raters coded every source of qualitative data, each source was coded by at least two reviewers. There were 2640 total observations that were coded by the researcher and three independent reviewers, of which 1894 were considered in agreement. The total percent agreement of the qualitative data was then calculated by dividing the total code agreement by the total number of coded observations. The percent agreement for inter-rater reliability was calculated to be 71.7%, which is considered well within the range of reliability.
**Constant comparative method.**

Although not all were utilized, qualitative data analysis was guided according to Erikson’s (1986) main elements for fieldwork reporting found in Table 3.7.

Table 3.7. Guiding Elements of Fieldwork Reporting

<table>
<thead>
<tr>
<th>Erikson’s Elements of Fieldwork Data Reporting</th>
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<tbody>
<tr>
<td>Empirical assertions</td>
</tr>
<tr>
<td>Analytic narrative vignettes</td>
</tr>
<tr>
<td>Quotes from field notes</td>
</tr>
<tr>
<td>Quotes from interviews</td>
</tr>
</tbody>
</table>

The elements used included quotes from interviews and field notes, interpretive commentary and analytic and narrative vignettes. Through the use of these main elements, a constant comparative method of qualitative analysis was utilized to ascertain any potential alternative interpretations in the data. Interview data were transcribed and analyzed using the preliminary coding themes of participant attitude, content knowledge and experience. These themes guided the analysis early, but allowed for modifications or additional grounded themes to appear.

**Case study design.**

The underlying importance of this study was to elicit the social construct between the participants and instructional staff and engage in and report the complex representative perspectives that each individual brought to the context of the study (Somekh & Lewin, 2005). In order to fully understand the experiences of the participants in an unfamiliar environment and with limited prior content knowledge, a qualitative case study design was used (Stake, 1995; Yin, 2003). Through the use of the case study
design, thick descriptions of participants, setting and context provide the reader opportunities to make “judgments of transferability” (Lincoln & Guba, 1995, p. 359).

Six case studies were developed based on the six individual participants. A cross-case comparison through methods of analytic induction was used to identify confirming and disconfirming evidence of common themes that reappear across individual cases. Data collected by mixed-methods were used to gain insight into the personal lives and experiences of the six participants, their educational backgrounds, recreational experiences, interests and challenges of accessibility in everyday living. These six cases were constructed from data collected from a demographic survey, semi-structured individual interviews, focus group discussions, participant journaling, and researcher observations and reflections all during the EES 199 course. Additional quantitative data yielded insight into the participants’ motivation to learn science as well as attitudes and conceptual understanding about geology, more specifically pertaining to cave geology.

**Trustworthiness.**

When reporting on qualitative research, steps to ensure the readers’ confidence in the assertions made from all collected data sources are paramount. Lincoln and Guba (1985) suggest that aspects of trustworthiness can be established through the credibility of the findings, the transparency of the researcher’s background and bias, neutrality of analysis and interpretation, as well as replication of the study in other contexts. The following sections articulate how trustworthiness in this study was achieved.

*Researcher background and bias.*

Establishing a sense of researcher neutrality through the reporting of research evidence is inherently important. Various underlying assumptions associated with this
study are potentially attributed to researcher perspective and bias, and therefore must be disclosed. The researcher assumed roles as observer, participant, and instructor, while attempting to remain neutrally objective and minimizing any undue influence of the outcome of the study. With minimal prior knowledge or experience with persons with mobility impairments, the researcher relied on relationships developed with disabilities practitioners, professionals and researchers in disabilities studies. No personal motive for conducting this investigation exists, other than the sincerity of providing a new opportunity to a commonly marginalized population.

The researcher’s background consisted of secondary (grades 7-12) and post-secondary teaching, including teacher education, science and technology methods, and geoscience content and field course instruction. Additional teaching experience includes facilitating online, in-service teacher courses in geology and mentoring pre-service teachers on various aspects of classroom management, pedagogy, and providing accommodations to both high and low-level learners. This previous teaching experience enhanced the geology content delivery of the study by being designed and delivered through a combination of teacher-centered instruction followed by student-centered, guided inquiry using rock samples, raised-relief maps, regional cross-sections, diagrams and images from the MCNP region whenever appropriate. Given the short duration of the classroom portion of the instruction, coupled with the fact that limited prior knowledge of the content was assumed, this instructional method allowed the participants to be active learners, taking full advantage of the opportunity to learn and retain the new material.
Researcher as an instrument.

As in any qualitative study, the data had to be manipulated through the interpretative capabilities of the researcher. In order to collect the desired data, this study required the researcher to both facilitate the research procedures and analyze the data through multiple perspectives and participatory roles. The researcher as an observer documented, among other things, how participants coped with novel situations, how they responded to differences in classroom-based and field-based instruction, and how they navigated physical or psychological barriers. The perspective of this role in the present study was used to generate data through both passive and active processes. Passive observations and student journaling coupled with more active individual interviews, focus-group discussions and instructor-participant interactions yielded the necessary descriptive qualitative data needed to respond to the primary research objectives.

The current study also required the researcher to serve as a participant in an attempt to understand the educational experience for students with mobility impairments, and to actively document the efficacy and impact of that experience. Prior to the commencement of the study, understanding the participants’ physical circumstances and personal needs was essential for the researcher to create a learning environment that was most conducive to their educational success. To do so required the instructor to not only serve as a researcher, but also a participant in the research, by conducting a preliminary investigation of the sample population of participants. This early investigation allowed the researcher to improve and accommodate the instructional methods both prior to and during the study. Because of this need for personal learning, the researcher-participant moved back and forth between the roles of a detached observer and active participant in
the research. Without this important component, the participants would undoubtedly focus on the unknown aspects of the study and concerns of mobility and potentially struggle to transfer the content being presented.

*Credibility.*

Credibility was established through prolonged engagement with the participant sample population, triangulation of the collected sources of data, and efforts to establish transferability (Lincoln and Guba, 1985).

Prolonged engagement requires a researcher to be involved in a population long enough to understand the culture of the group as well as obtain a significant amount of trust from the participants. Although time spent with the participants totaled nearly five weeks, from start to finish, the time spent understanding the culture and needs of the participants was significantly longer, resulting in increased levels of trust from the beginning of the study. Obtaining trust within the participant group is a “developmental process…to demonstrate to the respondents that their confidences will not be used against them...that the interests of the respondents will be honored…and [they will] have input into, and actually influence, the inquiry process” (Lincoln and Guba, 1985, p. 303). This trust was established through the efforts of pre-planning the research methods and field site visit and overall description of the study with members of the Office of Disability Services and the Ohio STEM Ability Alliance. Previously discussed in the *Logistical Planning* section of this chapter, presentation of the researcher’s logistical preparedness to the participants became necessary. Providing this information assisted in the establishment of trust between the participants and the researcher.
Research planning began nearly six months before the start of the study through discussions with the OSAA Ability Advisor, who had previously established a trusting relationship with many of the participants through her role as a comprehensive advisor. Because of this pre-planning, the participant sample who agreed to participate in the study were confident of the researcher’s commitment to adequately address their personal needs and also that the accessibility issues of the field site were held in full consideration.

As also briefly mentioned previously in this chapter, additional credibility was established through triangulation of multiple data sources. Information was collected both from the participants and through the observations of the researcher. Those sources included individual and focus group interviews, participant journals, and a demographic survey. An additional method included participant observations and peer debriefing with the OSAA Ability Advisor.

The construct validity of each of the cases was also strengthened through the use of peer and participant review of the draft manuscript (Yin, 2003). Member checks (Lincoln and Guba, 1985) provided credibility of the reported data in the individual case profiles. The pre-study planning discussions also became a form of preliminary member-checking with those familiar with disabilities research; to ensure that the study was aligned to the needs of the participants and to ensure that correct assumptions of the participant’s various needs and abilities were being made.

The issue of transferability was accomplished through the presentation of research instruments and planning materials that were used to conduct this study and would be necessary to design and implement a similar study. These materials are all found within the appendices of this dissertation.
Summary

This chapter presented the methodologies associated with the current dissertation study, along with a detailed description of the participants and context. Finally, the analysis of the collected data was discussed. This mixed-methods study provided a wide range of data evidence to support the three research questions, as well as respond to various preliminary research assumptions. In the next chapter, the profiles of each of the six cases are described and data are presented in detail and aligned to support the respective questions.
Chapter 4: Results

This chapter provides the study results for both the individual and collective perspectives of six mobility-impaired participants as obtained from their participation in a field-based undergraduate-level course on cave and karst geology. The issues of accessibility in a traditional geoscience field course was the primary focus of this study, and all six participants were able to take full part in the course that was designed to take them out of the classroom to interact with the content in the physical environment. As such, this chapter also provides an organized overview of the quantitative and qualitative data collected throughout the classroom and field experience. This chapter describes the profiles of the six case studies, and provides a cross-case comparison between the case related to the group dynamics, backgrounds and initial understanding of the content. Following the identification of the case studies, quantitative and qualitative evidence are presented and aligned to each of the research questions individually.

Analysis of Individual Cases

Each of the following cases is presented individually according to background information obtained through various formal data sources and informal conversation. Data used to develop the following cases were collected from all of the previously mentioned collection instruments as well as a demographic survey and through personal conversations and inter-personal interactions between the entire study population. Through the use of pseudonyms, all data presented within this document were completely de-identified to maintain the anonymity of the participants. Additionally, to prevent any assumption of stereotype, race has been purposely removed from the individual profiles.
and only provided as a whole in Chapter 3. Therefore, demographic information was limited to sex, age and physical diagnosis. To maintain credibility and establish an audit trail, all evidence presented was cited according to the individual, data source, and date collected (i.e. Jerry, Interview 1, April 9, 2010).

Case one: Jan.

Jan, the only one of the six who does not use a motorized wheelchair, was a 44 year-old mother of two. She was also the only participant without a congenital disability having obtained her physical impairment as a result of an automobile accident in 1982, which broke her neck when she was 16 years old. Jan was a very independent individual and comfortable following a daily routine within the walls of her own home, which has been modified to increase her overall domestic functionality. However, through indirect conversations, Jan worried about relying on, and being burdensome to others. She was also concerned with the degradation of her physical abilities as a result of her physical inabilities. As such, she refused to use a motorized wheelchair to combat the effects of atrophy in her arms and upper body.

Jan was a quiet, friendly, responsible, and conscientious individual who was also thorough and accurate, paying close attention to details. She was very considerate of those around her, and tried to remember specific or important details about people she was in contact with. Through informal conversations and observing her interacting with others, Jan was noticeably concerned with how others felt and was drawn to fields of study that allowed her to make a difference in the lives of others. Her past experiences seem to have been filled with practicality, focusing on things that have allowed her to work independently. A combination of her personality and interests, though, has led her
to pursue her Bachelor’s degree in Psychology with a focus in Human Factors. She will be able to do work that makes a difference in the lives of others, and her work will be more research and detail oriented than most traditional ‘helping’ professions.

Being a very introverted, sensitive person, Jan preferred to do things herself rather than rely on others simply because it allowed her to keep a more private life. Initially, Jan was very apprehensive to be a part of this study. Not only would she be with a group of people about whom she knew nothing at the time of commitment, but she would also be putting herself in a new and uncomfortable position with this group of people.

As Jan first considered being a part of this study, she was noticeably concerned about needing a Personal Assistant for the trip. Too many unknown variables in a field-based learning environment for her to maintain her current level of independence was the primary cause of apprehension. She discussed that she had been able to lead a very private and modest life, and that she was apprehensive about the idea of having a stranger help her with her personal care (i.e. toileting and morning and evening routines). When others offered to be back up help should she need it, she mentioned that she would not want to ‘put others out’ and be burdensome with random needs. However, Jan was able to have her mother fly up from Florida to accompany her on the trip and become a part of the group. Having a sense of personal comfort with someone she trusted was a major detail for Jan, and having her mother scheduled to be with her allowed her to focus on being an integral part of the group.

Through many informal conversations she clearly preferred to plan for every detail, to want to know what to expect at all times. Prior to the study, a limited amount of information was provided to the participants. Most of the participants involved in this
study were the type to plan ahead for accessibility reasons. Limiting information about the field site was purposely done in an attempt to reduce the amount of prior research they would undoubtedly do leading up to the trip to allow for natural learning experience through instruction. Because of the minimal information provided, Jan personally struggled to commit to this study and considered passing up the opportunity because of the many unknown variables. However, because of Jan’s enjoyment in the sciences and the lack of past opportunities to study in a natural field experience that was developed to be accessible, she agreed to participate in this study.

Prior to her accident, Jan was interested in and considering careers in the sciences. Throughout her education, she had a strong interest in the planetary sciences and chemistry, and had several outdoor science experiences as an able-bodied high school student. Since her accident, however, it was evident that Jan’s priorities changed considerably and she approached more practical career studies. “Before I was in a chair I had a lot of interest in Archeology. Once I had my accident I didn’t consider it anymore. Instead, I tried to find something more practical…something I could do” (Journal Entry, April 16, 2010). She also became a mother, which caused her to also become very altruistic, making sure she didn’t take risks that would jeopardize her responsibility and ability to raise her children. Because of this, Jan was focused on knowing and understanding as much as possible to be comfortable with every likely situation she faced. She was still very concerned to remain highly independent, and not to do anything that over-extended her comfort zone and level of independence for fear of physical harm to herself which would certainly impact her involvement as a parent.
However, the thought of making her boys proud and being a role model for "putting yourself out of your own comfort zone" motivated her and influenced her decision to be a part of the study. In addition, and regardless of her physical abilities, it appeared that she was drawn to the idea of being a part of an opportunity that would positively impact others with mobility impairments, allow her to approach areas of study that became unreachable for her when she acquired her disability and experience something she thought she would never have the chance to experience.

**Case two: Jerrod.**

Jerrod was a highly successful student who has presented at several psychology conferences and performed undergraduate research in the psychology department. He was extremely technologically savvy, an early adopter of the most recent gadgets available. He was a very detail oriented individual who was reliable with getting things done steadily and on schedule. He was drawn to doing research in Human Factors Psychology, and had a strong general science background. With research being a large part of his interest, Jerrod’s desire to be a part of this study was no surprise, and he was one of the first to agree to participate. Not only was he interested in the cave geology itself, but also in playing a role in the process of creating a virtual reality field experience for people with mobility impairments.

Jerrod had been living with Duchenne Muscular Dystrophy since birth, which caused a rapid degeneration of his muscles. As a result, with no use of his legs and very limited strength and use of his arms and hands, he required assistance with daily routines in the morning and evenings. He was extremely mobile, however, through the use of a top-of-the-line power wheelchair that even included elevating him vertically when
needed, a feature that was used often during the field-based learning experience in this study.

His practical and realistic personality as well as being very organized made Jerrod a thorough problem solver, a very valuable trait for someone with significant mobility impairment. Through advance planning, he was able to maintain a high level of independence and find logical solutions to accessibility issues without adding significant stress to his daily routine.

Jerrod planned ahead and tried to identify accessibility concerns before they occurred; however his realistic and logical personality helped him to realize the inevitability of situations that cannot be planned for. Jerrod had done his own accessibility research on Mammoth Cave National Park and the lodging facilities, finding no particular concerns; he also packed his extra wheelchair tire tubing, tool kit, duct tape, and WD40® lubricant.

Jerrod was surrounded by an extremely supportive and educated family unit. The accessibility at his home school district did not allow him to be very involved in extra-curricular activities. He was involved in Boy Scouts, but most of his experiences were a result of family outings. Throughout his youth, he took many trips with his family, including a trip to Grand Canyon National Park, camping, fishing, hunting, even snow and water skiing. Through discussions with Jerrod, he did not remember ever planning a family vacation for accessibility. The destination was always planned ahead of the accessibility of the location. Fostered through the many activities his family made accessible, Jerrod’s flexibility and independence were evident. After years of proving to his parents that he was very capable of identifying and solving problems on his own in an
efficient and thorough manner, Jerrod had become a successful independent problem
solver and an extremely confident young man. This, perhaps, added greatly to his sense
of adventure, and his ability to work around most every barrier he had faced in the past.

Jerrod was one of the fortunate three in the study group to have a parent serve as
his personal assistant. He was even more excited about the opportunity to be a part of
this study and share his experience with his father once he found out the location of the
field site visit.

Mammoth cave especially is on my list of things to do as I have strong family ties
to the exploration of Mammoth Cave. My great-great grandfather discovered
Rapiers pit by traveling into the cave via the Green River in the 1800s. (Jerrod,
Journal 3)

Not only did his father join him on this field-based learning experience trip to Mammoth
Cave National Park, but Jerrod was also joined by his mother on a post-study trip to
present his experiences to the Geological Society of America Annual Meeting in Denver,
Colorado.

**Case three: Jerry.**

Jerry was a 21 year old Political Science major with a minor in Sports
Management. He was an extremely active and athletic individual who enjoyed weight
training and playing adaptive rugby at the university despite being diagnosed with
Charcot-Marie-Tooth (CMT) disease shortly after birth. CMT is a neurological ailment
that is characterized by loss of muscle tissue predominantly in the feet and legs but also
in the hands and arms. Jerry had very little muscle mass in his legs and his forearms, but
stayed involved in and greatly enjoyed activities that required a significant amount of
strength.
A warm, empathetic and responsible individual, responsive to both praise and criticism, and being very attuned to the emotional needs of others made Jerry a great leader and socialite. He had currently declared Political Science as his program of study, which makes sense due to his ability to work easily with others.

Jerry was informed of this study when an instructor for one of his courses made an announcement that there was a unique opportunity to be a part of a study that would make a difference for other students with mobility impairments in the future, and that unfortunately at the current time the study was significantly short on interested participants. Jerry was not only interested in being a part of the study for the benefit of others with disabilities, but the more he learned about the opportunity, the more he saw the importance of being involved in the success of the overall research project. Jerry’s love for being with others likely added to his comfort in being a part of a study in which he would be participating with a group of people unknown to him.

Like many mobility impaired individuals who are unable to walk, Jerry did not come from a home that was modified for accessibility. The cost to do so was simply too significant for many families. Because of this, Jerry was comfortable with climbing stairs unassisted, by walking on his knees or pulling himself up. This made him very independent. However, many who have lived with considerable independence also lacked the desire to venture outside of their comfort zone. Jerry was not a risk taker for the sake of new adventures. He was quite comfortable in the life he was living and was able to negotiate the barriers of an everyday, simple routine. At first meeting, Jerry appeared to be the typical quiet, self-assured, male figure who was quite fearless. He was very familiar with his surroundings and did not deviate from the daily norm, which
allowed for his fearless persona. The problem with this was that any deviation from his typical routine would cause instant stress and fear to arise. Additionally, because of his innate sense of pride, Jerry allowed his ego to get in the way of asking for help, thus worrying about being a burden to others.

**Case four: Jessica.**

Jessica was very independent individual, despite living with Cerebral Palsy, which causes musculoskeletal posture issues, frequent spastic disturbances and greatly affects her ability to communicate clearly. Those who spent a fair amount of time with Jessica commonly found themselves translating for others who were unable to clearly decipher what she was saying. Her clarity was a major concern for her; she was very embarrassed by her difficulty with speaking and how others viewed her because of this. Despite any of this, she was very relaxed and had a great sense of humor.

Jessica assumed responsibility for all of her own personal care, and had very negative opinions regarding the idea of having assistance with personal activities such as showering and toileting. When she discussed her feelings on Personal Assistants, she talked a great deal about modesty and simply being uncomfortable letting someone she hardly knew take part in such private aspects of her daily life.

While growing up, her childhood home was not adapted to her physical needs and thus undoubtedly assisted in the development of her flexibility with trying new things and not being afraid of basic accessibility issues. She had had an entrance ramp into her house for only the past three years. Before this, she would park her chair outside, next to the side-door under the carport and crawl into the house. Her ability to care for herself in situations that many able-bodied people would find challenging, along with her
nonchalant personality made her a perfect candidate for adventurous trips such as this. Jessica’s science background consisted of general biology and chemistry. She had never had physics or geology, but was interested in this trip enough to be interested in geology as well. However, due to accessibility issues, she was never involved in field trips or outdoor learning experiences. Additionally, she did not take many vacations with her family as they were never into camping or enjoying the outdoors. Her only experience of nature occurred during a summer day camp that was designed for children with disabilities, where her most vivid memory was that of floating on the creek in an inner-tube while picking up rocks along the banks and in the shallows.

The researcher’s first impression of Jessica was that she was a very friendly individual. She noticeably enjoyed being in the moment with everything going on around her, whether in class or in public. Through observations of her interactions with others, she valued her personal space and was initially very quiet, but once she became familiar with someone, she was very open, honest, and quick to make friends.

Although she appeared to be loyal to those things she found important, Jessica was a very noncommittal person, struggling to even commit to a field of study. As such, she did not typically plan ahead and was comfortable with taking things as they came. For this reason, Jessica was relatively undaunted by the unknown aspects of the Mammoth Cave trip. However, once she made the decision to participate, she was committed to seeing it through. Like many of the other participants, Jessica was drawn to the idea of being a part of a study that could help others with similar physical abilities, and open a whole new world of scientific study to people with mobility impairments.
Case five: Julie.

Julie, the only graduate student, had the most science content background of the group. Her chosen field of study implements the research necessary to minimize physical barriers for people with disabilities. She had developed clear goals for herself about how to serve the common good and was organized and decisive about how to begin implementing her visions. This general description makes it very clear why Julie was pursuing a career in Human Factors Psychology, and had a particular interest in Social Psychology. She saw this career path allowing her to move towards a greater understanding of people and why they act the way they do. Because of her educational background and interests, she viewed her participation in this study as an experience from a researcher’s perspective rather than a participant. Her comments and reactions, at times, showed evidence of this struggling perspective.

Julie was very intellectual, and sought meaning and connection in ideas, relationships, and material possessions. Through the various conversations and study activities, it became clear that she was very insightful about the perspective of others and was interested in understanding what motivates people. Based on her strong science and mathematics background and work in psychological engineering, as she stated it, she was also very analytical, which was what likely has caused Julie to push her abilities past the assumed limits in order to do her best to keep up with her able-bodied peers. Doing so allowed her to discover a great sense of independence and adventure. However, she discussed that she struggled with how she believed others perceived her and she worked hard to exceed expectations, both internal and external, of this perception to feel accepted as one of the group.
Like most of the other participants, a great deal of Julie’s independence likely came from a desire to be alone and not rely on others beginning at a young age. Growing up in a large adopted family of 13 siblings, all with diverse physical, mental or emotional disabilities, Julie was forced to become as independent as possible, with limited assistance. Thus, a major barrier for Julie was feeling like a nuisance when trying to get her accessibility needs addressed. Julie did not want to be a burden to others, and therefore commonly disregarded her own needs to do the best she could with any given problem or situation rather than have others perceive her as being a needy person.

Julie was very concerned with her physical appearance and how people would look at her. As previously discussed, her most significant barrier was how other people perceived her. She worried about her appearance more in the summer than the winter due to the fact that her arms were more exposed during the summer. Her mobility impairment was caused by Arthrogryposis, a structural condition in which contractures formed due to a lack of space and movement in utero, causing the soft tissue (tendons, joints and muscles) to develop incorrectly and thus limiting joint motion. Her arms and legs were both shortened and she had very limited use of her hands because of the deformation. This condition was not completely hindering; Julie was the only one of the group that can get out of her wheelchair and walk short distances. However, her disability limited her ability to perform various tasks for an extended period of time. For example, standing was often difficult without something to lean on. She was unable to bend easily due to extreme stiffness in joints, some of which had been physically fused because of her condition. Additionally, Julie had Attention Deficit Hyperactivity Disorder (ADHD) which caused her to be very scattered in thought and communication.
with others. Because of this, Julie’s personality was undoubtedly a very colorful addition to the study group.

**Case six: Jason.**

Like Jessica, Jason also lived with Cerebral Palsy. Although Jason’s speech was much clearer, his level of spastic episodes was much higher than Jessica. He needed help with everyday routines including eating and writing. Growing up in a very small town, he was the only mobility impaired student in his school district. However, this didn’t stop him from being a part of the community. He was very involved in Cub Scouts and had many positive experiences playing adaptive sports and being a part of the high school football and track and field teams.

Like many persons with mobility impairments, Jason did not grow up in a home that was accommodated to his needs. He was noticeably very close to his mother and spoke very highly of her whenever she was mentioned in conversation. Jason relied heavily on her both at home and away, giving the impression that the two were a team throughout his youth. Jason and his mother did many things together, and she impressed upon him never to be satisfied unless he obtained what he wanted. “My mom brought me up to fight for what I want. [She] never said no, always said give it a shot, even if it’s only for one time, give it a shot” (Jason, Interview, April 26, 2010). This certainly provided Jason with many life experiences and gave him his current sense of independence. Given the limitations of his mobility, Jason’s mother always provided him with the best experience possible. “My mom would make sure, even if she had to carry me down, she would make sure that I would get to see it” (Jason, Interview, April 26, 2010). When asked if he ever felt that he missed out on any experiences because of his
mobility impairment, he responded “[N]o, not really. Usually with my mom, if we couldn’t find a way to get there, my mom would go in and take pictures and then bring them back out to me” (Jason, Interview, May 3, 2010). His mother joined him on the field study; Jason was one of the three who shared the experience with their parent.

Of all of the participants, Jason was the most warm-hearted, conscientious, and cooperative. Completing tasks through collaborative learning was clearly most enjoyable for him. Evident by his determination and follow-through, Jason needed to be appreciated for who he was and what he could contribute to the other participants. As someone who enjoyed spending time with other people, Jason was a detail oriented individual who cared about the perspective of others, and was consistently organized with advanced planning. He was driven to become a member of the FBI. His choice to pursue a career in Criminal Justice made perfect sense due to his appreciation for organization, rules and authority, and the previously mentioned desire to feel appreciated for contributions to society.

Jason’s interest in science came from having taken many trips with his family to such places as the Center of Science and Innovation (COSI), the Carnegie Science Center, the Smithsonian Museums in Washington DC, Grand Canyon and Yellowstone National Parks as well as having participated in several family vacations to lakes and the ocean. Jason was also very interested in forensic television shows (NCIS, CSI) which, along with several family members in law enforcement, likely contributed to his desire to study Forensics and Criminal Justice. Jason only completed the general science requirement during his secondary education, and none of those courses provided outdoor learning experiences. Because of his interest in being outdoors, the lack of outside
instructional activities proved to be a missed opportunity in his educational experiences. “I like [being] outdoors; I walk in the rain with the hoody and a ball cap on. All I do is cover up my controller and I walk outdoors. I would rather be outdoors” (Jason, Interview, May 3, 2010). Jason’s lack of concern for nature’s elements provided evidence for his flexibility, level of confidence and problem-solving skills, and likely assisted in his overall sense of adventure.

Like Jerrod, Jason has a personality that allowed him to step back and take things one step at a time focusing in on the details. That, in combination with his sense of planning and organization gave him the ability to make adjustments when things did not go as planned. He was successful at handling unexpected situations in a timely manner. His high confidence levels, willingness to act independently, and interest in trying new things dispelled high levels of anxiety in himself and others. This comfort with new and unusual situations was also a reason that Jason was at ease with volunteering for his role in this study.

Initial Cross-Case Comparison of the Experimental Group

A holistic view of the group, revealed both similarities and differences that were of particular interest to the overall perspective of this study. The following sections provide a comparative analysis of the participants, first guided by initial themes of expected evidence and followed by a grounded approach (Strauss and Corbin, 1998) allowing for unanticipated discovery.

Group dynamics.

This section describes the group dynamic as it relates to potential outcomes of the study. In what seemed like an obvious special interest community of students, a mention
should be made that only two of the six aforementioned participants were casually acquainted prior to their involvement the study. At the time of this project, Wright State University was home to over 100 mobility impaired students. With a community this large, it became less obvious that each student would have any interaction with everyone in the community. Even those who were involved in the same program of study were at different levels of progress that prevented their knowing one another. However, once the study began, the group coalesced and formed a strong bond; it was impossible to discern that anyone in this group were ever strangers.

**Physical abilities.**

Although all were living with various physical impairments that limited their mobility, each had different abilities that enabled them to interact and participate in this study. Ranges of abilities including writing and communicating, degree of independence, sense of adventure and levels of fear each had a significant impact on their involvement in the study.

**Initial scientific identity.**

An interesting aspect of the group was that, when asked during the first individual interview, none of them held the perspective that a scientist could be disabled. During the interviews, a question was asked of them what a scientist, in general, looked like to them. Every one of the participants responded with the stereotypical crazy-haired, unorganized male figure with glasses, a lab coat and a full pocket protector (Chambers, 1983). When asked about the physical ability of a scientist, the participants all responded that scientists were able-bodied, but few of the participants hesitated, as if to question themselves on their own physical abilities.
R: What about people in wheelchairs, can they be scientists?
Jessica: Yeah, they can, but at the same time it won’t be very safe.
R: I’ve noticed a lot that when you talk specifically about doing a science, you talk about doing science in a laboratory. What do you think about going out into the field, like going out into nature and collecting data? Do you think that lends itself to accessibility?
Jessica: Yeah, to a certain extent, but you can’t go on the beach; the road has to be paved or like rocks. You can’t go into mud, snow, and sand. (Jessica, Interview 1, April 26, 2010)

When asked for elaboration if her “crazy-haired scientist” was somebody being able-bodied, Jan responded: “Yes, automatically, unfortunately, and it’s not fair, but yes I do” (Jan, Interview 1, April 23, 2010). Of all of the participants, Jan and Jerrod were the only ones to mention that they were aware of the abilities of Stephen Hawking, a world-renowned English theoretical physicist who was almost entirely paralyzed due to a degenerative neurological debilitation.

When asked for their perspective of a geologist, each of the participants provided a description of a geoscientist as a rugged, field-ready individual who was in good physical condition. None of them felt that a geologist could be physically disabled. During an interview session with Jerry, he stated that in order to do anything with geology, you have to have the ability to:

[E]xplore over [r]ough terrain. You’ve got to be energized for it. You know, sometimes maybe you take a long walk like a couple of miles every day, and I do not know if a person with a disability can handle all that. Somebody who is able-bodied can of course do all that hard work.” (Jerry, Interview 1, April 16, 2010)

Julie, however, was more in depth with her understanding of a geoscientist as evidenced in the following journal entry:
Geologists can also work in a lab where they try to understand and get information out of the artifacts found in field expeditions. The lab geologists also have their subspecialties that helps define what they do. The subspecialties in the lab, research, and education careers are the ways that geology is mixed with all of the different sciences. I think geologists can also work in business and government as people who tell the higher-ups what the best way is to using some of Earth’s resources. Another way they can help business and government is by developing new ideas/ways and discovering new Earth resources that promote human effectiveness. (Julie, Journal 2)

Research Findings

In the following sections, research findings are aligned to the primary objectives. The anticipated themes, which included prior content knowledge and experience as well as various personal abilities and perceived barriers of accessibility and inclusion were used as preliminary building blocks through the design of the study, and guided exploration. These themes were drawn from a variety of sources, including researcher understanding of the aspects of physical rigor in field-based geoscience learning environments, anticipation of accessibility issues in field environments, and through discussions with those who interact daily with members of the mobility impaired community.

However, throughout the study, several unanticipated themes emerged from the data. Themes such as social barriers, issues of personal dependence, gratitude of inclusion, and common fears became prominent throughout the data obtained from each of the six participants. Evidence of both anticipated and unexpected themes that arose from the data sets that provide an impact and the evidence needed to answer the three research questions of the entire study are now presented.
Research Objective #1: Common Cave Misconceptions

What are common misconceptions of caves?

Prior knowledge and experience.

After the first classroom session, participants were required to begin making data entries in a journal. Although initial prompts (Appendix Q) were presented to the participants to assist in narrowing their focus, the journal was meant to be a free-writing assignment about a number of topics related to their experience: expectations of the various aspects of the study, prior experiences learning outside of the classroom, and science in general. These journals were used to expand their thoughts on the classroom instruction. Based on interview discussions, most of the science content being delivered was new to each of the participants. Additionally, information collected from the journals provided a deeper insight to the participants’ understanding of the geology, caves, as well as their preparation techniques and fears about going someplace unfamiliar.

Prior knowledge of the geosciences as well as experience learning outside of the classroom were both discussed with each of the participants and listed as a required journal entry. The six participants held varying levels of content knowledge and experience. While some had minor geoscience understanding, even without formal instruction, the lack of solid earth science content understanding was evident. Additionally, qualitative data provided evidence that each of the group members had extremely limited involvement in any field-based learning experiences.

Through discussions of accessibility and inclusion, most of the participants appeared to be frustrated by their past experiences.
I was always told that through technology, I could find another means to interact in the environment but I HATED that. I always felt gypped in science when people brought things to me through technology. I thought it was always better to not have anything to do with it than half-ass it. My attitude was that just because I’m disabled and cannot walk or use my arms like other people does not mean that I should get second-rate learning, and technology was second-rate to me. (Julie, Journal 1)

Julie goes on to describe a situation where she was left out of a field-trip because of her mobility impairment.

[Past memories of “geology” trips in elementary school came in my mind where all of the other students got to do cool stuff. However, I was only allowed to watch from a distance or go to another part of the field area and look at the different rocks. I remember saying specifically, “Why can’t I look for fossils too? I can see rocks and dirt at home.” My aide’s reply back to me summed up to be that I was too difficult to carry down to the site and that stuff was a bore anyway. [This] frustrated me because I was physically disabled and not given the chance to do anything active. (Julie, Journal 3)

Expectation of field site.

The participants were asked to discuss their prior scientific knowledge of cave geology and personal understanding of caves in the initial journal entries, including what they thought they might see when they experienced one for the first time. Of the many comments made leading up to the field site visit, some included information that was incredibly accurate: “mineral formations inside a cave will be destroyed if we just lightly touch them. We need to learn what our carelessness could do to the natural environment of a cave” (Jason, Journal 1). Jerrod also provided some of the most astute commentary on his thoughts of cave conditions:

When I think about caves I think of a cold, moist dark place that has bats and underground rivers. I also think of stalagmites and stalactites on the ground and ceiling along with dripping water, rocks everywhere and a very moist stagnant smell. The conditions inside of a cave versus outside of a cave vary
considerably. Inside of a cave the temperature and moisture levels stay very stable all months of the year where as outside varies from month to month. Also caves don't typically experience different weather such as rain and snow where as the outside does. Finally there are not the same animals in a cave as there are outside of the cave. For example caves have bats but not birds. When I think of the living things inside of a cave I picture them being dark colored and small to adapt to a cool dark place that has lots of small hiding places. (Jerrod, Journal 4)

Others’ depictions included personal fears: “I think it would be very claustrophobic. I am very concerned about the bats eating me alive!” (Jessica, Journal 3). Along with bats, Jessica also expected that “caves were where all of the bad animals lived” and through reading fairytales and watching cartoons, she grew up thinking that “dragons lived in caves!” (Jessica, Journal 1). A few were quite surprised that there were even caves in the United States.

When asked to discuss their expectations of what the conditions inside of the cave would be like, descriptions ranged from very spacious, dark, wet, and cold to being very cramped, hot, muggy and smelly with dripping water, mean animals and bats all over the walls. Many expectations included beautiful waterfalls with gems and minerals in the rock walls “something like in a horror movie, bats, water everywhere and small.” (Jerry, Journal 1) The following were excerpts from early journal entries where participants wrote about various thoughts of cave geology:

I do not know very much about caves except that they are formed by water flow and usually have a large buildup of calcium and have stalactites and stalagmites. I also know there are bats and eyeless fish that live in caves as well. The conditions of a cave are dark and cool and that there are many rock obstacles, pits, and small streams of water. (Jerrod, Journal 1)

The few things I know about caves are the stalactites and stalagmites. I think that they are formed from the dripping water or some kind of moisture in the caves. I want to say they are rich in some mineral and sometimes different colors, but I’m unsure. I remember these few things because I thought they were cool and
wanted to see them in real life. I know bats live in caves and they eat bugs, I think mosquitoes. (Julie, Journal 1)

The conditions of a cave are cool/cold, damp/wet, dark, and rocky. Wet rocks can be slippery. A cave can be a large roomy area or a tight crawl space. A cave can have a body of water - an underground river or stream. Caves probably do not have cell phone service. (Jason, Journal 1)

As the study progressed, participants’ understanding and expectations of the cave environment began to show evidence of increased content knowledge through classroom instruction.

Once in the elevator I think it will be a long slow bumpy ride to reach the bottom of the cave. The lower we go the cooler it becomes, until we reach a constant 56 degrees. When the elevator doors open a dingy artificial light creeps in. The walls are the color of sand, damp but smooth rock. As I roll across the ground my wheels will bump over the uneven rock. In the distance the cave will become narrow in spots and wide in others, showing the results of vadose and phreatic [shaped passageways]. Water will trickle down from cracks in the walls. Bats will sit on the walls like little mice. There will be various sizes of stalagmites and stalactites throughout the cave. (Jan, Journal 4)

Evidence of first-hand experience.

Once the participants entered the cave, observations and comments were recorded. The following is an excerpt from an impromptu focus group conducted once everyone was in the cave:

Jessica: I wasn’t expecting the lights. I was expecting a dark, cold area, not even wide enough, and it was very accessible. It was more accessible than sidewalks in a city

Jerrod: I thought it was going to be a little colder actually. I [also] thought there would be an echo.

Jan: Yes. I thought it would be dripping all along the walls because it had so much water.

R: What else? What do we see on the ceiling?

Jerrod: Names [written], what did they use? It wasn’t spray-paint!

R: No, it wasn’t spray paint. They actually put these on here from candles
and held their candles up and burnt the ceiling

Jessica: We can do that!
R: No we can’t, because it’s a national park now, and that would be vandalism. (In-cave First Thoughts, May 8, 2010)

Immediately following the cave experience, Jerry reflected on his experience with the following excerpt from the focus group interview:

I was shocked the first time, when I went down there, because like me, with my imagination, I watch too many movies anyway, so I’m thinking totally something different. It was weird, it’s like a place you’ve been before, just that you were surrounded by rock. So it was a great experience, I loved it. I’d go back if I had the chance. (Jerry, Focus Group Interview 2, May 9, 2010)

From this moment on, with increased experience, the participants’ descriptions and perceptions began to change. Although some of their initial assumptions were quite accurate, many participants were significantly surprised by their newly modified perspective. “It was awesome. I touched that wall like right away. It was unbelievable going into the cave.” (Jason, Focus Group Interview 2, May 9, 2010)

What surprised me most about the cave is that it was so large and mysterious. The cave had so many stories to tell and I wanted to hear them all. I learned how the cave was formed which is amazing by itself. But what surprised me is that there was so much more to the cave. Like all the signatures on the wall, how they got there and the stories of the tours. I could have sat in that cave all day exploring and listening to the past. When you left Julie and I alone in the cave for the first time, while you went back for the others, we went as far as we could in the cave until complete darkness. I was surprised how effortless it was to get around, the floor was so smooth. I made jokes that this was the part in the movie when the monster attacks…but I know we both really wanted to explore further…but didn’t out of respect for you and complete darkness. At that point I didn’t even know about all the signatures on the walls! (Jan, Journal 6)

Once we got past the elevator and doors the first thing I noticed was how low the ceiling was or at least the assumption that it was low. It was so close and real to me. I wanted to touch it so bad. I reached up and pushed my nose up on it, and I
Field site conditions.

The following section provides evidence of the participants’ experience through the collection of various qualitative sources, some of which were extensions of questions previously asked in quantitative assessments. The Cave Knowledge and Attitude Assessment (CKAA) asked very basic questions (Part B) related to personal experience in and around cave and karst environments. For the most part, the five questions did not provide enough data to support a full range of understanding of the participants’ true first-hand experience with caves and prior cave knowledge. However, the qualitative methods of this study allowed for a deeper understanding of their cave knowledge and experience. Once the participants were able to experience the field site, their personal reflections provided evidence for their changing perspective. The conditions of the cave were the primary focus, followed by the historical attributes, and the learning experience throughout the entire visit to the field site.

The things I liked the most were all the different lights because I could walk around and see everything and the paved roads. I wheeled around and we came up upon this spot where it echoed and it was fun. (Jessica, Journal 5)

The double doors open, you think you are in an old basement then in just 50 feet, it changed. Cool pleasant air surrounds you. The huge size and length of the cave is unbelievable! Oval shapes of tunnels, wide in the beginning narrowing the further you go. It’s as if you are following a dry river bed with beautiful rugged high walls and multi textured ceiling. (Jan, Journal 5)
A question found in Part D of the CKAA asked about the ability to adjust one’s eyesight to the darkness enough to see in a cave if all of the lights were extinguished. Many were surprised by the reality of the darkness of their unlit caving experience.

I didn’t like how very dark it is without lights. (Jan, Journal 5)

When the lights were turned off it was very hard to see and was completely pitch dark like nothing could be seen not even the slightest bit; it was ten times easier to see with the lights on. (Jessica, Journal 5)

We were going down there and it was all dark, that was really cool, and especially when we turned the lights off, it just felt more real, and I really liked it. (Julie, Focus Group Interview 2, May 9, 2010)

Due to the participants’ limited physical mobility, the temperature inside the cave became an issue that wasn’t planned for.

The air was not what I expected. It was much colder than I thought it would be and my hands hated it. My fingers were too cold to function which made it difficult to maneuver things in my lap. I loved when we were at the part where water was coming through. That was one of my favorite places. The air there felt so good even though it was cold and I could see my breath. (Julie, Journal 5)

In addition to the lighting and temperature of the environment, there were many other highlights of the overall experience including the lack of observable life inside the cave. Each of the participants provided evidence of an expectation to see bats throughout the entire cave environment, but was slightly disappointed.

It was pitch black without artificial lighting and was somewhat cold. We did not see very many bats, which I had hoped to see. (Jerrod, Journal 5)

I didn’t get to see any bats, expected to see many. (Jan, Journal 5)
Due to the elevator accessibility of the selected field site location, there were no natural entrances to the cave within several miles. Since bats remain relatively close to natural openings in the cave, chances to see bats were limited.

Additional highlights included the physical formation of the cave and the overall atmosphere. When asked about the aspects of the cave environment that were most surprising to them, the participants provided the following excerpts from their journals.

What surprised me most about caves is how versatile they are. They have large entrances, small entrances, tall ceilings, low ceilings, many types of animals and insects, and contain underground rivers. (Jerrod, Journal 6)

What surprised me the most about caves was how much different parts vary in size and the overall atmosphere in the cave. By the way, I thought it was absolutely sweet that you could see your breath only in places where the air was moist. I never knew that humidity made a difference in whether you can see your breath or not. It completely fascinated me when I learned that. (Julie, Journal 5)

We got to go off the trail. And I found that little cubby hole; it was really cool because I’m so short sitting down, I can just drive right in there. It’s like being in the shorter version of a parking garage. (Jerrod, Focus Group Interview 2, May 9, 2010)

Oh, I was completely surprised when I came through those doors and saw how wide, how large it was. I wasn’t expecting that, you know, I was thinking more tunnel, smaller, look in the distance and it shrinks down. And it just opened up. It was like unbelievable. I thought someone was walking by me and the air, because I felt a breeze. And then going through the coolness, I thought it would be damp and wet, and it was so dry, the walls, that surprised me. But until we got to Martha’s Vineryard, that’s what more I expected a cave to look like, in the spray of the water, so it was, I loved seeing both. (Jan, Journal 5)

Visit to the Green River seeing how the recent rain storm flooded the area under 9 ft. of water covering the greenery with a thick layer of mud. Learning how to map a cave and actually doing the process. [I] most liked Martha’s Vineyard because normally it is a place I would not have an opportunity to see. As I neared the area I could see the reason it’s called Martha’s Vineyard. Formations of the rock look like clusters of grapes. I could feel the cool air and the spray of
water as it trickled off the rocks. It made me want to explore further. (Jan, Journal 5)

_Cave mapping activity._

In order to provide a true experience similar to that of a practicing geoscientist, the participants were required to complete a cave mapping activity while in cave (Stop #3). During this activity, the participants were self-divided into two groups, male and female, and provided with equipment in which to collect measurements of the cave passages. Using 100 ft. tape measures, protractors and electronic distance meters, the participants collected the survey measurements (Figure 4.1) needed to accurately develop a map view of their location in the cave. The following is an excerpt from Jessica’s rendition of the experience.

I took a tape measure and one of the other girls held the other end of the tape measure and the other person took down all the measurements that were called out. We also used a compass to judge the direction from one point to the next. The mapping process was cool because we learned how geologists mapped out the caves to [find] the different entrances. I wasn’t aware of this process prior to this class so it was very interesting to learn about. The process was very surprising to me because I didn’t think people would even take the time to map out all different entrances. (Jessica, Journal 5)
Once the measurements were completed, and the participants returned to the research center above ground, they again divided into their data collection groups and began constructing their cave maps. The result was the development of a map (Figure 4.2) that, when compared to the actual cave map completed by speologists affiliated with the Cave Research Foundation (CRF), was an excellent representation for participants who were experiencing this activity for the first time. Although the two groups were working autonomously with one-another, when each of the two sections were merged, they fit perfectly together into one map. Figure 4.2 shows the two sections that were developed by the participants. Section 1, on the bottom of the map, was constructed by the female participants, while Section 2, on the top of the map, was constructed by the male participants. A larger version of the participant-developed map is available in Appendix S.
Figure 4.2. Participant-developed cave map superimposing the CRF map.

*Historical significance.*

Also during the in-cave visit to the field site, participants learned about the history of cave exploration within and around the park that included the use of slaves as tour guides. This discussion had a major impact on the participants, not only for the historical and cultural perspective of the signatures of past visitors and explorers surrounding them on every rock face, but also the historical significance of the evidence of slavery and the impact of the reality of history coming to life right in front of them.

When we were in the caves, you could see the 1800’s dates that were left by people who came through there. Even when we were by the rock table and we found the chicken bones and wine bottles that were left behind. I kept thinking maybe my ancestors came through there once in their lives. (Jerry, Journal 6)

It’s so quiet. How the signatures got on the walls. Learning the history of the Bishops, slaves who were freed, that guided tours of the cave. (Jan, Journal 5)
Listening to the stories at the rock was an impactful experience to me. Being there in that situation was the closest I ever felt or been in the “South” hearing real slave stories. It was all so very surreal to me and it made me get a knot in my throat. My whole body was infuriated and distraught because I know this stuff happened in the past and that black man had a “decent” job compared to others, but the oppression was absolutely crazy. Even though I’m not black, those stories make me think about myself and how I would be treated if I was alive back then. I know Asians were not necessarily slaves, but they were treated horrible too. Also, what scares me more is how PWD were possibly treated back then. I see videos and hear stuff about how white PWD were treated which was horrible, so I can’t imagine how other races with disabilities were treated or if they were given any life what so ever. I often imagine PWD were treated as if they were invisible and had no rights. Not only would they not get to do what they want, I feel that they wouldn’t have been even acknowledged as capable of doing anything. I know it is horrible being forced to do horrendous things and get beaten, but I question what would it be compared to someone who is expected to be unable to do absolutely nothing and treated just as bad without being able to contribute something to the world. In both situations I feel like you are extremely helpless, but it seems worse if you aren’t given a way to do something and have to watch others who are trying suffering so bad. It is the epitome of helplessness. This helplessness that I’m assuming that would happen is something that could have happened to people similar to me back then. It is so scary to imagine what life would truly be like for me/others with “severe” disabilities and different races in the past. What makes it scarier is that if the majority at that time, the whites, treated their fellow whites with disabilities that bad, and they treated other races bad already, I cannot even fathom what it would be like if a person was another race and disabled. (Julie, Journal 5)

In her journal, Julie wrote considerably about her experience and focused on relating her feelings about the moment she learned about the slaves to the struggles she faces as a mobility impaired individual.

*Learning experience.*

From the moment the participants arrived at the first stop during the field site visit portion of the study, learning was taking place. The effects of the trip were noticed in
many of the participants’ journal entries. The following journal excerpts show the impact of instruction and experience during the field site visit.

I learned a lot from class lecture, pictures and reading but seeing the sinkhole, Green River, Mammoth Cave and mapping the cave gave me a better understanding. The experience was remarkable, something I could never get from a book. (Jan, Journal 6)

I loved putting the helmet on and actually being in an area where I could feel up close and personal the cave. The cave saw each person as a person no matter how they walked or talked. Wearing the headlight was really sweet because for once I could actually point with my head and people actually understood what I was pointing at. (Julie, Journal 5)

What were the highlights? EVERYTHING! the echoing spot, seeing a bug on the snowball ceiling, chicken bones and brown glass bottles, water dripping into the cave, seeing a bat flying around, and names and years in the 1800s left behind by cavers. (Jason, Journal 5)

I couldn't wait to get out at the elevator. Going down over 300 feet in the elevator didn't take long at all. It was just amazing when we walked out of the elevator. It was just like being in a building. The path to walk on was paved and smooth. The cave was cool but comfortable, the air was fresh, and it was wheelchair accessible. I think we walked about a half mile to a mile beyond the Snowball Dining Room. The paved walkway did run out, but the dirt floor was still smooth and pretty even. There was one place in the floor that was smooth and a little steep for my bald tires on the front of my wheelchair. No problem, just slid a little. Seeing the names, years, and “Ohio” left behind on the stone walls was cool. I wish I could have looked into every hole or opening in the ceiling or walls that might have led to something new. I saw a bat flying around. The lights through the cave were great. Wearing the headband light made it nice to see a bug, stone formations, the chicken bones, and bottles, and broken glass. Jenny's table and the echo spot were cool. It was a perfect place to be. Doing our cave measurements was interesting. Going further into the cave the other way brought us to the dripping water and steps. I wish we could have kept exploring. I got a lot of good pictures. It was fun! (Jason, Journal 5)

The physical layout of the cave allowed everyone in without any separation among people. It was as if all of us, AB or PWD were all on the same level.
Because of this course, I have a much more positive attitude about geology and field work. (Julie, Journal 6)

Research Objective #2: Experience and the Construction of Knowledge

How does participation in a field geology experience about caves affect the construction of knowledge by students with no experience and limited content knowledge about caves?

Discussed previously in Chapter 3, the participants in this study were selected for multiple reasons. First, because of the assumption that students with mobility impairments are not pursuing geoscience degrees in higher education due to the field-based education requirements, the likelihood that these participants would be knowledgeable about the content presented in this study was low. Secondly, because most caves tours require a staircase descent to enter, the limited accessibility likely prevented any of the participants from having had any real experience inside of a cave. Because of these reasons, this participant sample provided a good gauge for assessing the construction of cave and karst knowledge from the instruction within this study.

During a discussion on the first day of the classroom portion of the study, the participants were very unsure what the science of geology entailed. The following excerpts from the final journal entry provide evidence of their reflection on the science of geology and the benefit of their learning experiences while participating in this study.

I really had no knowledge of geology before I took this class; I just thought it was just the study of rocks. But now that my experience is over, I now know there is more to that. Geologists work to understand the history of our planet. The better they can understand Earth’s history the better they can foresee how events and processes of the past might influence the future. (Jerry, Journal 6)
The study of geology is so much broader and valuable then I ever thought before taking this course. By understanding Earth’s past processes, helps us to understand what will happen in the future. (Jan, Journal 6)

Content knowledge was assessed using a subscale of the Geoscience Concept Inventory discussed in Chapter 3. Although this instrument was developed to assess general geoscience content knowledge, enough disparity provided in the content of the questions being asked provided an opportunity to collect evidence of the participants’ knowledge regarding the various geologic processes that are related to the promotion of cave and karst formation.

*Modified Geoscience Concept Inventory (mGCI).*

As a measure of participant learning outcomes as a result of the study’s science content instruction, a subset of the Geoscience Concept Inventory (Libarkin and Anderson, 2005) was employed. This 25-question subset of the full GCI used questions relative to plate tectonics, the lithologic and hydrologic cycles, and the geologic time scale. An additional five Likert-type response questions were added to the instrument by the researcher to elicit a level of participant knowledge specific to cave and karst features.

This assessment was administered to the experimental group three times during the study; once at the beginning, again after the classroom instruction and then one month following the field site visit. Results of the mGCI, shown in Figure 4.3, indicated a slight increase in content knowledge as a result of classroom instruction in five of the six participants, but a decrease in content knowledge in the same five participants one month after the study concluded. However, overall comparison shows that four of the five had maintained the same or improved level of content knowledge from the initial assessment.
to the final delayed assessment. One participant had increased in each of the three assessments while one decreased knowledge in each of the three assessments from the beginning to the end of the study.

Figure 4.3. Results of the Modified Geoscience Concept Inventory.

Cave Knowledge and Attitude Assessment (CKAA).

As described in Chapter 3, with exception of the mobility impairment statistic, the overall demographics of the experimental group are closely similar to that of the second validation group, used to validate the CKAA. The three primary constructs of the instrument included experience of caves, attitude regarding being physically inside caves, and cave and karst content knowledge. The experimental group of participants with mobility impairments completed the survey twice, once at the initial class meeting and again, following the entire intervention of this study. The time in between Experimental
Group test administration was approximately five weeks. The instrument validation group completed the survey once, during the summer quarter, 2010.

Comparison of the of the mobility impaired sample with the validation sample (Figure 4.4) provided evidence that the mobility impaired group scored as well, if not better than the instrument validation group in Parts B, C and D of the CKAA. Potential explanations of these findings are discussed further in Chapter 5.

![Figure 4.4. CKAA results compared between experimental and validation group.](image)

**Research Objective #3: Barriers to Field-based Learning**

What internal and external barriers do students with mobility impairments perceive regarding access to and studying within cave geology field environments?

With the challenges of obtaining cave and karst content knowledge, discussed previously throughout this dissertation, this research objective was prompted from the
assumption that most caves are not physically accessible to visitors with mobility impairments. Many environmental barriers were expected and planned for at the various stops during the field site visit. This objective ultimately sought to explore the unexpected barriers related to students going into unfamiliar places and attempting to focus on the content rather than on their anxiety and fears that developed from the issues of accessibility. The following sections provide evidence to support this research objective.

**Participant ability and perceived barriers.**

A barrier, as described in Chapter 1, is anything that impedes or separates; an obstacle. Quite often, for persons with mobility impairments, an obstacle may be internal, a psychological impediment that deters them from trying something new, or being adventurous to the point of moving beyond their comfort-zone and out of their typical routine. For the participants in this study, being adventurous and actually acting outside of their comfort zone were two different situations. The researcher purposely provided less than the necessary information about the field site than is typically required for pre-planning of personal strategies of access and mobility. The decision to participate may have been aggravated by these internal barriers for many of the participants. In the following sections, three barriers are discussed: personal, societal and environmental. In addition, the following unanticipated themes are discussed: asking for help, trust, and the frustration with the lack of control in decision-making.

**Personal barriers.**

“I am given continuously everyday challenges where my disability isn’t accommodated for so I have learned many different techniques that help me adapt to any
situation” (Julie, Journal 1). These words provided evidence for students with physical
disabilities having the ability to adapt to a variety of everyday challenges. However,
many barriers are internalized limitations placed on them by society, as evident from an
interview with Jan:

R: At the time you were going to rehabilitation after your accident, what
were the barriers [that] you were thinking that [were preventing you from
being] able to go into a scientific career?

Jan: Because I wouldn’t be able to do the job, I just knew that, it wasn’t
anything I had to talk to anybody about, it was just common sense. (Jan,
Interview 1, 4.23.2010).

Once Jan realized the details of this study, this “common sense” turned her initial
excitement to concern about being taken out of her typical routine, out of her comfort-
zone. This was an internal barrier that almost prevented her from participating.

[F]inding out we were going to Mammoth Cave added to my excitement, what an
adventure! As I found out more information the reality and anxiety set in.
Mammoth Cave is five hours away, we would be staying for two nights and
where we were staying wasn’t anything like an accessible hotel. Did I mention
we all share a bathroom that isn’t even in the same building! Now, I have to
admit I was questioning if I wanted to go. As the deadline approached to sign up
for the EES class I thought about what an opportunity this was: a chance to learn
about and experience a cave. The only thing that was stopping me was my fears
involving my disability. Funny I use the word only, it sounds very minimal, but
to me it’s not. It’s enough to keep me from doing the things in life that I would
like to do. (Jan, Journal 3)

Surprisingly, agreeing to participate and simply discussing the anticipated conditions of
field site visit were not major concerns among the other participants. Jan was the only
one of the six who was deeply apprehensive about the unknown aspects of the study,
especially if she would be able to complete the requirements of participation.
**Motivation.**

To understand the effect of motivation on the results of the study, the Science Motivation Questionnaire was administered to determine to what level being motivated to learn science prompted the participants’ willingness to take part in overall experience and if there was an impact in their responses to the various aspects of the study.

**Modified Science Motivation Questionnaire (mSMQ).**

Learning in the field is a true test of a students’ personal flexibility. Conditions are not always ideal when so many environmental variables of nature are involved. Motivation is a primary variable in learning when it comes to geoscience fieldwork. The likelihood that unmotivated students will retain content knowledge through instruction may be doubtful in the face of a stinging rain storm along the side of a busy roadway while making observations of a sedimentary outcrop, nor will they reflect positively on the experience if such unanticipated events cause them to lose focus on the learning at hand. Although none of the participants were science majors, they were assessed based on their motivation to learn science to examine how the experience might have affected them personally. Administering this instrument was done to remove any research assumption that learning science might be a perceived barrier to the participants, regardless of the specific science discipline.

Two iterations of the Science Motivation Questionnaire (Glynn & Koballa, 2006; Glynn, Taasoobshirazi, & Brickman, 2009) were administered, before and after the study to determine any change in the participants’ science-learning motivation. The aforementioned published assessment contained many questions which focused on the level of motivation regarding “the science”. Therefore, for the purposes of this study,
most of the questions that were written about “the science” were modified to elicit a response for motivation to learn “science” in general. The questions that were not modified included numbers 6, 7, 14, 15, 17, 18, 19, 22, and 24.

Responses to the 30 question instrument, found in Appendix L, were coded according to the four-point Likert-type questions. Based on the way each question was written, it was possible that a *strongly agree* response would equate to the most negative response and a *strongly disagree* would represent a positive response for a particular question. A score of four was given to the most positive responses and a one score was given to the most negative. Therefore each question was coded independently, ensuring that reverse coding was done as necessary. Once coded, each question response from each of the six respondents was tallied and averaged for both pre and post-study test administration.

Multiple analyses were completed on the data collected. The instrument was developed around six “motivational components that influence self-regulatory learning” (Glynn et al., 2009, p. 131). Initially, a comparative analysis of each individual question (Figure 4.5) was conducted. A calculated average of each individual response showed a slight increase in motivation (pre-test: 3.05; post-test: 3.14, 4-point scale) to learn science from the beginning until completion of the field site experience for the six participants.
Although the overall change of motivation is statistically insignificant, Figure 4.5 provides evidence for several questions with measureable change (±0.3 or larger) in response to motivation, either positively or negatively from the first to second test administration. The data in Figure 4.5 graphically represents the difference between pre and post-test administration for each individual question. On the left of the figure are the questions with the most variance, from pre to post-test administration, of decreased motivation while questions on the right side of the graph reflect the most change in response to increased motivation for the same change in pre to post-test. The solid bars near the center of the graph represents the overall average change in motivation from pre-test to post-test administration. The average change is indicative of an increase in motivation through the duration of the study. Additionally, Table 4.1 provides a list of questions that have the greatest difference between test iterations as indicated the average
point change of ±0.3 or larger. The top portion of the table represents the largest to
smallest increase in motivation. The bottom represents the largest to smallest decrease in
motivation, with a minimum response difference of ±0.3 or larger from pre to post-test
administration.

Table 4.1. Response Changes in Motivation

<table>
<thead>
<tr>
<th>Item #</th>
<th>Increase in Motivation (largest to smallest):</th>
</tr>
</thead>
<tbody>
<tr>
<td>13.</td>
<td>I worry about failing science tests.</td>
</tr>
<tr>
<td>14.</td>
<td>I am concerned that the other students are better in science.</td>
</tr>
<tr>
<td>10.</td>
<td>I think about how learning science can help me get a good job.</td>
</tr>
<tr>
<td>21.</td>
<td>I am confident I will do well on science labs and projects.</td>
</tr>
<tr>
<td>15.</td>
<td>I think about how my science grade will affect my overall grade point average.</td>
</tr>
<tr>
<td>09.</td>
<td>I use strategies that ensure I learn science well.</td>
</tr>
<tr>
<td>01.</td>
<td>I enjoy learning science.</td>
</tr>
<tr>
<td>11.</td>
<td>I think about how science will be helpful to me.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Item #</th>
<th>Decrease in Motivation (largest to smallest):</th>
</tr>
</thead>
<tbody>
<tr>
<td>02.</td>
<td>Science I learn relates to my personal goals.</td>
</tr>
<tr>
<td>20.</td>
<td>It is my fault, if I do not understand science.</td>
</tr>
<tr>
<td>28.</td>
<td>I am confident I will do well on science tests.</td>
</tr>
<tr>
<td>05.</td>
<td>If I am having trouble learning science, I try to figure out why.</td>
</tr>
<tr>
<td>24.</td>
<td>I believe I can master the knowledge and skills in science courses.</td>
</tr>
</tbody>
</table>

A second analysis of the data was conducted according to the grouping of all of
the instrument questions into the appropriate subscales which were derived from the
exploratory and confirmatory factor analysis during the instrument validity and reliability
testing completed by Glynn et al. (2009). The six instrument subscales included
intrinsically motivated science learning (items 1, 16, 22, 27, and 30), extrinsically
motivated science learning (items 3, 7, 10, 15, and 17), personal relevance of learning science (items 2, 11, 19, 23, and 25), self-determination (responsibility) for learning science (items 5, 8, 9, 20, and 26), self-efficacy (confidence) in learning science (items 12, 21, 24, 28, and 29), and anxiety about science assessment (items 4, 6, 13, 14, and 18) (Glynn et al., 2009). Figure 4.6 shows an overall increase in average motivation responses across the six subscale components.

![Graph showing change in motivation](image)

**Figure 4.6. Pre and post-study subscale results of the SMQ.**

Several of the participants were confident in the help of those around them to fully participate in this study. However, once the field site visit occurred, many of the participants realized what being outside of their comfort zone was truly like.

**Common comforts and daily routines.**

Many students with physical disabilities rely heavily on routines and strict schedules to get through their days. Discussions with the six participants revealed that a
common comfort of using the bathroom each day had to be scheduled ahead of time since each of them needed some sort of assistance. Even in an emergency situation while on campus, trained staff are on-call who could assist them. However, when pressed to think about what learning would be like away from campus and in a field-based learning environment, some of the participants started to show their concern for leaving these common comforts behind. In the following interview excerpt, Jerry, the one who appeared fearless and completely easy-going before the trip, discusses the challenge of leaving the comforts of on-campus disability services.

R: What do you feel about working outside of a classroom? Like if you go into the field what do you feel about that?
Jerry: I like going out and exploring you know just being out in the sun and just looking at some things you have never seen before. You get something new because you really do not see that every day.
R: Exactly so working outside?
Jerry: Right.
R: It would not bother you at all?
Jerry: No. No.
R: So when we get into to talking about working outside you know especially for students like yourself, you might be getting out of a comfort zone. You know when you are in the classroom somewhere that you have bathroom facilities nearby, you have the support that you might need. When you go out into the field those go away.
Jerry: Right.
R: How do you feel about that?
Jerry: It is challenge.
R: It is. I noticed you are smiling more now.
Jerry: It is a challenge you know it is going to be very interesting to see how we are so used to everything being handed to us but when you go out on the field you have to do everything yourself. (Jerry, Interview 1, April 16, 2010)

Toward the end of this brief conversation, Jerry began to show a sense of nervousness or anxiety through his body language. When pressed, he admitted that he was used to being
on campus, a familiar place that allowed him to navigate with little effort through his daily routine. Jerry was not the only participant to show the same concern for leaving the safe confines of campus to learn in an unknown environment. Stated in his last journal entry, Jason wrote that “a barrier for some people [was the] fear of the unknown” (Jason, Journal 6).

After getting to know them through this study, the researcher understood that these participants relied on pre-planning and organization as a solution to common personal and environmental barriers. By withholding information regarding the whereabouts of the field site visit and detailed information about what to expect, the participants were faced with the aspect of choosing between adventure and self-comfort. “The most difficult barrier related to this course [and] trip was calming my anxious self. I am not entirely sure why I was freaking out in my head, but I was. I could not pinpoint what all the anxious feelings were, but they were there” (Julie, Journal 6). This anxiety led most to simply rely on the fact that, as an academic research study, the details would be worked out for them. In fact, several of the participants’ fears were reduced almost entirely because of assuming that accessibility issues would be planned out ahead of time, regardless of the lack of information provided them prior to the start of the study. When asked what her biggest fears of leaving the common comforts of the classroom for a field-based learning opportunity, Julie simply responded by saying “I really don’t have any because I see that it is a grant [funded project] in academia so everything will be figured out and I don’t need to worry” (Julie, Interview 1, April 16, 2010).
Issues of dependence and independence.

Because of their varying abilities, most of the participants were required personal assistant for bath-rooming, bathing, and dressing. Four of the six participants needed extra assistance with food preparation and eating, even the most basic finger foods. However, instead of requiring full-time living-assistance, each of the participants maintained pre-planned meetings with a personal assistant during the day to accommodate their various needs.

A comparison of the participants provided a contrasting view of personal independence and dependence: the level in which participants are open to being assisted with respect to everyday activities and routines, as well as situations that occurred unexpectedly. An assertion can be made that an individual’s sense of adventure may be directly related to their level of independence. The more independent one is means the less adventurous they permit themselves to be. To explain this further, if someone had managed to become self-sustaining and independent with their limited mobility then they are most likely living in a routine that allowed them to be independent. Therefore, these individuals did not attempt to deviate from their typical, daily routine for fear of losing their sense of independence with the need of relying on personal assistance.

Trust.

As evident in the beginning of this section, with limited information about the conditions and accessibility of the field site provided to the participants, being involved in this study became an issue in trust. With a strong sense of trust in others’ ability to convey the level of accessibility for unknown places to them, several of the participants made it very well known that they were handing over their trust to the researcher.
following excerpt from one of Julie’s initial journal entries, she talks about her level of confidence for the researcher and the instructional staff.

I am realizing through talking to [R and AA] that I am putting a lot of trust in them that things are going to be good and extremely accessible. Honestly, who is to blame me for putting trust in them. You can see in small things that they do or say that they truly are trying to make this go as smoothly as possible.

I honestly think they are worrying way too much about it, but I understand why they are. PWD (people with disabilities) are a unique population that can have crazy emergency things happen at any time of the day. It is a little bit risky for someone who deals with disabilities all of the time, so for two ‘newcomers’ who probably have not ‘lived’ (been in daily living situations) with people with disabilities it is probably an unknown territory and overwhelming. On top of that, you have this group of people from different fields and ages, but are unique because they are the top people in the PWD group because of their intellectual level, personal independency, and skills for self-advocacy and problem solving.

(Julie, Journal 3)

Jan also had similar sentiments, although she did not automatically assume that the researcher and instructional staff were as trustworthy as Julie believed.

The most difficult barrier related to this course was the field trip. Before I could go I had to make sure it was something I could do. Also, I had to put a lot of trust in [R and AA] that you guys knew what you were doing, which you proved that you did. Thank you. (Jan, Journal 6)

During an interview with Jessica, the subject of participation was addressed. Leading up to the start of the study, she was clearly nervous about agreeing to participate. With limited knowledge of what was required of her, she was of course, skeptical. Even after learning of the study’s content and purpose, and hearing where they would be going, many of the participants continued to be nervous. However, when they were informed that the Director of the Office of Disability Services, who is mobility impaired, had been
to the field site ahead of them, in order to assist in the logistical planning, they were able to calm some of their nervousness.

R: Is it just that it’s a new place, and it’s making you a little nervous?
Jessica: Yeah, yeah.
R: Did that cause you to hesitate to say I’ll go?
Jessica: Um, yes. Yes, but I like to try new things.
R: Is that what caused you to decide that you wanted to do it?
Jessica: Yeah.
R: What do you think is the main reason that caused you to want to do this?
Jessica: Because when I went to the first meeting, and I saw that Jeff went before we went. That helped out a lot.
R: So you knew that you would be able to do it?
Jessica: And he came back alive, so yeah!
R: Are you worried about the accessibility of it all or are you just trusting?
Jessica: I’m trusting you. (Jessica, Interview 2, May 3, 2010)

Even though most were putting faith into the fact that issues of accessibility would be handled before their arrival, some were simply more confident in setting themselves at ease. In his personal background, Jerrod’s personal confidence in his abilities to overcome barriers was evident. However, increased self-confidence may be a result of being reared in a confident family who taught constant preparation and never made a big deal out of situations that did not go as planned.

R: Do you think you were relying on a lot? Do you rely and trust that people have [accessibility] set up when you go on trips?
Jerrod: No. I come prepared.
R: Do you? How are you prepared?
Jerrod: Just know when some place is not accessible and you have to think quick on your feet.
R: So mentally prepared?
Jerrod: Yes. (Jerrod, Interview 2, April 30, 2010)
Jerrod clearly planned ahead for any situation and did not concern himself with any deviations in his planning or routine that would detract from his experiences, as evident in conversations with Jerrod as well as observing his interactions with others during the study. Additionally, he was not afraid to ask for help when he needed it. He did not have the same negative perspective of asking for help that others within the group had.

**Asking for help.**

“I hope I won’t have to ask for too much help” (Jan, Journal 3). Of the six participants, most were adamant about not being too quick to ask for help. Many felt that asking for help detracted even farther from expressing their physical abilities and personal independence. Asking for help was perceived very negatively.

R: Do you think [being taken out of your comfort zone] would deter a lot of people from [being adventurous]?  
Jan: I do, because of the frustration and the worry about being burdensome to other people? “That is very difficult for people who are disabled. For example, I’m so glad that I get this chance to go down into the cave, and I would never get the chance to do this, ever, if you didn’t do this research, because two reasons, a lot of times, since I’ve been disabled, it’s like you’re look through a window watching everybody else do things, because you don’t, it’s hard to do it, or it’s not accessible, or you don’t want to ask someone to help you do it. [If it were] set up where, you know I was able to do it all myself, then it would be wonderful, and you wouldn’t have to worry. It’s hard when you have to depend on someone else and ask somebody else for help.

R: So the comfort level that you have about doing something, going out in the field, is it more of being away from the typical comforts of a facility, or is it of being a burden, which would you say is more of a worry to you.  
Jan: I’d say being the burden. My husband gets so angry at me, because he’s like, you’re so independent, just ask me when you need something. I don’t like it, it’s terrible to think that way, but it is an uncomfortable feeling and you are very vulnerable, if you are put in a situation where if you can’t get out of it if you need to. That’s why I feel so comfortable at my own home, because I can take care of myself there, and I don’t have a problem, I’m fine. But if you get me out of my element, then I don’t know what I’m
going to experience, I don’t know if I’m going to need help, I don’t know if someone’s going to be there that I’m comfortable to ask for help. You know, then there you [are] with that uncomfortable feeling to have to ask for help.

R: What does that do to your experience?
Jan: You worry, and it keeps your mind away from really enjoying the moment, because you worry, and I hate that, it drives me crazy. (Jan, Interview 2, May 3, 2010)

R: Were you ever afraid to ask for help?
Jason: Yeah, I always like to try, like even here, I like to try to do things by myself, until I drop something, and then I’m like, OK, you can help. But I won’t give up.
R: Do you feel like asking for help is a barrier for you? That you don’t want to, or that you’d rather not ask for help?
Jason: Yeah, I’d rather not ask for help, I want to be like a normal person like my mom brought me up to be and not be treated any different than a normal person. (Jason, Interview, May 3, 2010).

**Instructional accommodations.**

The level of inclusion, interaction and accommodation also became a focal point of personal frustration, and even a barrier for some of the participants. As stated previously, many of these participants were afraid to be a burden to others, and therefore chose to struggle with a task rather than ask for help. However, for some, expecting academic accommodations was not something that they felt they needed to ask for. Julie became very frustrated at the lack of effort put into modifying courses for accessibility issues. She felt that most of her accessible classes were simply thrown together last minute, and many modified the level of content understanding, which indicated a stereotype that students who needed physical modification also needed cognitive modification. (Julie, Interview 2, April 30, 2010). Her main reservations for taking part in this trip weren’t about accessibility, because as discussed before, she didn’t worry about accessibility being taken care of for an academic research project. Julie was more
worried about the level of activity and inclusiveness of the instruction. “Being able to do the science, is it going to be hands-on? Is it going to be really hands-on?” (Julie, Interview 2, April 30, 2010). She also provided this type of questioning in her journal entry: “I wondered if this really was going to be hands-on and if so, is it going to be disabled hands-on or actually the true hands-on.” (Julie, Journal 3). Julie, who was the only one of the six who was mobile away from her chair, had a different level of accessibility than most other students who are mobility impaired. With minimal movement in her arms and hands, she was more limited in her daily activities than someone whose lower body mobility was the primary affect of their disability, maintaining significantly larger mobility in their upper limbs.

A concern that I had in the beginning and still now was that even if this is really a good hands-on, I wondered if it would provide opportunities where my body is physically involved. As much as I love cool accessible things, I always feel like the accessible version is still not super accessible for me or it uses only half of my abilities. I wish I could do something that truly lets me get the absolute most out of the experience as possible. The accessible [courses] I hated with a passion because all of the lab sessions they made accessible were inaccessible for me. What appeared to be the rule that defined whether a session was good for the accessible lab was that you could do it sitting and/or you had functioning arms. For me, that sucked, because I have little functioning in my arms, but I can do more with my legs. (Julie, Journal 3)

_Fear of the unexpected._

Preparing for a completely inclusive class and field-trip such as this took nearly one and one-half years of logistical planning. Discussions with field site experts and disability studies advisors were necessary to ensure that every detail was covered. So much time and effort went into planning for accessibility and inclusion, and establishing a level of confidence that everyone’s needs were addressed, that a major variable was
missed. What wasn’t taken into consideration was that these participants would have common fears just like their able-bodied peers, regardless of their level of experience outside of the classroom. The following excerpt from an interview with Jessica began to reveal an interesting perspective from someone with very limited outdoors experiences let alone a caving experience.

Jessica: I was interested, but I was nervous. I was like ‘caving! Are you serious?’
R: So tell me what made you nervous?
Jessica: Like going to a cave? Below ground? And you won’t tell us how ‘below’ it is.
R: (laughing) So what if it was two feet below ground or one hundred feet below ground. Does that matter?
Jessica: Um, yeah. I’m afraid of heights.
R: Well, we’re below ground, why do you worry about heights?
Jessica: Well, ok, you know how you get on an elevator, and the elevator shoots right up? (Jessica, Interview 2, May 3, 2010)

This was one of the most interesting themes discovered in the data. Having a fear of heights below ground is very common for those with caving experience. Even below ground there are locations that provide drastic changes in level, including pits that drop for several hundred feet. However, this very intuitive connection was being made by an individual who, until the study began, didn’t realize that there were even caves in the United States. She had never experienced a cave other than what she had seen from watching cartoons and movies. The aspects of a cave that would elicit a fear of heights are not something that many people would typically stop to consider.

[N]obody seems to link being in a cave to a fear of heights, which is so similar. You can look down over the edge and you’re looking way down, and it’s funny, even though you’re below ground, there’s still an aspect of being afraid of heights. (AA, Researcher/Ability Advisor debrief, May 7, 2010)
This fear was well-founded, but discerning the background information she held to obtain this fear was difficult. Jessica goes on to state:

R: So tell me what else made you nervous about this?
Jessica: The bats. Aren’t there bats in that cave?
R: Are you afraid of bats?
Jessica: Yeah.
R: Have you ever seen a bat?
Jessica: No.
R: So what are you afraid of?
Jessica: Because you know how in movies bats eat people alive! (Jessica, Interview 2, May 3, 2010)

This discussion leads the researcher to believe she was still holding on to fears from her cartoon experiences and was most likely drawing the same experiences, in one way or another, to develop a fear of heights from an underground environment. However, this fear of heights may be a connection to a negative past experience with elevators that she was holding on to. Jessica was not the only participant to be nervous about the elevator:

The elevator makes me a little nervous. I think I would rather be stuck in a cave than an elevator. Yet, I’ve never been in a cave so I might change my mind. (Jan, Journal 3)

I would have to say my primary concern for the trip is rain. My only other main concern is the elevator trip down into the cave as I have heard stories. (Jerrod, Journal 3)

The fear of heights appeared not only during the underground stop of the field site visit, but also during the first stop of the trip, at the overlook to the Sinkhole Plain (Stop #1, see map Appendix E), where several of the participants indicated a fear of heights because of sitting up higher in an accessibility bus than a regular car and driving so close
to the drop-off. Jerry, in particular, mentioned the drop off in both discussion and in his journal.

Jerry: [In the shuttle, when we were…the shuttle is big already so when we were driving on the gravel, there was like this, what is that on the side?]
R: The drop off?
Jerry: Yeah the drop off, it was a big drop off so it was like, we were already leaning over to begin with, so that just freaked me out. (Focus Group Interview 1, May 8, 2010)

Going out of a classroom scene and actually doing something that was fun and still a learning experience was just amazing. At first, I thought I would never be scared of heights, but after we came close to cliffs I was kind of nervous. Subject wise there was nothing difficult, but I would say going across the gravel, and getting stuck in the sand which I thought was quicksand was the worst part. (Jerry, Journal 6).

Fear also emerged from several environmental barriers that occurred naturally during the trip. In the previous excerpt, Jerry also discussed the loose gravel and sand that they encountered at several locations during the trip. Because of their inability to manually free themselves from such environmental barriers, an assertion can be made that this leaves them extremely vulnerable with a feeling of entrapment.

[A]t the end, when I got stuck, I thought that I would never get out. Every time I kept moving forward and backwards, my two front tires kept going deeper and deeper, and I thought I was going to get stuck. (Jerry, Focus Group Interview 2, May 9, 2010)

Evidence of these unanticipated fears surfaced during the first day of the field site visit. The following excerpt is from the Researcher and Ability Advisor debrief at the end of day one.

Jerry and Jessica sound like they have more normal fears or are nervous about things, but what I’m finding interesting is they’re the ones without fears and they
are the most independent. You know the ones that are more independent don’t have to admit yes I need help, or acknowledge that oh, it’s an intimidation factor no matter who you are or what you are and there’s stereotypes. They’ve learned to adapt their life enough to not have someone help them, but they know that in order to do that, they can’t push the envelope.

He was so quick to say yes, but yet he’s worried about so much. He’s afraid of bugs, he’s afraid of heights, [to this point] he’s afraid of [most] of this entire trip, but yet he didn’t ask a single question when he agreed to come. He didn’t know us from a hole in the wall, you know? It’s not like he trusted us. And those are things that you commonly don’t think of when you start thinking about accessibility. We stopped thinking about the fears of the average person, you know, a person without a disability what things you consider for those people and we spend so much time on everything else. (AA, Researcher/Ability Advisor debrief, May 7, 2010)

Implicit and indirect fears also emerged leading up to the first day of the field site visit. These are fears that arose because of the participants being asked too many questions or seeing nervousness in any one of the instructors or MCNP staff, which gave the impression that they should actually have been afraid of something.

I think that was our tension, because like everyone had built it up to being such a bad thing, which I think was, at least for me, caused nervousness in the beginning. (Julie, Focus Group Interview 2, May 9, 2010)

Additional conversation regarding unexpected fears occurred during the focus group interview on the final day of the field site visit. Once the activities of the trip concluded, some of the participants appeared to be more comfortable talking about the issues of fear that they held leading up to and during the field site visit.

AA: Well, Jan had a lot of reservations and she was the one in my office almost daily, and then once you got here, it was like they were all gone.
Jan: Right, because I think we talked about it and prepared beforehand so all the anxiety, once we got here it was ok
AA: Jerry, because I know you the least, you’re the quietest with me; we probably had the least of the relationship. I felt like once you got here, you
had a lot of anxiety, and it was almost backwards. I didn’t expect you to have any fears. And suddenly I was hearing fears of heights and I was seeing fears of bugs. You got here and you did the opposite of Jan! (Focus Group Interview 2, May 9, 2010)

Societal barriers.

During the field site visit, it appeared that the most impactful barrier to the participants became the limitations placed on them from society. Each of the six participants exhibited a sense of frustration with respect to the perceived inability to make sound independent choices for themselves and to be deemed an equal in a social perspective. The question of equality in science professions was presented to them in the early interview sessions.

R: So if somebody like yourself is trying to go into a scientific career, do you think that would be available to you?
Jerrod: I think it is available to me but it is definitely one of those where I feel like the odds are against me. (Jerrod, Interview 1, April 16, 2010)

The following excerpt, which reaffirms a pre-study assumption, depicts frustration shared by many of the participants regarding the separation of their physical and cognitive abilities.

I knew I was different than everyone else, and I wanted to be like everyone else. This goes back to [people thinking that] everybody who is disabled is retarded and don’t know anything. I hate to be negative, but it is what it is. (Jessica, Interview, May 3, 2010)

Julie, the only graduate student of the six participants, had repeatedly expressed interest in wanting to complete a doctoral degree. She felt that with this degree, she would be more respected in the academic community and be able to have an impact on
the lives of others with her expertise and knowledge of living as a mobility impaired individual.

I’m hoping to gain credibility from the world as an equal with my work. This is because the people’s perspective of disability has been negative and oppressive. They [society] think we’re dumb and can’t do anything worthwhile. It has changed and is much better now, but because of that stereotype, it lingers to affect people still. [I hope my major,] with the credibility of a PhD will let me move the disability movement to a higher level. I don’t think that others get what they need because of society. So what I really want to do is help provide ways for them to do what is needed and help change society’s views of us.

(Julie, Interview 1, April 16, 2010)

Julie was very driven to fight for accessibility, and doing whatever was necessary to get what she and others like her needed in order to be successful. She felt that because of her disability, she was oppressed by the limitations of society, but didn’t dwell on the fact. She accepted this perception for what it was and strived to move forward.

_Frustration about lacking control in decision-making._

While planning for the study, efforts focused on providing the most extensive field site experience to the participants. Not only were the participants going to be able to experience the cave through the service entrance of the elevator, but also permissions were granted to take them into the Historic Entrance of the cave; a natural entrance with approximately 100 steps to get into the largest opening of Mammoth Cave National Park. Because of the logistics involved to accommodate six individuals with extremely limited mobility, several volunteers were needed to help carry them into the cave. Additionally, to reduce the overall level of fear and anxiety, the plan had to be presented to the participants in order to allow them to mentally prepare for the activity.

During the classroom portion of the study, information was presented to the participants in increments to reduce any undue stress and minimize fear. The exact cave
and anthropologic features were not provided in detail, but participants were told that there were aspects of this section of cave that were significantly different than any other cave in the world. By the time the field site visit occurred, the participants were eager to go into the Historic Entrance, regardless of the necessary physical difficulties.

Following the stop at the Green River (Stop #2, see map, Appendix E), a discussion was held between the Researcher, Ability Advisor and the MCNP Staff. A decision was made not to attempt the entry due to the limited personnel available to manually carry the participants into the cave. The months of planning and careful preparation with the participants proved to be unfruitful, and the participants were extremely disappointed. Unfortunately, the decision was made by a group of people who were able-bodied and did not consult the experience and expertise of those the decisions were made for. The following excerpts from journal entry and discussions provide evidence of this frustration and allow for implications of future study found in Chapter 5.

I did not like that we could not go into the historic entrance. I understand the reasons why we couldn’t and it made sense for the most part. It was just irritating and frustrating being denied the ability to go when we were fully capable of going and being safe. It underestimates our ability to make decisions. I think that what bothered me the most with not being able to go is that for once I was participating in an activity where I did not feel oppressed. (Julie, Journal 5)

I get how they got to talk to you guys to see you know, what you think, but we came here too, so, it would be cool if [the MCNP Staff] came to us and was like, well, this is what we think, what do you think? You know? (Jerry, Focus Group Interview 2, May 9, 2010)

It could be even themselves having their own fears, if they had to be carried down and their trust issues. Because we all have to trust more than, I guess, the average person. They’re like, I can’t be carried down like that, because they don’t know how to let go. (Julie, Focus Group Interview 2, May 9, 2010)
During the final Focus Group Interviews, the issue of disappointment was discussed with the participants. Without mentioning the lack of personnel to carry them into the cave, the participants mentioned several other factors as potential reasons for the ultimate decision to not attempt the entry. The decision being made without their input resulted in the participants placing personal blame on themselves for their lack of responsibility and preparedness. Additionally, they felt that the park staff rushed into this decision because of having a limited knowledge of the participants’ abilities to transport themselves over obstacles and down stairs without assistance, and an overall concern for the liability of getting the participants into the cave.

I was thinking because I wasn’t responsible for not having my [manual] chair and then I went into the crevasse with [Jerry’s PA] and I was kind of getting stuck. I could see the negative [attitudes] start, like Oh, if she gets stuck like that then we’re not going to risk it. (Julie, Focus Group Interview 2, May 9, 2010)

At first I thought it was like my fault at first, because if you think about it, if you look at everybody else, they are like real smaller than me, so I started thinking, ok, so Jerry, he’s the biggest, so, he’s not going to do it, I mean, he can’t do it. So I started thinking that it was my fault at first. (Jerry, Focus Group Interview 2, May 9, 2010)

[How we can get people to understand that you’re completely able-bodied making a decision for me and you have no idea what I can and can’t do. You have no idea what the trust I have for other people helping me, you know, they don’t have that perception. (Jessica, Focus Group Interview 2, May 9, 2010).

[T]hey really don’t know our limits. I can only speak for myself, my whole life I’ve been going up and down stairs by myself. I would pick up my chair and carry it up the steps by scooting up the steps. I have full body strength in every other part of my body, so it would be no problem if I was going down steps. Even if I had to like, scoot down the steps or anything like that, or come up the steps, for me, it would have been no problem. So for them to say, it’s a safety issue, they really don’t know our limits or anything like that. (Jerry, Focus Group Interview 2, May 9, 2010)
It makes sense, why there was a liability issue, because if something did happen, and that had gotten into the news, and I think that is the biggest fear to them. (Jan, Focus Group Interview 2, May 9, 2010)

Prior to going inside the cave through the service entrance (Stop #3, see map Appendix E) the participants noticed a sense of tension in the MCNP staff. This tension caused an increase of implicit fear to develop in the participants, as previously described in the Fear subsection of Personal Barriers. Tom (a pseudonym), a MCNP staff member, had invested a significant amount of time in the study by participating in all of the preliminary study planning related to the field site visit. It was his responsibility to ensure the safety of the participants and establish a contingency plan for any mechanical failure of the service elevator. In the event of a mechanical failure, Tom had other MCNP personnel on hand to operate a wench-system to extract the elevator and the participants if necessary. To minimize the anxiety within the entire group, the participants were not made aware of these contingency plans.

    Jerrod: When I rode down with Tom, he was nervous, and it actually made me nervous with him being nervous in there.
    Jan: They [felt that they] were responsible for us, I’m sure. So they had to make sure we were safe.
    AA: I don’t know what propagated it. It might have been [the park staff], because when we were coming out, on the last elevator out, I saw a difference in Tom. He was relaxed, he got all of you guys out. (Focus Group Interview 2, May 9, 2010)

Once inside of the cave, this tension continued to build. The participants later discussed these issues by questioning the level of experience that the park staff may or may not have had in past learning situations with participants with physical disabilities.

    Jan: I think Tom was nervous though because when we were down there, he
said, just please don’t go down those steps. I said, I’m not going to go down the steps (laughing).

Jerrod: Yeah, he was really worried. I felt that they really respected us academically, saw our intelligence, but they really didn’t have a lot of confidence in what we actually physically could do, and they were just really worried about that.

R: They were, I think, shocked at how adventurous you all were, you all were just checking stuff out on your own without somebody going forward and checking it out first.

Julie: I wonder how much [the MCNP staff] had worked with disabilities, especially younger aged ones too.

R: So here’s the issue, you all had your own idea about what the cave was going to look like. Perhaps [the MCNP staff] had their own idea about what you guys were going to be like.

Jerrod: I think they seemed pretty surprised when, you know when we were doing the whole, you know how we had to measure the thing, on how we just basically grabbed everything and took off and started going. And when we got back here we were all able to draw it out and do a really good job with it. (Focus Group Interview 2, May 9, 2010)

**Overcoming social barriers: Gratitude of inclusion.**

For many of the participants, inclusion in group activities often resulted in undue stress due to instructional accommodations being ineffectively executed as well as feeling a sense of burden to instructors and peers. These feelings often turned into personal barriers for the participants. The following sections have been included as evidence for participants’ feelings of overcoming such barriers, and the appreciation they felt for being included in an activity designed for them and the feeling community that ensued.

During the classroom portion of the study, many of the participants struggled with the fact that they were being provided an opportunity to experience something they never had, and questioned the trustworthiness of the opportunity. Because of this, they were
unsure of what to expect and waited for the reality of their physical inabilities to hinder their overall experience.

My mind was racing to try and figure out a way to go. This was a place that was not accessible to disabled people. A place that under normal circumstances I being disabled would not be included… and qualifications for this trip was to be disabled. That made me feel good… people were willing to get us to this place and wanted us to go. (Jan, Journal 3)

Because [the research team] has put so much work into this, I am extremely happy and proud to be participating in it. It makes me feel good that people are attempting to make things accessible to me. Having this trip shows me that attitudes are changing for the better and positive attitude changes in any ways gives me hope for the future PWD. (Julie, Journal 3)

Once the participants realized that the reality of the experience enabled them to do exactly what was being presented to them in class, they became more comfortable about their role in the study and provided strong evidence of the value in their journals and interviews. “It was not like anything I have experienced. The experience made me feel like an important team member.” (Jerrod, Journal 6)

This whole class and trip was so disability friendly. Actually, it wasn’t just disability friendly, it was a place and time where I was accepted as me and the disability was just a part of the package you see. It wasn’t an add-on, bonus feature or a defect, but a characteristic, just like I’m Asian American. In this environment, I was given for the first time the ability to be myself and learn about it without any stressors pertaining to disability. I’ll be honest, it was really strange for me at first. (Julie, Journal 5)

I loved it, because, many people don’t get to go down there who are disabled. (Jessica, Focus Group Interview 2, May 9, 2010)

I felt like it really was tailored for me, to do everything (Julie, Focus Group Interview 2, May 9, 2010)
This is my first experience where I did the work…and I will never forget how to map a cave! I loved mapping the cave and had such a feeling of accomplishment when the boys map fit perfectly to our map! (Jan, Journal 6)

This experience by far was definitely the best because I actually had teachers who were willing to teach me everything the cool way like everyone else. I liked that unlike other experiences I’ve had that I did not have to lead the lesson or demand to be given the opportunity to have an out of classroom lesson but actually was taught and guided by people who knew what they were doing. [R and AA] were more worried than they needed to be and were ready to take on the worst-case scenario or just go with whatever happens. I loved that they were prepared for us and had extremely positive attitudes about working with us. There was absolutely no sense or feeling that we were a nuisance, burden, or an overall pain to be taught because of our different needs. (Julie, Journal 6)

My thought on the study of geology are different now that I have gone thorough with this study. I now view geology as not only very practical but also as a science that can be accessible to students with disabilities. At the beginning of this course I assumed the opposite. Also I view geology as a field that uses the scientific method as much as any field. When in the cave, hypotheses were developed, data was collected, then the data was interpreted and plotted. As far as traveling outside of the classroom to learn, this was a very enlightening experience. I was able to take something learned in a classroom and apply it to a real life situation. This experience cannot be put into words as it was such a fantastic experience. I learned more in two days then I could ever learn from a book or in a classroom setting. It is one thing to hear and read about something, but to actually see it is downright awesome. (Jerrod, Journal 6)

I now find geology extremely intriguing and get excited each time I see news articles about it. Throughout this whole experience, I have questioned whether I would have actually pursued geology if I was given the chance to do it and was told I could do the work. I felt like a little kid learning things for the first time and I absolutely loved it. I felt like I was given a real chance to learn material the way it should have been presented to me the first time. I loved going out in the field, too. (Julie, Journal 6)

Once I thought geology was all about fieldwork. Now I know that geologist work in a variety of settings that include offices, laboratories and classrooms. A disabled person could easily do the job. (Jan, Journal 6)
Development of a community.

Early in the study, the comfort level between the participants was evident. The level of teasing one another created an easy, fun atmosphere almost immediately, and continued throughout the study. “It’s good to see that we’re all here for each other, but we’re all going to laugh at you if you fall over.” (Jessica, Focus Group Interview, May 9, 2010). Additionally, the participants were equally inclusive of the instructional staff, and focused just as much banter on the researcher and Ability Advisor as they did their peers.

I was actually worried that it was going to be something that was not that adventurous. I mean when you first told us about it you were wearing a new suit. I guess that was a rare occasion. (Jerrod, Interview 2, April 30, 2010)

However, despite the abundance of teasing within the group, there was a significant level of sincerity in the way that relationships were being forged between everyone associated with this study.

Julie: I find it really interesting, we may have not said it to each other or anything like that, but when we were all out there, it seems like a lot of us just looking at each other, like kind of all of us had each others’ back, in a weird way, I don’t know if any of you had that same sense of feeling Even though that is not our focus, there is so much team building right here in this environment and it’s out in the nature, you know, and just having that little thing last night was so much more [than in a team-building exercise for a mentoring class], because we had to work everything out, and just doing it individually. It was great.

Jerrod: Yeah, we build off of each others’ strengths.

Julie: All of us working together, that’s what I love the most how close we have all gotten we were all looking out for each other.

Jerrod: I was thinking about how I could tie Jerry up with the back of my chair and pull him out of the ditch. I would have pulled you out Jerry. (Focus Group Interview 1, May 8, 2010)
In her final journal entry, Julie described something much deeper than the community that developed as a result of this study. She discussed a social “hierarchy” that is perhaps is an issue that many people with disabilities face every day that might not be so common for their able-bodied peers. The following excerpt provides evidence for a significant variable in the need to make field-based learning opportunities accessible for all students, regardless of their physical abilities.

I would tell other people who are mobility impaired to try an experience like this. I’d let them know that they need to go into it with an open mind and let go of any negative attitudes or feelings pertaining to their disability, others with disabilities, and outside work. I’d also like to tell them to get throw away the disability social hierarchy and all of the judgments that go with it. Yes, this class was for just PWD, but we are much more than that hierarchy. We are individuals that look out for each other and work together. I am so happy and glad that we all got along and formed a bond. (Julie, Journal 6)

**Environmental barriers.**

Discussions occurred leading up to the field site visit regarding the common environmental barriers often encountered in everyday living. The participants were then required to elaborate on their thoughts of expected barriers to the field site through journal entries. Related to past experiences or their general perception of cave accessibility, the following excerpts show the participants’ feelings of limited opportunities for cave exploration prior to becoming part of this study.

It is not fun to go somewhere that should be exciting only to end up disappointed because it is not wheelchair accessible. (Jason, Journal 5)

I do remember on a family vacation about 8 or 9 years ago - I think it was in Virginia or Maryland, I was unable to tour a cave with my mom because it was not wheelchair accessible, so I waited in the gift shop for everyone. I guess caves are the one and only attraction that I always missed out on. (Jason, Journal 3)
When it came to talks about caves I’m pretty sure I didn’t pay as much attention because I never thought I could actually do or see the caves hands-on because of my disability. (Julie, Journal 1)

**Field site barriers.**

Once the field site experience occurred, the participants were capable of articulating the physical barriers to the environment more clearly. Typical barriers that were common structural and environmental obstacles regardless of the location in the environment, as well as more personal issues that would become a barrier for anyone, regardless of ability, were apparent during the field site visit.

Another difficult barrier was getting in and out of the van in some areas. Sometimes I would slide out of my chair because the ramp wasn’t level due to the gravel and grassy surface. Another difficult area for my chair were the entrances to both the research center and place where we slept. The doorway was raised which made it difficult to get in and out of both places. Also the women’s toilet was not functioning so it became a barrier to me because I had to use the men’s restroom which made it frustrating to both me and the guys. (Jessica, Journal 6)

After day one, the participants were asked to discuss the barriers they experienced so far during the trip. From their vantage point seated in a wheelchair, the participants were unable to see over such common obstacles as hand railing. When asked to discuss the barriers at the overlook (Stop #1, see map Appendix E), Julie provided the following: “To see? The [hand] railing [was blocking my view]” (Julie, Focus Group Interview 1, May 8, 2010). Jan also discussed this when she was explaining her disappointment of having a good view at the overlook: “I wanted to see what everybody else who was taller was seeing” (Jan, Focus Group Interview 1, May 8, 2010). Additionally, while in the cave and discussing the 150-year old artifacts that can still be found in the cave today, Julie talked about her frustration of accessibility and not being able to look more closely
at the objects: “The only thing I wished to do was climb up on the ledge where the wine pieces and chicken bones were laying” (Julie, Journal 5).

Other environmental barriers included traveling on unconsolidated terrain and the constantly changing surfaces both in and out of the cave. To someone in a wheelchair, mobility is dependent upon the surface conditions. When those conditions are uneven or compromised by loose sediment or even small objects, anxiety will quickly rise.

Uneven gravel walkway is like quicksand for someone in a wheelchair - the heavier a person plus his wheelchair is, the harder it is for anyone to help him. When this kind of situation happens to me, I get mad, upset, disappointed, and I don't care if I ever come back. (Jason, Journal 5)

The most difficult barrier in the cave for me was the dusty conditions, cold climate, and the low lighting. Also, some of the dirt was hard to navigate through and I almost got my chair stuck in a patch of sand. (Jerry, Journal 6)

Jan: I’d say that the loose gravel is what bothered me the most.
Jerry: [W]ell, I couldn’t even back up, my big wheel was like spinning in the gravel. Then when we were leaving, there was like a little dip still in the gravel, that I still got stuck on, and then he had to pull me out of there so I don’t know, I just don’t like gravel.
Jerrod: [A]nd not to mention all of the weights in the center of them which was definitely a problem for that gravel. Because not only did we have the small wheels sinking in, the center of it sinking in and you get stuck, and it’s kind of a small path to turn around on which was somewhat of a nuisance. (Focus Group Interview 1, May 8, 2010)

Situations even arose during the study and became accessibility issues, which could not have been controlled for ahead of time. Just one week prior to the field site visit, the entire region was hit with massive rains and flooding, so much so that the Green River crested well above flood stage. In fact, the Army Corps of Engineers stated that it would be considered a 1000-year flooding event (Marcum, 2010). Nashville, merely an
hour drive-time from the field site was declared a Federal Disaster by President Obama (FEMA, 2010). Although the water had receded enough to continue with all aspects of the field site, the disaster affected several features of the experience.

Jan: It would have been nice to have packed down dirt, a little bit more accessible, but I don’t know if you could do that because of the flooding.
Jessica: Yeah, and there was mud on the railing, so you couldn’t lean on the railing.” (Focus Group Interview 2, May 9, 2010)

Summary of Analysis

This chapter has provided a thick description of the six cases, along with qualitative and quantitative evidence needed to respond to the preliminary research assumptions and support the primary research questions of this study. Conducted through the structure of transformative learning and experience-based education, the data was analyzed according to the preliminary themes of participant attitude, content knowledge, and experience. Secondary themes emerged from the initial analysis and were presented in the various sections of this chapter.

Chapter 5 will present a discussion of the impact of the data collected from this study on each of the three main research questions. Additionally, contributions of the current study are aligned to main points of the literature presented in Chapter 2. Limitations and delimitations of the current study will be presented along with a discussion of suggested modifications to studies of similar designs. Finally, the next chapter will close with a discussion of implications of future research as it is directed towards multiple levels of education.
Chapter 5: Discussion

The significance of this study is that common methodologies are aligned to an uncommon research focus: developing an accessible geoscience field-based learning course that both accommodates and includes students with mobility impairments. Through a combination of previous literature and the evidence of the current study, this chapter provides a discussion of the assertions made for each of the primary research objectives and four additional research assumptions that were posed in Chapter 1. As mentioned in Chapter 2, the following sections provide an overview to how this study was framed according to Transformative Learning Theory (TLT) and the instructional aspects of constructivism and conceptual change as related to experiential education. The chapter concludes with a discussion of the study’s limitations as well as implications for future research.

Connecting to the Literature

During the development of this study, previous research literature was assessed for evidence of accessibility, inclusion, and accommodation of students with mobility impairments in field-based geoscience courses. The following sections revisit the primary aspects of experiential education, novelty space and the fragile nuance of students with mobility impairments.

Obtaining the experience of learning in the field is an important aspect of geoscience curriculum (Elkins & Elkins, 2007; Garrison & Endsley, 2005; Libarkin & Anderson, 2005; 2008; McKenzie, et al., 1986; Orion, 1993; Potter, et al., 2009; Thomas & Roberts, 2009; Thrift, 1975). However, very few studies provide evidence for the
importance of inclusion and accommodation in traditional field-based learning courses.

“[E]xperience is essential to a good science and engineering education. The student with a disability should be encouraged to participate” (Summers, 2003). This study provides valuable evidence for the necessity to both accommodate existing field courses as well as include participants with physical impairments in the planning and development of accessible field studies. As described by Dewey, experience is a relationship between the individual and the environment (1938). The findings of this study report the experiences of participants with mobility impairments within a geoscience, field-based learning environment.

Conducted under the framework of TLT, this study was directly related to the aspect of experiential education. Throughout the study, participants were highly encouraged to think for themselves, while the study design also provided the opportunity for equal ownership in the outcomes of the study and allowed for the growth of trust and autonomy within the group (Eisen, 2001). While generating an accessible experience for the participants of this study, a critical transition occurred during the field site visit that both aligns to the literature of promoting active learning over passive instruction in geoscience education courses (McKenzie et al., 1986) and offers transformative opportunities for reflection (Mezirow, 2003). This transition occurred during the cave mapping exercise, with the participants actively engaged in scientific exploration. Although not directly measured, the construction of knowledge obtained from the experience of this activity was, perhaps, stronger than any passive instruction about the creation of geologic cave maps and their value in understanding the cave environment.
During the study, participants were presented content through both classroom and field-based instruction. While in the field, the participants spent a considerable amount of time listening to geoscience instruction and making individual and group observations, relative to that instruction. However, once the participants were required to construct the geologic map of a section of the cave, transformative learning occurred. The group activity of constructing the cave map, described in Chapter 4, allowed the participants to socially construct meaning from the experience through two of the primary tenants of TLT: internal reflection and communication (Mezirow, 1997). As described in one of the propositions developed by Mezirow (1997), transformative learning experiences require the learner to negotiate personal subjectivity and express one’s own values, perspectives and understanding rather than accepting those of others. While working as two autonomous data collection groups, the participants collaboratively negotiated the process of recording the cave measurement data for use after the field site visit concluded. To do so required communication skills that were not simply agreeing with someone else’s judgment, but having a voice in the collaborative process. As a result of this experience, the participants also enhanced their ability to critically reflect, both individually and socially as a group, through interviews and journal writing.

This cave mapping activity also provided opportunities to observe the aspects of socio-cultural context within the participants, as well as the development of a group dynamic. Discussed during the Development of a community section of Chapter 4, the participants were surprised by their own relationship building and how the group congealed during the experience. Additionally, as evidence of Julie’s discussion of a disability related “social hierarchy” (Julie, Journal 6), some were aware of and often
discussed the sociological differences between them as a result of their diverse physical abilities. The aspects of socio-cultural context and the development of group dynamics, both important characteristics of TLT, also provide rationale for the learning transformation, which occurred during this study.

During the class discussions and cave mapping exercise, the participants modeled the aspects of social construction of knowledge in which they relied on one-another to both assimilate the new content with their own prior knowledge structures, but also constructed, or accommodated new meanings and understandings through the social perspectives of their peers. The theoretical aspect of conceptual change suggests that original cognitive dissonance was reduced when the participants were required to support their own knowledge in the face of conceptually different perspectives during the discussions and instructional activities. Through open communication and trust, as related to transformative learning, changes in perspective and content knowledge occur socially, and internal meaning structures become more established.

In Chapter 2, an assertion was made that students with mobility impairments should not be considered fragile, and unable to perform the same tasks as a traditional, able-bodied student in geologic field-based coursework, but rather as specialists of a physical environment that presents ever-changing barriers to everyone, regardless of physical ability. These students offer an alternative perspective of reality. This study provides evidence that participants with mobility impairments may offer an extraordinary perspective in the development of field-based instruction, and perhaps an enhanced capability in spatial awareness developed as a result of their diverse physical perspective and world-view. These students should be considered collaborative learning partners,
providing a field-based perspective of the physical environment that able-bodied students may not often consider.

Equally important to mention in this discussion of participant identity are the concepts of Novelty Space (Orion & Hofstein, 1994) and Embodied Fieldwork (Nairn, 1999), both included in the discussion of Chapter 2. Novelty Space is an understanding of the geographic, cognitive and psychological barriers that students negotiate during the field-based learning process. Embodied Fieldwork is an understanding of how the rigor of performing fieldwork impacts the student, both cognitively and physically. The aspects of Novelty Space and Embodied Fieldwork are both important variables to the overall field-based learning experience. During the current study, these aspects enabled the participants to begin developing a personal identity previously unknown to them: a field-based geoscientist.

Each of the participants brought their own perspective, prior understanding, and expectations into the experience of this field-based learning opportunity. Just as essential to content knowledge are the aspects of psychological and environmental barriers that each of the participants negotiated due to their participation in this study. Any student who conducts geologic field study, regardless of their physical abilities, is faced with field-related barriers as part of their individualistic learning experiences. Presented in further detail in the response to research question #3 in this chapter, the participants were dealt multiple challenges in completing the field-based learning experience and constructing geoscience content knowledge. Novelty Space and Embodied Fieldwork are both inherently more complicated for students with physical impairments attempting to complete a traditional geoscience curriculum. The evidence obtained as a result of their
involvement provides insights for instructional improvement, which are also presented later in this chapter in the *Implications for Future Research* section.

**Response to Research Objectives**

This section discusses the outcomes of the study as they are related to each of the primary research objectives, followed by an explanation of the preliminary research assumptions presented in Chapter 1.

**Research objective #1: Common cave misconceptions.**

**What are common misconceptions of caves?**

Used in conjunction with qualitative interviews and participant journaling, to provide evidence for this first research objective, the CKAA was developed out of necessity as a measure of attitude, experience and content knowledge assessments for cave and karst understanding. However, as this study appears to be the first documented development of an instrument to understand misconceptions surrounding cave and karst content knowledge, much more detailed information is needed. With multiple constructs in the current instrument, the CKAA could be divided into a content measure as well as an attitudinal assessment regarding field-based learning in a cave environment. The validation of the instrument has only been initiated as a result of this study, and will need additional rounds of revision and testing.

During the analysis of the CKAA, pre-assessment results indicated that the participants’ knowledge of cave and karst features measured higher than those of the validation group to whom they were compared. This higher score could be related to a few factors. First, the participants involved in this study were aware, before the class sessions began, that the content focus was cave and karst systems. Knowing this ahead
of time and given their need for information regarding pre-planning of accessibility issues, the participants could very well have began studying aspects of caves before taking the pre-assessment. Also, while the validation group was asked to provide 15 minutes of their time to take an assessment, with no compensation in return, the responses provided could have been submitted without much thought to the questions. Without having more data for comparison, this difference will remain questionable until the study can be continued with more participant resources for validation.

Initial results of the CKAA indicate that common misconceptions about cave and karst systems cover a wide range of concepts from cave conditions to life found in caves. The participants held naïve views of conditions inside of the cave; expecting the entire environment to be cold, wet, and dark with stale air and bats swarming the stalactite-covered walls. They expected to see pools of water and water flowing out cracks and down the walls. Expectations were also held that the cave would be so small that mobility inside of the cave would be hindered due to the narrow passages and low-lying ceilings. However, these conditions were not what the participants experienced, as provided in the Field Site Conditions section of Chapter 4. This understanding is not completely misconceived, as caves commonly possess these features. The misconception lies within the fact that the participants only expected to experience the cave conditions they had imagined.

**Research objective #2: Experience and the construction of knowledge.**

*How does participation in a field geology experience about caves affect the construction of knowledge by students with no experience and limited content knowledge about caves?*
When data for this particular objective was analyzed, inconclusive evidence was found to support any definitive response to this question. Due to the lack of a true control group, data obtained were not compared to a control group that would provide evidence for a measureable effect based on first-hand field experience and increased knowledge gains. In retrospect, multiple groups of participants with similar demographics would allow for a true experimental design to include randomized control and experimental groups. In order to maintain equal and ethical standards of instruction for a control group population, a delayed treatment method would need to be instituted. To do this, multiple trips to the field site would be needed to ensure that both groups were given equal access to the instructional experiences. The cost and time needed to pursue a delayed treatment method within this study would be significantly greater than what was covered through the external funding allocations. Additionally, this type of design was not possible given the constraints of utilizing a specialized participant population.

As a result of this field experience, participants used observation and interpretation skills that required higher ordered thinking that could only come from the field-site experience. The participants collected measurement data about the internal features of the cave in order to construct a geologic map. The success of their work was easily verified when the map the participants created was a close replication of the official geologic map of the cave created by the Cave Research Foundation. Additionally, with limited content knowledge and no prior physical experience of the field site, these participants were able to develop interpretations involving a sense of geospatial understanding many geoscience students struggle with. As a result of the both the instruction and experience gained from this study, the participants increased their
content knowledge of geoscience processes relative to cave and karst systems. Although not statistically significant, the improvement in knowledge from pre- to delayed-post assessment showed a measurable increase, as provided in the evidence in Chapter 4.

**Research objective #3: Barriers to field-based learning.**

What internal and external barriers do students with mobility impairments perceive regarding access to and studying within cave geology field environments?

As expected, several barriers were identified that were associated with taking students with mobility impairments into the field. While some were environmentally related, which were mostly expected, personal and societal barriers figured prominently in the outcomes related to this study.

As discussed in previous chapters, a motivation to learn science pre- and post-assessment was administered to the participants to determine if motivation could be considered as a personal barrier in choosing against science as a potential field of study. However, the analysis of each of these assessments provided evidence that the participants’ motivation was not only high after the pre-test, but had a measurable increase as a result of the experience. Motivation as a personal barrier for the participants not choosing to become science majors was therefore discounted as a potential barrier.

Primary barriers of this study included fears of entrapment generated from issues with various ground surfaces (gravel, sand, uneven surfaces) as well as a fear of heights, both in and out of the cave. Additionally, a significant dissatisfaction surfaced with respect to decisions that directly impacted the participants being made without allowing them to provide any input. Regardless of their physical appearance, individuals with
physical impairments have abilities that are commonly not considered by people who are physically able-bodied. Not considering the participants as having an equal say in decisions that directly involved them created frustration and anger towards those making the decisions. These personal and societal barriers were unanticipated through the design of the study and provide opportunities for further research with a much broader population of students with physical impairments who are faced with field-based learning requirements.

**Reflection on Preliminary Research Assumptions**

Prior to beginning the study, the researcher identified several preliminary assumptions related to the objectives of the study. Each of the four assumptions presented at the beginning of the study is listed and accompanied by evidence to support the validation of them.

**Assumption #1: Most geologic field sites (caves in particular) are not easily accessible to persons with mobility impairments.**

With over one and one-half years of logistical planning to ensure a successful field excursion for these participants, this experience was not without disappointment. The original plan for the field site visit included two excursions into the cave, at different entrances. With the exception of the one service elevator entrance, every entrance to the cave is only accessible by way of sets of long, and often, narrow stairs. The various entrances to the park were not developed to be accessible, and modifying them to be accessible is simply not feasible. However, once inside the cave, visitors are often surprised to observe smooth, paved and well illuminated paths on many of the tour routes that would accommodate visitors with mobility impairments.
Permission was obtained from the administration of MCNP to manually carry the participants into the Historic Entrance, which involved several discussions both with the MCNP park staff as well as the participants to ensure that everyone’s personal needs and safety concerns were considered. However, after arriving at the field site, on the second day, a decision was made not to attempt access into the Historic Entrance. This decision was made for three reasons. First, since there are no current accessibility tours at MCNP, attempting the entrance in full view of the public would undoubtedly raise questions regarding the availability of similar tours for other potential visitors with mobility impairments that the park was not capable of accommodating. As a result, the only permissible times that the participants could go into the Historic Entrance were early in the morning (6:00 am) or late in the evening (9:00 pm). With limited lighting at the entrance, descending over 100 steps with poor lighting became a major safety and liability concern, which was the second reason for the decision not to attempt the entrance. Finally, even if the decision was made to progress with the Historic Entrance visit, the manpower available to move six participants into and out of the cave was less than was physically required. According to the park’s administrative request, six people were needed for every participant being carried, in order to maintain safety. Given these considerations, the decision was made to not attempt the Historic Entrance. This decision was made without consulting with the participants, which immediately caused frustration among the group.

Assumption #2: Direct educational experience in geology leads to stronger understanding: A lack of experience is a factor in the construction of knowledge misconceptions.
Due to the design of this study, evidence needed to support this assumption was obtained during researcher observations of the participants during the cave mapping exercise as well as individual and focus group interviews during and after the field site visit. As discussed previously, the transformative learning that occurred as a result of the cave mapping activity confirms that the construction of knowledge and understanding were clearly impacted by active learning rather than passive instruction. While some of the participants were completely unaware that such maps were even necessary, obtaining the first-hand experience in collecting geologic data and creating the cave map enabled them to understand the value of such geologic tools for geologists who use them during exploration of the environment and interpretation of cave and karst formation.

Additionally, the results of the post and delayed-post GCI as well as the post CKAA assessment may have also been impacted by the field-based learning experience. The combination of classroom and field experience produced gains in content knowledge measured by these two instruments. However, the exact factor of the knowledge gain remains unknown and provides implications for future research.

**Assumption #3: With limited opportunities for accommodated field-learning experiences, students with mobility impairments are uninterested in studying content that requires field study components.**

Evidence showed, through the many interviews, observations and interactions with the study participants, that many of the participants felt they were not capable of pursuing undergraduate degrees in the geosciences, let alone considering careers in geology. However, this feeling was not developed as a result of their physical limitations; but rather, the social stigma of logistical accommodation and liability combine for a lack of field-based learning opportunities made available to them. Once
many of the participants became involved in this learning experience, they were awakened to a new world of possibilities that they had failed to fully consider previously.

**Assumption #4: An individual’s cognitive ability is independent of their physical ability.**

Of the previous assumptions held prior to the start of the study, this is perhaps the one that was securely maintained and perhaps strengthened by the evidence obtained. Of the many instructional activities, both within the classroom and during the field-site visit, the participants were fascinated with the level of inclusion and accommodation made to allow them to fully participate. To the surprise of the instructional and park staff at the field site, the participants were eager to learn about the environment, and were full of questions and responses. Additionally, during the cave mapping exercise, although each of the participants scored differently on the content knowledge assessments, the participants were able to work with very limited instruction to collect geologic field site data. This field site data was used to construct a geologic map of the cave site that closely resembled the map professionally created by the geoscientists of the Cave Research Foundation.

**Limitations of the Current Study**

This section describes several limitations related to the study design.

**Research design.**

The researcher originally envisioned a large quasi-experimental study with experimental and control group participants in sufficient numbers to support statistical comparisons. The reality of recruiting an experimental group of participants with mobility impairments with the necessary sample size for quantitative measures caused the researcher to change the plan to a qualitatively rich case study design. However, the
benefit of this scenario was that because of the smaller sample of participants, the level of thick, qualitative data promoted a deeper, more realistic understanding of each individual involved.

**Limited duration of study.**

The duration of the entire study was eight weeks. Given the qualitative nature of the research design, the amount of sustained interaction that the researcher conducted with the participants was adequate for prolonged engagement (Lincoln & Guba, 1985). Limited interaction with the participants presented only minor internal validity concerns with respect to the richness and authenticity of the data being collected. However, most of this limitation of personal interaction with the researcher was overcome by the inclusion of the Ability Advisor into the logistical planning of the study. The Ability Advisor, as discussed in Chapter 3, had previously established a trusting relationship with many of the participants through her role as a comprehensive advisor. Having a confidante present during the various planning phases of the study alleviated any anxiety of interacting with an unknown researcher from the beginning of the study, placing confidence in the group that the participants’ needs would be met.

**Able-bodied bias of researcher.**

Taking an objective role in a qualitative research study is extraordinarily difficult. As described in Chapter 3, the background and bias, as well as the limited research experience of the researcher must be listed as a limitation of the study.

**Generalizing the current findings.**

As with any qualitative study, the goal is not to generalize the research findings to a broader population. Although this dissertation reports the experience of six
participants, the informative data can provide guidance to other researchers who wish to engage students with mobility impairments in a variety of field-based learning experiences. Additionally, the findings made within this study can now be used as pilot data in the design of a much larger study.

The initial validation measures of the CKAA instrument provides insight into the primary factors of development for an assessment tool that did not previously exist. Although the quantitative data collection and analysis of the CKAA instrument development maximized the use of resources available, the investigation did not include enough respondents to adequately generalize the findings into a fully validated assessment instrument. As such, with improved participation and a modified instrument grounded in the results of this study, the CKAA instrument validation will be continued in future work.

Regardless of any such limitations, this study provides solid evidence to support the need for additional research in the areas of access and inclusion for students with mobility impairments. Additional examination is also needed to validate the use of virtual field trips as a supplemental alternative for field-based instruction.

**Implications for Future Research**

This study attempted to give an emancipatory voice to a commonly marginalized population of students relative to geoscience field-based education. Although findings in this study cannot be generalized to a broader population, aspects of this research may be beneficial in multiple levels of education. The following sections describe the implications for future research based on the findings in this study in geoscience education.
**Elementary and secondary education.**

Virtual field trips are becoming more prevalent in elementary school settings (i.e. Virtual Trip to the San Diego Zoo, Mrs. Deisher, 3rd Grade, Helke Elementary, Vandalia, Ohio). Such virtual field trips would begin providing first-hand experience of geologic phenomena for students studying rocks, minerals and fossils for the first time. Perhaps a trip that takes them to a sedimentary outcrop at the Grand Canyon National Park, a glimpse of the fossils at Dinosaur National Monument, or perhaps seeing the formation of igneous rock in real-time at Mt. Kilauea in Hawaii would provide a glimpse into a real-world experience that would promote the scientific engagement for students who might otherwise lack interest in pursuing scientific careers. Given obvious logistical, financial and liability constraints, physically taking an entire elementary class to any of these locations would clearly be impossible. Additionally, with the limited time allotted for science instruction, virtual field experiences would provide quick, meaningful and memorable experiences for students observing the basics of many science disciplines for the first time. Students can get these experiences without ever leaving their classrooms, and not even miss their afternoon recess!

These experiences should not be limited to elementary students, however. Secondary education is limited by the same constraints of time, money, liability, and the potential interference with other instructional coursework. The difference is that many of today’s innovative schools have more specialized courses focusing on the earth sciences. Some of the more progressive schools, including many alternative Science, Technology, Engineering, and Mathematic (STEM) institutions, provide extended trips for field instruction during spring, summer and winter breaks. The cost for these trips is typically
supplemented through fundraisers and by the families of the students. These courses, however, are most likely not accessible for students with various physical impairments. This suggests opportunities in both access and inclusion using both traditional field experiences and field trips using immersive virtual reality for all students, regardless of physical ability.

**Higher education.**

In secondary education, access to science content is covered with inclusive educational classrooms and differentiated instruction for students with special needs. However, students with physical disabilities are often left out of post-secondary instruction that have out-of-classroom and field-based learning requirements. Once they enter post-secondary education, students are often separated by physical ability. Very few opportunities exist for students with disabilities to learn in traditional field courses outside of the necessary resources within a controlled classroom setting. Those who have physical limitations may be reluctant to pursue fields-of-study that require coursework in field-based instruction because of the lack of true accommodations to support full inclusion into the instructional culture of the course. With evidence obtained from this study, however, once given the opportunity to participate, students with mobility impairments may be more interested in pursuing courses that require field-based learning requirements. Access and inclusion in field-based learning environments continue to be major issues that need to be addressed in research and instructional design in higher education.
Disability studies.

This study provides evidence for the capabilities of and potential for collaboration between disability studies and the various disciplines within the geosciences. The concepts of Universal Design, which aims to provide equal, barrier-free access to the environment, is currently being enhanced with respect to access to formal and informal learning environments (National Research Council, 2009). Technological advancements in geologic data management and presentation can also allow students the opportunity to pursue careers in the geosciences that require them to make interpretations of geologic formations that they are physically unable to traverse. Thus, an even greater awareness needs to be promoted for students who have interests in the sciences and feel that they cannot complete the course requirements due to their physical abilities.

Additionally, as discussed in Chapter 2, conducting a study with six individuals with mobility impairments provided insight on the development of field-based learning opportunities. Without the added perspective of these individuals, a study would merely be developed through an able-bodied perspective, missing full opportunities for inclusion, accommodation and access. The reciprocity that occurred from the diverse perspectives within this study provides a wealth of future opportunities for additional research in collaboration between geoscience education and disability studies including not only research perspectives, but also student perspectives.

Geoscience education.

With improved resources and a larger participant sample in a future study, the natural progression of this research will be to build a standard of accessibility and inclusion in field-based learning environments. Due to the evidence provided in this
study, the researcher argues that the culture of geologic field work must be redefined in order to be more inclusive for learners with mobility impairments. The disadvantages of current field-based educational practices include the individualization (Lawrence, 1998, p.2), or labeling of students who do not fit the persona of a young, able-bodied field researcher, with good cardiovascular endurance, as being ‘disabled’ for most field-based educational experiences. This must be transformed from the discriminatory notion that the problem lies with the student, to there being an issue with the field environment. Including the first-hand perspective (lived experience) of students with mobility impairments in the development of supplementary, alternative field-based learning environments will provide new options for inclusion of students with mobility impairments that should be explored and developed.

   Constructed to acquire the perspective of the participants, this investigation obtained a deeper understanding of the accessibility needs of students with mobility impairments. Additionally, through the direct experiences of these participants, this study addressed the aspects of potential personal, environmental, and societal barriers students with mobility impairments may encounter in traditional undergraduate geology field courses. The researcher hopes that this work will further inform the broader research community on understanding the importance of the qualitative aspects of field-intensive coursework design for non-traditional students.

   Virtual field environments.

   Learning the geosciences in its natural field-based environment setting has no substitute. However, due to various departmental constraints, fewer opportunities for students to study the geosciences in traditional field-based learning experiences are
anticipated. The current factors that are threatening to change the traditional nature of geologic field experiences in geoscience education are not uncommon, nor are they new issues. The changing future of geologic field work has been a concern for several decades. Don Thrift spoke of the current issues that threatened the use of geologic field study from an article in 1975: “budget problems, liability concerns, reports of poor educational experiences on past field trips, or just general apathy in regard to the multitude of benefits which can be derived from a well organized field trip” (Thrift, 1975, p. 137). However, to overcome the logistical constraints on geologic field study, technological advances being made in imagery and visualization, as well as understanding earth’s processes through animations and simulated experiences appear to be having an impact on field-based learning.

Virtual trips offer utilities that are an advantage to all students, regardless of their physical abilities. Virtual field studies may enhance existing field courses in either pre-trip content knowledge acquisition, or post-trip review of concepts. All students may profit from using virtual or hypermedia materials to explore familiar territory at their own pace, expanding on things seen and catching up on things missed in order to make the field excursion a more worthwhile experience (Holt, 1996). Instead of using synthetic materials to replace an existing field course, a necessary investigation would be to assess how such materials might either enhance preparations of a traditional field study and/or act as a review of the field site after the trip concludes (Spicer & Stratford, 2001).

Currently, internal Light Detection and Ranging (LIDAR) scan data from portions of Mammoth Cave National Park are being used to begin developing a virtual re-creation of the field site in order to accommodate significantly larger student populations. This
data will be developed into a virtual recreation of the physical environment providing field-based learning experiences for anyone, regardless of their physical abilities, unable to visit the field-site associated with this study.

As described previously, virtual field environments have the potential to radically modify the way geoscience education is presented to all students, regardless of their physical ability. Accessibility to field-based learning environments should not prevent students from pursuing careers in the geosciences (Cooke et al., 1997). These synthetic environments have the potential to enhance the geoscience curriculum by focusing on technology-based interpretations of new and archived geoscience data sets. Cooke et al. (1997) suggests that most modern geoscience careers utilize lab-based inquiry as a primary means of geologic interpretation, and do not require all members of an interpretation team to collect observational data from an external field site, but instead have an understanding of how field data are collected. With this in mind, given the potential for developing an interpretation-based geology curriculum based on preliminary geoscience data, an argument could be made that becoming an expert geoscientist without direct, traditional fieldwork experience is possible. A future vision of field-based geoscience curricula could suggest that this advanced, technology-based interpretation track is geared towards career-minded students regardless of their physical abilities. Technology is now making science more accessible for everyone (Summers, 2003).

In consideration of equal access to all students, virtual trips offer utilities that can be an advantage for traditional and non-traditional students alike. As noted previously, a reasonable assumption exists that virtual field studies may provide alternative ways to enhance existing field courses in either pre-trip content knowledge acquisition, or post-
trip review of concepts. Current students would profit from using virtual or hypermedia materials to explore *familiar territory* at their own pace (expanding on things seen and catching up on things missed) in order to make the field excursion a more worthwhile experience (Holt, 1996). Instead of using a virtual tool to replace an existing field course, these materials would either enhance preparations of a traditional field study and/or act as a revision tool after the trip itself (Spicer & Stratford, 2001). Even more so, virtual field trips will present opportunities for students who do not have access to the field, either because of financial or distance barriers or physical limitations.

However, from the geoscience departmental perspective: why spend all of the money to develop virtual field excursions for such a small return on investment? Perhaps the answer rests within the idea that with increased opportunities for access and experience lies increased consideration to pursue geoscience courses, majors and careers for often marginalized, non-traditional students. Additionally, once developed, the expense to maintain and update these courses would be minimal, benefiting both the department and the student through a field-based course enhanced with synthetic resources without the cost and logistics of physically going to the field site. Certainly more research is needed to understand the effectiveness of utilizing such innovative instructional techniques in traditional geoscience coursework.

**Summary**

Evidence presented in this study suggests that once given the opportunity, students with physical disabilities are eager to participate in scientific field exploration. However, several barriers exist with respect to the logistics of field site planning as well as the physical field excursion. First, students need reassurance that the field site is
accessible. As much planning as is involved in a typical day, any lack of control related to issues with accessibility may place them at risk to lose focus relative to the geoscience content being presented. Secondly, the slightest changes in terrain will cause an increase in anxiety. Uneven sidewalks or pavement, gravel or sandy walkways, and uneven surfaces may elicit anxiety and a fear of entrapment that has the potential to interfere with content retention and the overall flow of the educational experience. Finally, placing students with physical disabilities into an unpredictable field environment yields an increased liability. Ideally, trip changes due to dynamic conditions should be accomplished with the input from the students themselves. Decisions made on behalf of the students without their perspective, leads them to believe that they are not valued as a part of the learning process. Any decisions made during the field experience should also include their first-hand perspective and a firm understanding of what they can and cannot accomplish given the specific barriers they face.

This study has opened the door to study persons with mobility impairments and provided a realization that learning outside of a classroom setting in an environment that was thought to be unattainable, is in fact possible. This also has the ability to enhance any current research in geospatial understanding from participants of mobility impaired populations. From the evidence obtained during the cave mapping exercise, these participants were completely capable of collecting geologic data to create geologic maps. The next step in the research would be to assess how using skills taught to them through classroom and field-based instruction assists with the development of geologic maps and other interpretation tools. With the discovery of these skills, perhaps additional variables are involved in the students’ construction of knowledge that this study did not uncover.
New questions to an entirely new study begin to arise: Where are these students deriving their spatial understanding? Is there an aspect of deeper awareness of their surroundings as a result of their physical limitations?
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Appendix A: Recruitment Flyer

EDUCATIONAL FIELD TRIP: Experience Accessible Caving!

Open to Students with Mobility Impairments and Personal Assistants

Students with mobility impairments and trained Personal Assistants are invited to attend an informational meeting about a three day, two night caving experience May 7-9, 2010. Family members of students with disabilities may attend as personal assistants. As part of this trip, students will be requested to enroll in EES 199 and participate in a research study that involves taking part in individual and group interviews, completing surveys and journal writings during the field trip.

INTERESTED IN LEARNING MORE?

Contact Brittany Boyne
Brittany.boyne@wright.edu
(937)775-4628
Appendix B: Research Consent Form

The Ohio State University Consent to Participate in Research

Study Title: Expanding Geoscience Diversity: Introductory Cave Geology for Non-Traditional Students

Researcher: Christopher L. Atchison

Sponsor: NSF OEDG Planning Grant #0939645; Ohio’s STEM Abilities Alliance

This is a consent form for research participation. It contains important information about this study and what to expect if you decide to participate. Your participation is voluntary. Please consider the information carefully. Feel free to ask questions before making your decision whether or not to participate. If you decide to participate, you will be asked to sign this form and will receive a copy of the form.

Purpose:
The primary objective is to understand the relationship between the experience of field-based instruction and the construction of knowledge for students with a limited prior understanding of the subject matter. Assuming that knowledge is independent of one’s physical ability, this study will also examine the potential barriers with respect to field-based education for students with mobility impairments. The investigation will seek to understand how students with mobility impairments experience the world around them, their perception of their surroundings.

This project is investigating the use of immersive virtual reality as a means for providing an effective supplement to traditional geologic field-based education. However, before we begin this investigation, we need to first determine how geology is learned from the perspective of students with mobility impairments.

We need you to teach us about you!

Procedures/Tasks:
The course affiliated with this study, EES 199 Introduction to Cave and Karst Systems, is a 2 credit hour course and graded pass/fail. The course will meet for three-3 hour classroom sessions in April on Wright State’s campus, and a three-day field trip to Kentucky in May to a cave currently being studied by students from the Wright State University (WSU) Earth and Environmental Sciences and the Ohio State University (OSU) School of Earth Sciences.
You will learn about cave systems, and will be taken to a cave to observe it first-hand. As a result, you will be an integral part of providing input for the development of an innovative tool of inclusive educational technology. This technology will allow future students the opportunity to study geology from an immersive virtual reality environment. Your participation in this study will help us design this environment!

During the course, you will be asked to participate in research activities that are in addition to the course requirements, which will include no more than five (5) individual and focus group interviews, daily student journaling and taking two brief surveys.

To participate in this study you will need to be:

- Registered with the Office of Disability Services (ODS) at WSU OR a personal assistant to a student registered with ODS at WSU
- Academically good standing
- Enrolled in the IS 199, Introduction to Cave and Karst Systems – (to be done at your request by ODS Staff).

Duration:
As a part of the course, participants will be expected to attend all classroom sessions of the geology course (three 3-hour sessions) along with a three-day, two-night field site visit. Total time estimation will be 9 hours of classroom and 56 hours of the field-site visit. Additional time necessary for the research portion, over and beyond what is collected during the course will be for individual and focus group interviews, journal writings and brief surveys. This will be minimal addition to the total (less than two hours total per student over the course of the study).

You may leave the study at any time. If you decide to stop participating in the study, there will be no penalty to you, and you will not lose any benefits to which you are otherwise entitled. Your decision will not affect your future relationship with either Wright State University or Ohio State University. Due to the compensatory nature of the field trip, if you decide to discontinue participation in the study once beginning the course, you will have the option to cover your own expenses to attend the field trip, or to complete the research-based project to fulfill the requirements of the course in place of going on the field trip. The research-based geology project will have a similar time and academic requirement.

Risks and Benefits:
For the field-site visit, you will be taken outside of the comfort of a traditional classroom and into a natural geologic setting. The potential risks are that you may have limited or no prior learning experience in a field-based environment of this nature, and it would be reasonable to expect that you may be unsure and uneasy about negotiating the terrain, overcoming physical obstacles, etc. There will also be an elevator ride into the cave. Although this ride will be as safe as any other elevator ride, it is reasonable to expect that this too may cause slight uneasiness.
The researchers have undergone an inspection of the field site with professional staff members from ODS at WSU as well as the course instructors and park staff at Mammoth Cave National Park to identify, plan, and make arrangements to safely accommodate all course participants and ensure that your personal needs are met.

Confidentiality:
Efforts will be made to keep your study-related information confidential. However, there may be circumstances where this information must be released. For example, personal information regarding your participation in this study may be disclosed if required by state law. Also, your records may be reviewed by the following groups (as applicable to the research):

- Office for Human Research Protections or other federal, state, or international regulatory agencies;
- The Ohio State University Institutional Review Board or Office of Responsible Research Practices;
- The sponsor, if any, or agency (including the Food and Drug Administration for FDA-regulated research) supporting the study.

To protect your identity and anonymity, pseudonyms will be used for the narrative sections of the data analysis which will include focus group and individual interview data. Assessments and documents will all be immediately de-identified and kept in a locked office. All electronic media including the list that connects the pseudonym to your name will also be kept in a locked office and on a password protected computer. Only the principal investigators will have access to the research data.

This study has been approved by the Institutional Review Boards at both Ohio State and Wright State Universities. The confidentiality of all participants is assured.

Incentives:
Participants will be given paid registration and course materials for completion of the coursework (including participation and content assessments) and research activities (including interviews, journals and surveys). Refreshments during the classroom portion of the course, as well as transportation, lodging and meals during the field-trip portion of the course will also be provided. There is no cost to you to take this course and participate in this study.

Participant Rights:
You may refuse to participate in this study without penalty or loss of benefits to which you are otherwise entitled. If you are a student or employee at Ohio State, your decision will not affect your grades or employment status.

If you choose to participate in the study, you may discontinue participation at any time without penalty or loss of benefits. By signing this form, you do not give up any personal legal rights you may have as a participant in this study.
Since all expenses of the field trip are covered by external funding, if you decide not to participate in the research study once beginning the course, you will have the option to cover your own expenses to attend the field trip. If you choose not to attend the field trip, you may complete a research-based project to fulfill the requirements of the course in place of going on the field trip. The research-based geology project will have a similar time and academic requirement.

Institutional Review Boards responsible for human subjects research at The Ohio State University and Wright State University have reviewed this research project and found it to be acceptable, according to applicable state and federal regulations and University policies designed to protect the rights and welfare of participants in research.

Contacts and Questions:
For questions, concerns, or complaints about the study, or if you feel you have been harmed by participation, you may contact:

Chris Atchison
atchison.6@osu.edu
937-623-3386

For questions about your rights as a participant in this study or to discuss other study-related concerns or complaints with someone who is not part of the research team, you may contact Ms. Sandra Meadows in the Office of Responsible Research Practices at 1-800-678-6251.
Request to Participate

Expanding Geoscience Diversity: Introductory Cave Geology for Non-Traditional Students

Please check one box, then sign, date and return to the researcher.

You will be provided with a copy of your signed consent form.

☐ Yes, I would like to be enrolled in EES 199 and participate in the research study by going on the field trip to Kentucky. If I enroll in the course and later choose not to participate in the research study, I will be responsible for the cost of the field-trip (approximately $350).

OR

☐ Yes, I would like to be enrolled in EES 199, and participate in the research study by completing a classroom research project instead of the field trip to Kentucky.

OR

☐ No, I would not like to be enrolled in EES 199 or participate in the research study.
Signing the consent form

I have read (or someone has read to me) this form and I am aware that I am being asked to participate in a research study. I have had the opportunity to ask questions and have had them answered to my satisfaction. I voluntarily agree to participate in this study.

I am not giving up any legal rights by signing this form. I will be given a copy of this form.

______________________________  ________________________________  AM/PM
Printed name of subject                  Signature of subject

__________________________________________  __________________
Date and time

______________________________  ________________________________  AM/PM
Printed name of person authorized to consent for subject (when applicable)  Signature of person authorized to consent for subject (when applicable)

__________________________________________  __________________
Date and time

Investigator/Research Staff

I have explained the research to the participant or his/her representative before requesting the signature(s) above. There are no blanks in this document. A copy of this form has been given to the participant or his/her representative.

______________________________  ________________________________  AM/PM
Christopher L. Atchison                  Signature of person obtaining consent

__________________________________________  __________________
Date and time
Appendix C: Recruitment Letter

April 6, 2010

Dear Students:

I am writing to ask for your participation in a learning and research opportunity about geologic processes. This project is investigating the potential of interactive, visual technologies as a means for providing an effective supplement to traditional geologic field-based education. However, before we begin this investigation, we need to first determine how geology is learned from the perspective of students with mobility impairments.

We need you to teach us about you!

Title:

Expanding Geoscience Diversity: Introductory Cave Geology for Non-Traditional Students

Purpose and Procedures:

The course affiliated with this study, EES 199: Introduction to Cave and Karst Systems, is a 2 credit hour course and is graded pass/fail. We will meet for three 3-hour classroom sessions in April on Wright State’s campus, and a three-day field trip to Kentucky in May to a cave currently being studied by students from the Wright State University (WSU) Earth and Environmental Sciences and the Ohio State University (OSU) School of Earth Sciences. There are two options for completing the course: you may choose to attend the field-trip to Kentucky, or you may choose to complete a research project of a similar time requirement. Both options, however, involve participation in the research study.

You will learn about cave systems, and will be taken to a cave to observe it first-hand. As a result, you should expect to be an integral part of providing first-hand input for the development of an innovative tool of inclusive educational technology. This technology, designed in part from data collected during this study, will allow future students the
opportunity to study geology from a virtual recreation of the real cave environment you will visit. Your participation in this study will help us design this virtual reality environment!

**Benefits:**

As a participant, you will be given paid registration and course materials for completion of the coursework and research activities, which includes no more than five (5) individual and group interviews, student journaling and taking two brief surveys. Refreshments during the classroom portion of the course, as well as transportation, lodging and meals during the field-trip portion of the course will also be provided.

There is no cost to you to take this course and participate in this study.

To participate in this study you will need to be:

- Mobility impaired and be registered with the Office of Disability Services (ODS) at WSU
  OR a personal assistant to a student registered with ODS at WSU
- Academically good standing
- Enrolled in the EES 199, Introduction to Cave and Karst Systems

**Duration:**

As a part of the course, participants will be expected to attend all classroom sessions of the geology course (three 3-hour sessions) along with a three-day, two-night field site visit. Total time estimation will be 9 hours of classroom and 56 hours of the field-site visit. Additional time necessary for the research portion, over and beyond what is collected during the course will be for individual and focus group interviews, journal writings and brief surveys. This will be minimal addition to the total (less than two hours total per student over the course of the study).

**Risks:**

For the field-site visit, you will be taken outside of the comfort of a traditional classroom and into a natural geologic setting. The potential risks are that you may have limited or no prior learning experience in a field-based environment of this nature, and it would be reasonable to expect that you may be unsure and uneasy about negotiating the terrain, overcoming physical obstacles, etc. There will also be an elevator ride into the cave. Although this ride will be as safe as any other elevator ride, it is reasonable to expect that this too may cause slight uneasiness.

The researchers have undergone an inspection of the field site with professional staff members from ODS at WSU as well as the course instructors and park staff at Mammoth Cave National Park to identify, plan, and make arrangements to safely accommodate all course participants and ensure that your personal needs are met.
Confidentiality:

The confidentiality of all participants is assured. To protect your identity and anonymity, pseudonyms will be used for the narrative sections of the data analysis which will include focus group and individual interview data. Assessments and documents will all be immediately de-identified and kept in a locked office. All electronic media including the list that connects the pseudonym to your name will also be kept in a locked office and on a password protected computer. Only the principal investigators will have access to the research data.

Contact:

Should you wish to have further information about the study before making a decision as to whether or not you would like to participate, please contact me at:

Chris Atchison

atchison.6@osu.edu

937-623-3386

If you have general questions about giving consent or your rights as a research participant in this research study, you can call the Wright State University Institutional Review Board at 937-775-4462.

For those of you affiliated with Ohio’s STEM Abilities Alliance (OSAA), whether or not you participate in this project, your involvement with OSAA will not be affected in any way.

Your participation is purely voluntary. You may opt out of the research study at any given time without negative affect to your grade in the course. However, should you decide to withdraw from the study, you will be required to complete the course in accordance with WSU registration policy.
Request to Participate

Expanding Geoscience Diversity: Introductory Cave Geology for Non-Traditional Students

Please check one box, then sign, date and return to the researcher.

You will be provided with a copy of your signed consent form.

☐ Yes, I would like to be enrolled in EES 199 and participate in the research study by going on the field trip to Kentucky. **If I enroll in the course and later choose not to participate in the research study, I will be responsible for the cost of the field-trip (approximately $350).**

OR

☐ Yes, I would like to be enrolled in EES 199, and participate in the research study by completing a classroom research project instead of the field trip to Kentucky.

OR

☐ No, I would not like to be enrolled in EES 199 or participate in the research study.

Name: ______________________________

Signature: ___________________________ Date: _____________
### Appendix D: Cave geology course schedule

<table>
<thead>
<tr>
<th>Day</th>
<th>Topic</th>
<th>Time</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day 1</td>
<td>Introductions</td>
<td></td>
<td>WSU</td>
</tr>
<tr>
<td></td>
<td>GCI assessment #1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>The Earth System</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Four dimensions of geology</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Geologic time</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Plate Tectonics</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ohio’s geologic past</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day 2</td>
<td>Cave Knowledge and Attitude Survey</td>
<td></td>
<td>WSU</td>
</tr>
<tr>
<td></td>
<td>Review Plate Tectonics</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rock Cycle: Weathering, Erosion, Deposition</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hydrologic Cycle</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Chemistry of Cave formation: Dissolution</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day 3</td>
<td>Review: Hydrologic Cycle</td>
<td></td>
<td>WSU</td>
</tr>
<tr>
<td></td>
<td>Cave formation: types, causes, hazards, impact on the environment</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Understanding Cave and Karst of Mammoth Cave Region</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>GCI assessment #2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Field site trip logistics and planning</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day 4</td>
<td>Travel to MCNP (Eastern Time Zone)</td>
<td>12:00pm</td>
<td>MCNP</td>
</tr>
<tr>
<td></td>
<td>Arrive/unload (Central Time Zone)</td>
<td>4:00pm</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Introductions with park staff</td>
<td>4:30pm</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Depart for Sink Hole Plain</td>
<td>5:00pm</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Review of the cave and karst system</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Evening workshop session at CRF – cave safety and logistics</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Student Journaling</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day 5</td>
<td>Safety and logistics review</td>
<td></td>
<td>MCNP</td>
</tr>
<tr>
<td></td>
<td>Depart for Green River</td>
<td>9:30am</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Depart for Cave tour – Snowball</td>
<td>1:30pm</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cave mapping exercise</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Afternoon workshop session at CRF – Accessibility in the geosciences</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Skype with Educational Outreach Coordinator at NCKRI</td>
<td>7:00pm</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Historic Entrance</td>
<td>9:00pm</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Student Journaling</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day 6</td>
<td>Morning workshop session at CRF – Skype with Interpretive Geologist,</td>
<td>10:00am</td>
<td>MCNP</td>
</tr>
<tr>
<td></td>
<td>Anadarko Petroleum Corporation</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Focus Group Interviews</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Return to WSU (Central Time Zone)</td>
<td>1:00pm</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Arrive WSU (Eastern Time Zone)</td>
<td>7:00pm</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Student Journaling (Due during the week)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix E: Field Site Stop Locations

Image Credit: Cave Research Foundation, Mammoth Cave National Park
Appendix F: Project Planning Timeline

November 2008:
Researcher contacted the Mammoth Cave International Center for Science and Learning (MCICSL) to begin discussing the possibility of developing a workshop and later virtual environments for mobility impaired students to learn about geology and the geosciences.

December 2008:
MCICSL facilitated a meeting between Researcher and several key members of Mammoth Cave National Park’s management staff. At this meeting preliminary discussions were begun as to what might be possible during a workshop for mobility impaired students and different virtual options.

Mammoth Cave National Park wrote a letter of support for Researcher’s NSF proposal.

December 2009:
MCICSL facilitated a multi-day meeting between Researcher, Director of Educational Outreach from the National Cave and Karst Research Institute, MCICSL staff, and various Mammoth Cave staff. The meeting included discussions about logistics for the workshop, activities that we might do during the workshop, visiting potential sites that we might go during the workshop, a demonstration of the interactive remote cave tours that MCICSL has begun conducting, and other topics necessary for planning a workshop for mobility impaired students.

MCICSL and Mammoth Cave National Park began having serious discussions about what locations were realistically possible for the workshop participants to safely go.

MCICSL staff provided Researcher copies of Mammoth Cave National Park’s Emergency Management plan for cave tour participants and data from LIDAIR scans currently being conducted in Mammoth Cave.

February 2010:
Researcher and MCICSL began planning for a pre-workshop visit by OSU and Wright State University advisory members.

MCICSL obtained permission from the Park Superintendent, Chief of Interpretation, and Chief of Facilities Management to use the elevator to take the advisory members into the cave.

MCICSL met with members of Mammoth Cave National Park’s Facilities Management, Law Enforcement, and Interpretation Divisions to determine the protocol for the pre-workshop cave trip and an Emergency Action Plan in case the elevator stopped working while we were entering or exiting the cave on the pre-workshop visit.

Mammoth Cave National Park made arrangements to have someone on duty who could work the elevator crank in case the elevator became stuck during the pre-workshop cave
trip. The park also called the elevator company and alerted them that if the elevator malfunctioned during the trip, that we would need assistance ASAP.

On the day of the pre-workshop visit, Law Enforcement parked a vehicle with a stair chair in the elevator parking lot in case it was needed. An emergency bottle of oxygen and blankets were also placed in the elevator car in case of emergencies.

MCICSL staff led Researcher and his pre-workshop participants on a tour of the Snowball Dining Room portion of Mammoth Cave and discussed logistics of the upcoming workshop.

March – April 2010:

MCICSL and Mammoth Cave National Park continued discussions about the logistics of the upcoming workshop and which entrances we may be able to use.

MCICSL provided Researcher educational resources and continued to act as a liaison between him and the park.

May 2010:

MCICSL obtained permission from the Park Superintendent, Chief of Interpretation, and Chief of Facilities Management to use the elevator during the workshop for a tour of the Snowball Dining Room area of Mammoth Cave.

MCICSL staff had numerous discussions with various park staff about the feasibility of taking the students into the Historic Entrance.

MCICSL met with members of Mammoth Cave National Park’s Facilities Management, Law Enforcement, and Interpretation Divisions to determine the protocol for the workshop cave trip into the Snowball Dining Room. The Emergency Action Plan in case the elevator stopped working while we were entering or exiting the cave was revised based on the increased number of workshop participants and the park personnel available on the day of the workshop.

Mammoth Cave National Park made arrangements to have someone on duty who could work the elevator crank in case the elevator became stuck during the cave trip.

MCICSL staff contacted the Park Mammoth Resort Park to arrange for the group to visit the Park Mammoth Overlook which is located on private property.

MCICSL staff obtained permission to drive the vehicles down to the River Styx Spring.

MCICSL staff spent two days working with the workshop participants and teaching them about the karst geology of the area.

(Credit: S. Trimboli)
## Appendix G: Pre-Trip Logistics Checklist

### TRIP PLANNING & ACCESSIBILITY CHECKLIST

<table>
<thead>
<tr>
<th>TRANSPORTATION AND TRAVEL</th>
<th>✓</th>
</tr>
</thead>
<tbody>
<tr>
<td>Find and reserve vehicle(s) to fit 6 wheelchairs</td>
<td>✓</td>
</tr>
<tr>
<td>Ramp or lift equipped</td>
<td>✓</td>
</tr>
<tr>
<td>Tie downs for wheelchairs</td>
<td>✓</td>
</tr>
<tr>
<td>Does vehicle have space for luggage/equipment</td>
<td>✓</td>
</tr>
<tr>
<td>Does vehicle have hitch for trailer</td>
<td>✓</td>
</tr>
<tr>
<td>Reserve 12 passenger van for able-bodied passengers and personal assistants</td>
<td>✓</td>
</tr>
<tr>
<td>Acquire a trailer to fit all necessary equipment (extra chairs, medical equipment, food, tools, etc)</td>
<td>✓</td>
</tr>
<tr>
<td>Driver knowledgeable of operating lift/ramp</td>
<td>✓</td>
</tr>
<tr>
<td>Driver knowledgeable of manual operation of lift</td>
<td>✓</td>
</tr>
<tr>
<td>Driver on the university approved driver list</td>
<td>✓</td>
</tr>
<tr>
<td>Travel time could easily double</td>
<td>✓</td>
</tr>
<tr>
<td>It takes time to load and unload a group on a bus/van</td>
<td>✓</td>
</tr>
<tr>
<td>It takes time to use the wheelchair tie-downs</td>
<td>✓</td>
</tr>
<tr>
<td>It takes time to load and unload wheelchairs from the trailer</td>
<td>✓</td>
</tr>
<tr>
<td>Planned rest stops for restroom breaks every 2-4 hours</td>
<td>✓</td>
</tr>
<tr>
<td>(pre-identify accessible stops such as Rest Areas and McDonalds)</td>
<td>✓</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PARKING - FACILITY</th>
<th>✓</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drop off zone</td>
<td>✓</td>
</tr>
<tr>
<td>Handicap parking available</td>
<td>✓</td>
</tr>
<tr>
<td>Level ground to building entrance</td>
<td>✓</td>
</tr>
<tr>
<td>Curb cuts and accessible sidewalk</td>
<td>✓</td>
</tr>
<tr>
<td>Possible hazards for wheelchair users – uneven ground, snow/ice/mud, rocks, glass</td>
<td>✓</td>
</tr>
<tr>
<td>MEALS</td>
<td></td>
</tr>
<tr>
<td>-------</td>
<td></td>
</tr>
</tbody>
</table>
| Choose foods that do not require significant dexterity to eat (ie spaghetti was deemed difficult to eat by most students) | ✔  
| Tray/food prep assistance needed by any students |  
| Feeding assistance needed by any students |  
| Need long bendy straws |  
| Need stable plates (not flimsy) with sides (a significant lip to avoid food sliding off of the plate) |  
| LODGING AND ALL BUILDINGS ENTERED |  
| Unloading/loading zone | ✔  
<p>| Entrance wheelchair access |<br />
| Roommate assignments: those without PA’s matched based on physical ability in case of emergency |<br />
| Can 2 chairs maneuver in the same room at once? |<br />
| Width of room &amp; bathroom doors – 36” –wider for camber chairs |<br />
| Room keys /Access to room (doors may be heavy) |<br />
| Beds- height from the ground? Top bunks not accessible |<br />
| Restroom – space for a wheelchair to move around |<br />
| Showers- roll in? |<br />
| Remind students to bring special equipment needed – shower chair, BiPAP (breathing apparatus), toileting supplies etc |<br />
| Even a 2 inch lip from one room to another can block access for a chair user |<br />
| Movable furniture - so wheelchairs can move around |<br />
| Table access for wheelchairs |<br />
| Chairs removed for wheelchair seating |<br />
| Restroom sink/soap/hand towels accessible |<br />
| # students who need a PA to assist them and space for those PAs |</p>
<table>
<thead>
<tr>
<th>OTHER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emergency contact info for all attendees</td>
</tr>
<tr>
<td>All health forms and waivers completed</td>
</tr>
<tr>
<td>Locate nearest hospital and on-call nurse agencies</td>
</tr>
<tr>
<td>Let emergency park staff know of our arrival and departure and special needs of the population</td>
</tr>
<tr>
<td>Pack plastic baggies to protect power chair joy sticks in wet weather</td>
</tr>
<tr>
<td>Duct tape</td>
</tr>
<tr>
<td>Wheelchair repair kit (particularly Allen wrenches)</td>
</tr>
<tr>
<td>Emergency road kit</td>
</tr>
<tr>
<td>First Aid Kit</td>
</tr>
<tr>
<td>Shower Chairs</td>
</tr>
<tr>
<td>Wheelchair tire tubing/patch kit</td>
</tr>
<tr>
<td>Manual chairs in addition to power chairs</td>
</tr>
</tbody>
</table>

(Credit: WSU Office of Disability Services)
Appendix H: Suggested Participant Packing List

Things to pack (or consider if YOU will need):

- Rain gear (for you and your chair)
  - We will bring extra baggies for joy sticks
- Bedding (sleeping bag will be sufficient)
- Pillow
- Towel
- Flashlight (the rooms have lights, but the switches are not reachable from the bed)
- Medications
- Wheelchair charger
- Manual chair
- If you have an air filled cushion, you may want to bring an extra
- Extra tire tubes and Fix a Flat if you have air filled tires on either wheelchair
- Tools/Duct Tape
- Clothes
  - An extra set in case we get caught in the rain
  - Pajamas
  - Sweatshirt or jacket (no matter what the weather channel says!)
- Shower chair (if you need it)
  - Wipes/wash cloth (if you are choosing not to shower during the trip)
- Bathroom supplies/toiletries (this will be specific to your own routine and needs)
- Pen/writing tool of choice
  - Remember we will be journaling so if you need a certain type of writing accommodation you will need to bring it
- The “field book” you have been creating in class
- Camera/Audio recorder
- Batteries
Appendix I: Participant Information Form

Course: EES 199 Introduction to Cave and Karst Systems

Name: ___________________________ Gender: __________________

Date of Birth (Mo, Day, Year): ____________________________

Address: Current Residence:

Street: ___________________________ City: __________________
State: _____ Zip: _________ Phone number: __________________________

Emergency Contact:

Name: ___________________________ Relationship: __________
Address: __________________________
Phone: ___________________________ Alt. Phone: __________________________

Medical Information:

Describe or list any limitations or conditions (serious allergies, other medical, etc. that we should know about):

________________________________________________________________________

________________________________________________________________________

My regular physician is:

Name: ___________________________ Phone: __________________________

As appropriate, my specialist is:

Name: ___________________________ Phone: __________________________

Personal medical insurance (please provide insurer): __________________________

Insurance policy holder if other than participant: __________________________

_____ I give my consent for any medical treatment that I might require while participating in the field activity during the period May 7 to May 9, 2010. I authorize and request The Ohio State and Wright State University personnel to refer me to duly licensed medical authority when indicated, including transfer to hospitals. I hereby grant authority to a qualified physician to render such medical treatment as the physician deems necessary under the circumstances.

_____ I request that my emergency contact authorize any medical treatment I might require while participating in the field activity during the period May 7 to May 9, 2010.

Signature: ___________________________ Date: __________________________
Appendix J: EES 199 Syllabus

EES 199 – Introduction to Cave and Karst Geology
Spring Quarter 2010
Department of Earth and Environmental Science
College of Science and Mathematics

Instructors:
Christopher Atchison  atchison.6@osu.edu   (937)623-3386
Rebecca Teed  rebecca.teed@wright.edu   (937)775-3446

Office Hours: by appointment (before or after class)

Class Location: Russ 145

Class Time: Friday 3:45-6:45 (4.9, 4.16, 4.23, 5.7, 5.8, 5.9)

Description:
This course will study a broad overview of the geologic systems that surround us. We will analyze the four dimensions of observation and interpretation necessary in the geosciences. Understand the geologic history of Ohio and the surrounding region and the environmental impact humans have on the environment. Finally, we will discuss the accessibility of careers in the geosciences.

Objectives:
As you work through this course, you will:
Listen to geology presentations on a broad range of geologic topics relating to cave formation.
Conduct hands-on activities pertaining to the presentation topics and field site visit.
Interact with fellow workshop participants and instructors on various discussion topics.
Meet with geoscience industry representatives both in person and via videoconferencing regarding geoscience career opportunities.
Conduct scientific observations and interpretations in a geologic field environment
Keep a journal of your understanding, knowledge, experience and feelings as the workshop progresses.
Have fun!

Required text: None, field book will be developed during class

Grading
This course is graded “Satisfactory (S)” or “Unsatisfactory/(U)”. To receive a grade of “S” and earn the 2 credit hours for the course you must complete all assignments and
requirements for course participation. Much of the value of a seminar class comes from what happens in class activities and discussion in the three class sessions, so attendance is critical. If you miss a single class, you will not pass this course. Points lost due to absence cannot be “made up” regardless of the reason for the absence.

Course Assignments and Participation

<table>
<thead>
<tr>
<th>Tentative Schedule</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Week(s)</strong></td>
</tr>
<tr>
<td>April 9</td>
</tr>
<tr>
<td>April 16</td>
</tr>
<tr>
<td>April 23</td>
</tr>
<tr>
<td>May 7</td>
</tr>
<tr>
<td>May 8</td>
</tr>
<tr>
<td>May 9</td>
</tr>
</tbody>
</table>
## Appendix K: Modified Geoscience Concept Inventory (mGCI)

### Part 1: Select only one response

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water and air movement are destructive processes (destroy things)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ohio was once covered by a warm, tropical sea, and located near the equator</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air and water movement are constructive processes (build things)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All of the contents have remained in the same location since the formation of the earth</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The Appalachian Mountains in the eastern United States were once tallest mountains in the world – taller than Mt Everest!</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Part 2: Multiple choice responses

1. Which of the following can greatly affect erosion rates? Choose all that apply.
   - (A) Rock type
   - (B) Earthquakes
   - (C) Time
   - (D) Climate

2. Which is the best definition of a tectonic plate?
   - (A) All solid, rigid rock beneath the continents and above deeper, moving rock
   - (B) All solid, rigid rock beneath the continents and oceans and above deeper, moving rock
   - (C) All solid, rigid rock that lies beneath the layer of loose dirt at the Earth’s surface and above deeper, moving rock
   - (D) All solid, rigid rock and loose dirt beneath the Earth's surface and above deeper, moving rock
   - (E) The rigid material of the outer core

3. Where do you think glaciers can be found today? Choose all that apply.
   - (A) In the mountains
   - (B) At sea level
   - (C) At the South pole
   - (D) Along the equator only
   - (E) Anywhere except along the equator
4. Some people believe that they have evidence that can prove whether the very center of the Earth is a solid, liquid, or gas. Which of the following is an accurate statement about the innermost part of the Earth?

(A) The very center of the Earth is mostly made up of gases
(B) The very center of the Earth is mostly made up of liquids
(C) The very center of the Earth is mostly made up of solids
(D) We do not know the state of the very center of the Earth

5. If you could travel back in time to when the Earth first formed as a planet, what would the Earth look like?

(A) The Earth would be mostly covered with water
(B) The Earth would be mostly covered with molten rock
(C) The Earth would be mostly covered with ice
(D) The Earth would be mostly covered with solid rock

6. Which of the following figures do you believe is most closely related to what you might see if you could cut the Earth in half?

![Figure A](image1)
![Figure B](image2)
![Figure C](image3)
![Figure D](image4)
![Figure E](image5)
7. Which of the following are actively contributing to the heat inside the Earth? Choose all that apply.
   (A) Gravitational energy from the Sun
   (B) Energy from the Earth’s formation
   (C) Heat energy from the Sun
   (D) Energy from radioactivity

8. Which of the following best describes mountains? Choose all that apply.
   (A) Old mountains are taller than young mountains because old mountains have been growing longer
   (B) Old mountains have gentler slopes than young mountains because old mountains have been wearing down longer
   (C) Old mountains have more vegetation than young mountains because old mountains have had plants growing on them longer
   (D) Old mountains have rougher surfaces than young mountains because old mountains have been around longer
   (E) All mountains are roughly the same age regardless of shape, size, vegetation or roughness

9. What is the connection between clouds and rain
   (A) Clouds are empty, and fill up with water. When the clouds are full, it rains
   (B) Clouds are empty, and fill up with water and other things. When the clouds are full, it rains
   (C) Clouds are empty, and fill up with water. When the clouds get too heavy, it rains
   (D) Clouds are made up of water. When the temperature gets high enough in the cloud, it rains
   (E) Clouds are made up of water. When the temperature gets low enough in the cloud it rains

10. Scientists often talk about the Earth’s tectonic plates and their role in mountain formation, volcanism, and earthquake occurrence. Which of the following figures most closely represents the location of the Earth’s tectonic plates?

![Diagram Options]

(A) [Diagram A]
(B) [Diagram B]
(C) [Diagram C]
(D) [Diagram D]
11. Which of the following statements do you think best describes the relationship between people and dinosaurs?
   (A) People and dinosaurs co-existed for about five thousand years
   (B) People and dinosaurs co-existed for about five hundred thousand years
   (C) Dinosaurs died out about five thousand years before people appeared on Earth
   (D) Dinosaurs died out about five hundred thousand years before people appeared on Earth
   (E) Dinosaurs died out about fifty million years before people appeared on Earth

12. Some people believe there was once a single continent on Earth. If this single continent did exist, how long did it take for the single continent to break apart and form the arrangement of continents we see today?
   (A) Hundreds of years
   (B) Thousands of years
   (C) Millions of years
   (D) Billions of years
   (E) It is impossible to tell how long the break up would have taken

13. Which of the following can be caused by wind? Choose all that apply.
   (A) Tectonic plate motion
   (B) Waves
   (C) Earthquakes
   (D) Mountain-building
   (E) Erosion

14. Over which of the following areas would the most clouds form?
   (A) One square-mile of land
   (B) One square-mile of ocean
   (C) One square mile of a region covered with plant life
   (D) One square-mile of a humid region along the equator

15. Which of the following responses best summarizes the relationship between volcanoes, large earthquakes, and tectonic plates?
   (A) Volcanoes typically occur on islands, earthquakes typically occur on continents, and both occur near tectonic plates
   (B) Volcanoes and large earthquakes both typically occur along the edges of tectonic plates
   (C) Volcanoes typically occur in the center of tectonic plates and large earthquakes typically occur along the edges of tectonic plates
   (D) Volcanoes and large earthquakes both typically occur in warm climates
   (E) Volcanoes, large earthquakes, and tectonic plates are not related, and each can occur in different places

16. Below the outermost rocky shell of the Earth, it becomes:
   (A) Hotter, molten, and gravity increases
   (B) Hotter, gaseous, and magnetism increases
   (C) Colder, solid, and pressure increases
   (D) Hotter, denser, and pressure increases
   (E) Colder, denser, and pressure increases
17. What is the best explanation for the movement of tectonic plates?
(A) Lava moves the tectonic plates
(B) Currents in the ocean move the tectonic plates
(C) Earthquakes move the tectonic plates
(D) Gravity moves the tectonic plates
(E) Magnetism moves the tectonic plates

18. What does "density" refer to?
(A) How thick something is
(B) How quickly particles move
(C) How much material exists in a space
(D) How much air is contained in an object
(E) How slowly liquids move

19. Which one of the following is most closely related to events that cause large earthquakes?
(A) Buildings falling
(B) Weather changing
(C) Bombs dropping
(D) Continents moving
(E) Earth’s core changing

20. How big was the planet Earth when dinosaurs first appeared?
(A) Smaller than today
(B) Larger than today
(C) Same size as today
(D) We have no way of knowing

21. The map below shows the position of the Earth’s continents and oceans today. The gray areas represent land, and the white represents water. Which of the following best explains why the ocean basins look the way they do?

(A) Meteor impacts caused the ocean basins to form this way
(B) Continents moving caused the ocean basins to form this way
(C) The Earth cooling caused the ocean basins to form this way
(D) The Earth warming caused the ocean basins to form this way
22. Are rocks and minerals alive?
   (A) Yes, rocks and minerals grow
   (B) Yes, rocks are made up of minerals
   (C) Yes, rocks and minerals are always changing
   (D) No, rocks and minerals do not reproduce
   (E) No, rocks and minerals are not made up of atoms

23. If you put a fist-sized rock in a room and left it alone for millions of years, what would happen to the rock?
   (A) The rock would almost completely turn into dirt
   (B) About half of the rock would turn into dirt
   (C) The top few inches of the rock would turn into dirt
   (D) The rock would be essentially unchanged

24. If you could travel back in time to when the Earth first formed as a planet, how many years back in time would you have to travel?
   (A) 4 hundred years
   (B) 4 hundred-thousand years
   (C) 4 million years
   (D) 4 billion years
   (E) 4 trillion years

25. Some people believe there was once a single continent on Earth. Which of the following statements best describes what happened to this continent?
   (A) Meteors hit the Earth, causing the continent to break into smaller pieces
   (B) The Earth lost heat over time, causing the continent to break into smaller pieces
   (C) Material beneath the continent moved, causing the continent to break into smaller pieces
   (D) The Earth gained heat over time, causing the continent to break into smaller pieces
   (E) The continents have always been in roughly the same place as they are today

This assessment has been modified from the Geoscience Concept Inventory (GCI) produced by Libarkin and Anderson (2005)
Appendix L: Modified Science Motivation Questionnaire (mSMQ)

Science Motivation Questionnaire – modified

These 30 questions were answered using the following format:

Ο Strongly Disagree  Ο Disagree  Ο Agree  Ο Strongly Agree

01. I enjoy learning science.
02. Science I learn relates to my personal goals.
03. I like to do better than the other students on science tests.
04. I am nervous about how I will do on science tests.
05. If I am having trouble learning science, I try to figure out why.
06. I become anxious when it is time to take a science test.
07. Earning a good science grade is important to me.
08. I put enough effort into learning science.
09. I use strategies that ensure I learn science well.
10. I think about how learning science can help me get a good job.
11. I think about how science will be helpful to me.
12. I expect to do as well as or better than other students in science courses.
13. I worry about failing science tests.
14. I am concerned that the other students are better in science.
15. I think about how my science grade will affect my overall grade point average.
16. Learning science is more important to me than the grade I receive.
17. I think about how learning science can help my career.
18. I hate taking science tests.
19. I think about how I will use the science I learn.
20. It is my fault, if I do not understand science.
21. I am confident I will do well on science labs and projects.
22. I find learning science interesting.
23. Science is relevant to my life.
24. I believe I can master the knowledge and skills in science courses.
25. Science has practical value for me.
26. I prepare well for science tests and labs.
27. I like science that challenges me.
28. I am confident I will do well on science tests.
29. I believe I can earn a grade of “A” in science courses.
30. Understanding science gives me a sense of accomplishment.

Appendix M: Early Cave Content Knowledge Assessment

1. Please mark each personal demographic area that best applies to you.
   - Male
   - Female
   - Permanent mobility impairment (requires use of wheelchair or other mobility assistance device)
   - White
   - African American
   - Hispanic
   - Asian
   Other race/nationality (please specify)

2. Additional demographic Information.
   Highest level of education completed (High School, Trade School, some college, AS, BA, BS, MA, MS, PhD, etc.)
   Post-secondary majors/minors (N/A if none)
   Approximate number of geology classes completed in post-secondary education (N/A if none)

3. Please answer the following questions with a yes or no response.
   I have been inside of a cave or mine
   I have seen or read stories about caves in movies, books or other media
   I would like to learn about caves
   I would be able to feel an earthquake while inside of a cave

4. Please answer the following whether you strongly agree, agree, disagree, strongly disagree with the question.
   I would enjoy exploring a cave with a small group of people
   I would enjoy camping overnight in a cave
<table>
<thead>
<tr>
<th>Statement</th>
<th>Agree Options</th>
<th>Disagree Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>I would be afraid of getting lost while exploring in a cave</td>
<td>strongly agree</td>
<td>strongly disagree</td>
</tr>
<tr>
<td>I am afraid of tight spaces</td>
<td>strongly agree</td>
<td>strongly disagree</td>
</tr>
<tr>
<td>I would be afraid of getting stuck in a small opening in a cave</td>
<td>strongly agree</td>
<td>strongly disagree</td>
</tr>
<tr>
<td>I am afraid of a cave collapsing while I am inside</td>
<td>strongly agree</td>
<td>strongly disagree</td>
</tr>
<tr>
<td>I would be afraid of things I couldn't see in the dark of a cave</td>
<td>strongly agree</td>
<td>strongly disagree</td>
</tr>
<tr>
<td>I am afraid of the things that may be living in the cave</td>
<td>strongly agree</td>
<td>strongly disagree</td>
</tr>
<tr>
<td>Caves play an important role in the environment</td>
<td>strongly agree</td>
<td>strongly disagree</td>
</tr>
<tr>
<td>All caves are made from water</td>
<td>strongly agree</td>
<td>strongly disagree</td>
</tr>
<tr>
<td>All caves are found underground</td>
<td>strongly agree</td>
<td>strongly disagree</td>
</tr>
<tr>
<td>All caves have stalactites and stalagmites</td>
<td>strongly agree</td>
<td>strongly disagree</td>
</tr>
<tr>
<td>All caves are made from limestone</td>
<td>strongly agree</td>
<td>strongly disagree</td>
</tr>
<tr>
<td>Bats found in caves will attack people</td>
<td>strongly agree</td>
<td>strongly disagree</td>
</tr>
<tr>
<td>The world’s deepest caves can reach the center of the earth</td>
<td>strongly agree</td>
<td>strongly disagree</td>
</tr>
<tr>
<td>Underground rivers are real</td>
<td>strongly agree</td>
<td>strongly disagree</td>
</tr>
<tr>
<td>When it is cold outside, it is cold inside of the cave</td>
<td>strongly agree</td>
<td>strongly disagree</td>
</tr>
<tr>
<td>When it is warm outside, it is warm inside of the cave</td>
<td>strongly agree</td>
<td>strongly disagree</td>
</tr>
<tr>
<td>If my light were to go out while exploring in a cave, my eyes would be able to adjust to the dark</td>
<td>strongly agree</td>
<td>strongly disagree</td>
</tr>
<tr>
<td>Caves can be found in all parts of the world</td>
<td>strongly agree</td>
<td>strongly disagree</td>
</tr>
<tr>
<td>Caves are useful to understanding the environment</td>
<td>strongly agree</td>
<td>strongly disagree</td>
</tr>
</tbody>
</table>
Select the best response to the question.

4. It takes millions of years for caves to form.
   - True. However, caves can also form quickly through earthquake processes
   - True. Gas bubbles from the earth's interior began creating the vast openings long ago when the surface was still molten rock
   - True. The early hominids were the first to begin building most of the caves, many of which are still unfinished today
   - False. Water is powerful enough to wash through solid rock in a matter of months
   - False. Plants found in the caves suggest that they haven’t been there for very long
   - False. Most caves are still wet, meaning they haven’t been there long enough to completely dry out

6. I would be able to feel an earthquake from inside of a cave.
   - True. Earthquake waves travel through rock, and I’m standing inside that rock. An earthquake shakes the earth, regardless of where you are standing
   - True. Since I would be standing closer to the center of the earth, I would be able to feel the earthquakes easier
   - True. I would be able to feel a rush of wind as the earthquake waves pass me underground
   - False. Because I am surrounded by all of that rock, I wouldn't be able to feel anything
   - False. Earthquake waves that are felt are surface waves, not interior waves. However, loose rocks may fall.
   - False. Earthquake waves travel through the air, and I would not be able to feel that underground

7. Caves are different from caverns.
   - True. Caves are large and caverns are small
   - True. Caves are above ground and caverns are below ground
   - True. Caves have natural light and caverns do not
   - False. The terms cave and cavern are commonly used interchangeably
   - False. Cave is shortened terminology for cavern
   - False. Caves and caverns are both man made
8. All caves form within limestone.
☐ True. Fossils found in caves can only be found in limestone
☐ True. Because limestone is the only rock that can be broken down by water
☐ True. Limestone is the only rock that is strong enough to withstand the erosional processes of cave formation and remain standing without collapse
☐ False. Sandstone can weather and erode, forming cavities and voids just like limestone formations
☐ False. Caves don’t form in limestone sediments at all
☐ False. All caves form by expanding cracks in igneous rock

9. Water found in a cave is pure and safe to drink.
☐ True. Cave water is the same as natural spring water and therefore naturally filtered and safe to drink
☐ True. If it is safe for cave shrimp, it is safe for me
☐ True. Cave water is free of impurities due to it not being on the surface and exposed to pollution
☐ False. Cave water is water that has filtered from the earth’s surface, carrying potential impurities
☐ False. Cave water isn’t really water at all, it is a natural chemical that is unfit for consumption
☐ False. Cave water is very stagnant and stale from being stuck in the cave for so many years
# Appendix N: Cave Knowledge and Attitude Assessment (CKAA)

1. Please answer the following questions with a yes or no response.

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>I have been inside of a cave or mine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>There were caves near my hometown</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I have seen or read stories about caves in movies, books or other media</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I would like to study caves</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I have friends and/or family that have been inside of a cave and described their experience to me</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. Please answer the following attitude questions whether you strongly agree, agree, disagree, or strongly disagree with the question.

<table>
<thead>
<tr>
<th>Question</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>I would enjoy exploring a cave with a small group of people</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I would enjoy camping overnight in a cave</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I would be afraid of getting lost while exploring in a cave</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I am afraid of tight spaces</td>
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<tr>
<td>I would be afraid of getting stuck in a small opening in a cave</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I am afraid of a cave collapsing while I am inside</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I would be afraid of things I couldn't see in the dark of a cave</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I am afraid of the things that may be living in the cave</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The thought of going into a cave frightens me</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
For places with limited accessibility, I would feel comfortable with being carried into the cave and transferred to a manual chair once inside.  

3. Please answer the following content questions whether you strongly agree, agree, disagree, or strongly disagree with the question.

<table>
<thead>
<tr>
<th>Question</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caves play an important role in the environment</td>
<td>strong agree</td>
<td>agree</td>
<td>disagree</td>
<td>strongly disagree</td>
</tr>
<tr>
<td>All caves are made from water</td>
<td>strong agree</td>
<td>agree</td>
<td>disagree</td>
<td>strongly disagree</td>
</tr>
<tr>
<td>Cave water is free of impurities due to it not being on the surface and exposed to pollution</td>
<td>strong agree</td>
<td>agree</td>
<td>disagree</td>
<td>strongly disagree</td>
</tr>
<tr>
<td>All caves are found underground</td>
<td>strong agree</td>
<td>agree</td>
<td>disagree</td>
<td>strongly disagree</td>
</tr>
<tr>
<td>Caves form quickly due to earthquakes</td>
<td>strong agree</td>
<td>agree</td>
<td>disagree</td>
<td>strongly disagree</td>
</tr>
<tr>
<td>All caves have stalactites and stalagmites</td>
<td>strong agree</td>
<td>agree</td>
<td>disagree</td>
<td>strongly disagree</td>
</tr>
<tr>
<td>All caves are made from limestone</td>
<td>strong agree</td>
<td>agree</td>
<td>disagree</td>
<td>strongly disagree</td>
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<tr>
<td>Bats found in caves will attack people</td>
<td>strong agree</td>
<td>agree</td>
<td>disagree</td>
<td>strongly disagree</td>
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<tr>
<td>Most caves are still wet, meaning the cave is young, and hasn’t been there long enough to completely dry out</td>
<td>strong agree</td>
<td>agree</td>
<td>disagree</td>
<td>strongly disagree</td>
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<tr>
<td>The world’s deepest caves can reach the center of the earth</td>
<td>strong agree</td>
<td>agree</td>
<td>disagree</td>
<td>strongly disagree</td>
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<tr>
<td>Underground rivers are real</td>
<td>strong agree</td>
<td>agree</td>
<td>disagree</td>
<td>strongly disagree</td>
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<tr>
<td>The air temperature outside of a cave affects the temperature inside of a cave (if it is cold outside then it is cold inside, etc.)</td>
<td>strong agree</td>
<td>agree</td>
<td>disagree</td>
<td>strongly disagree</td>
</tr>
<tr>
<td>If my light were to go out while exploring in a cave, my eyes would be able to adjust to be able to see in the dark</td>
<td>strong agree</td>
<td>agree</td>
<td>disagree</td>
<td>strongly disagree</td>
</tr>
<tr>
<td>Statement</td>
<td>Agree</td>
<td>Disagree</td>
<td>Strongly Agree</td>
<td>Strongly Disagree</td>
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<td>--------------------------------------------------------------------------</td>
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<tr>
<td>Caves can be found in all parts of the world</td>
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<td>Caves are useful to understanding the environment</td>
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<td>Natural spring water that comes out of the ground is completely pure and safe to drink</td>
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<tr>
<td>New water is created everyday</td>
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<td>Water that seeps into the ground is lost forever</td>
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<td>There is more water on Earth today than there has been in the past</td>
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<td>All caves are wet</td>
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<tr>
<td>Cave water is the same as natural spring water and therefore naturally filtered and safe to drink</td>
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<td>It takes millions of years for caves to form</td>
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<td>Caves are different from caverns</td>
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<tr>
<td>Earthquakes can be felt from inside of a cave</td>
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<tr>
<td>Most caves formed from gas bubbles from the earth's interior long ago when the surface was still molten rock</td>
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<tr>
<td>Cave water is very stagnant and stale from being stuck in the cave for so many years</td>
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<tr>
<td>Plants found in the caves suggest that the cave itself is very young</td>
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<tr>
<td>The early hominids were the first to begin building most of the caves, many of which are still unfinished today</td>
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<tr>
<td>Cave water isn’t really water at all, it is a natural chemical that is unfit for human consumption</td>
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<tr>
<td>Caves can form in a matter of months by water powerful enough to wash through solid rock</td>
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Appendix O: Preliminary Demographic Information Form

Name: ________________________________ Date of Birth: ____________________

Gender: M F Race: White African American Hispanic Asian Other

Primary E-Mail Address: ________________________________________________

Where did you attend high school? ______________________________________

Did you receive special education services in high school? Yes No

If yes, what were they?

______________________________________________________________

Did you transfer from another college(s) or university(ies)? Yes No

If yes, where from?

What quarter/year did you begin at Wright State? __________________________

When do you anticipate graduating? _________________________________

List your major/minor or degrees already earned? (undergraduate and graduate if applicable)

List any previous science classes completed. (highlight completed geology courses)

Describe any specific informal science learning experiences that you find most memorable? (museums, parks, interesting television shows, etc.) PLEASE PROVIDE DETAILS

Common outdoor leisure activities or experiences?

________________________________________________________________________

________________________________________________________________________
What is the diagnosis of your mobility impairment?
________________________________________________________________________________________
________________________________________________________________________________________

Have you had this mobility impairment since birth?  Yes  No

If No, please explain WHEN and HOW your disability was acquired.
________________________________________________________________________________________
________________________________________________________________________________________

Using your own words, please describe your disability(ies) and how it affects your ability to function on a college campus (in the classroom, fieldtrips, etc).
________________________________________________________________________________________
________________________________________________________________________________________

Explain how your disability affects your ability to function in public (shopping, eating, attending events)?
________________________________________________________________________________________
________________________________________________________________________________________

If applicable, please list any adaptive and/or computer technologies you will be using.
________________________________________________________________________________________
________________________________________________________________________________________

Please list what medical or mobility equipment you use daily.
________________________________________________________________________________________
________________________________________________________________________________________

Please list the physical accommodations and services (including transportation and personal assistants) you are using, including how many times per day/week.
________________________________________________________________________________________
________________________________________________________________________________________

Please list any other documented disabilities you may have.
________________________________________________________________________________________
________________________________________________________________________________________

Participant Signature:___________________________ Date:_________________________
Appendix P: Semi-structured Interview Protocol

Interviews: semi-structured prompts will be similar to the following:

1. *Students’ perspective of science:*
   - What is your current perception of science? Scientists? Scientific careers?
   - Explain what you know about geology and what geologist do.
   - Geologists learn a lot about the environment while working outside of a typical classroom, would you enjoy doing this? Why or why not?

2. *Students’ perspective learning science:*
   - Would you prefer to learn in a classroom versus learning in the field? Why or why not?
   - What science classes have been the easiest for you? (not the learning, but the doing)
   - What have challenges in your past studies done with your perception of that science?
   - How have these challenges affected your decision to pursue a career in that science?

3. *Students’ perspective accessibility:*
   - What are the most common barriers that you deal with (physical, psychological) when going places? Which ones keep you from trying something new?
   - How often do you try to go to new places? When is the last time you went someplace new and where was it? Were you nervous about going there? What made you nervous?
   - What worries you the most about going to places you’ve never been before?
   - Would you be interested in helping to improve accessibility for future users? Working to overcome obstacles for your own learning?
   - Tell me about the most challenging place you have ever been. What made it so challenging? What were the physical barriers that you faced? How did you feel about it before you went? After you went? How did you overcome the fears you faced with visited this place?

Focus Group Interview 1:
   - So we have talked a lot about the science of cave formation, and the cave and karst system. There are now things that you probably didn’t expect. With the trip last night, we got our first taste of being outside in a non-controlled environment. What are your feelings about everything this morning? What were the biggest problems from last night? Remember, we are all here to learn from each other. I have been able to work through my fears in a year and a half of planning and a firm understanding and knowledge of what we were going to be doing this weekend. You haven’t had this luxury. What are you most concerned with now?
Focus Group Interview 2:

- Thoughts from the previous day?
- I could tell that there was tension prior to the elevator decent. In not just you, but everyone involved. How did you feel about the overall experience? Tell me your initial thoughts as you entered the cave.
- Obviously we had a let-down with the trip. Tell me what you were thinking as you started to hear the rumblings that our trip into the Historic entrance was in jeopardy and when you started hearing that we weren’t going to be allowed down there?
Appendix Q: Semi-structured Journal Protocol

Student Journal Prompts will be similar to the following:

- **Journal 1:**
  - Discuss what you currently know about cave geology, where you learned it (be as accurate as possible). What lives in caves, what are the conditions in a cave? Why are caves important? (this journal was completed prior to the class discussion on this topic)

- **Journal 2:**
  - How would you plan for a weekend camping trip? How do you prepare? What types of camping equipment will you need? What personal items do you need to take?
  - What types of jobs do geologists do? Would you be interested in these types of jobs? Why or why not? (this journal was completed prior to the class discussion on this topic)

- **Journal 3:**
  - As you begin your journey into discovering cave geology, what are your current feelings, excitements, concerns?
  - How might you prepare to overcome your concerns?

- **Journal 4:**
  - Describe what you "see" when you think about caves. What is it that you expect the cave to look like? What are the conditions inside of the cave versus outside? Be as detailed as possible. Draw me a picture in words of how you envision the cave to be.

- **Journal 5:**
  - Now that you have been inside of a cave, how would you share/describe your experience with others? What were the highlights?
  - What did you like the most?
  - What didn’t you like?

- **Journal 6:**
  - Describe your thoughts about the study of geology? How have they changed since the beginning of the course?
  - For many of you, this was your first time learning outside of the classroom. Explain what this was like for you. How would you put this experience into words for someone who is mobility impaired?
  - What have you learned about caves that surprised you most?
  - What were the most difficult barriers related to this course? Please explain.
Appendix R: Qualitative Data Coding Schema

Qualitative Data Coding Schema

Interaction (I)
Defines the interactions between members of the group, inclusive of instructional staff, that create a unified group dynamic. Interactions may include both direct and reflective communication between participants and instructional staff.

Secondary Codes:
- Reflection (I-R)
  o Participant reflections of the experience with respect to group dynamics.
- Inter-relationship engagement (I-IR)
  o Participant discussions of the importance of the group dynamic both participant-to-participant and participant-instructional staff.

Language Evidence and Examples: Trust, making friends, building relationships, open communication, honesty, safety
Coding Relationships: Attitude

Attitude (At)
All statements written and verbal that represent a state of emotional perception related to all areas of the study prior to and inclusive of the field-trip experience.

Secondary Codes:
- Fear (At-F)
  - Implicit (At-FIm)
    ▪ Any fear that was created by questions being asked of the participants about any aspect of the experience; participants beginning to feel that due to the questioning, they should be worried or afraid of something to come.
  - Innate (At-FIn)
    ▪ Any fear that the participants brought with them either from past experience or preconceived notion.
- Enjoyment (At-En)
  o Obtaining any level of enjoyment from the experience either physically, emotionally or cognitively.
- Efficacy (At-Ef)
  o Relates to how the participants see themselves performing in science roles or practicing as Geoscientists either prior to or after the field experience.
- Satisfaction (At-S)
  o Whether the participants obtained satisfaction from the experience, either classroom, field study or both.
- Frustration (At-Fr)
  o The level at which the participants were frustrated with the experience due to internal and/or external factors and barriers.
Language Evidence and Examples: I was frustrated..., angry, happy, sad, loved, was surprised, couldn’t believe, I can do ..., I didn’t think I would be able to..., Made me think, amazed, describing physical attributes with qualifiers, afraid, didn’t want to

Coding Relationships:

Experience (E)
Data that highlight the participants’ prior understanding of the study focus, including all past experiences and content understanding.

Secondary Codes:
- School/Education (E-E)
  o Content knowledge obtained directly from prior formalized schooling structures.
- Family/Friends (E-F)
  o Content knowledge obtained indirectly from personal relationships.
- Indirect (Media) (E-I)
  o Content obtained from media sources such as TV, radio, newspapers, etc.

Language Evidence and Examples: in school, teachers, professors, saw on television, read, heard about, my friends, parents

Coding Relationships: Knowledge, attitude

Ability (Ab)
All data collected that depict the participants’ personal day-to-day routines and functionality within society.

Secondary Codes:
- Dependence (Ab-D)
  o The level at which the participants identified being dependent on others for a complete experience or for their learning.
- Independence (Ab-I)
  o The level at which the participants identified being independent of others for a complete experience or their learning.

Language Evidence and Examples: By myself, needed help, assistance

Coding Relationships: Attitude

Knowledge (K)
All evidence of participants’ geoscience content knowledge prior to and during the study.

Secondary Codes:
- Prior (K-P)
  o All participant content knowledge (either accurate or misconceptions) that were securely held prior to the study.
- Developed (K-D)
  o All content knowledge that participants developed throughout the study.
- Misconception (K-M)
  o All scientific misconceptions that the participants either had prior to the study or that changed during the study.

*Language Evidence and Examples: learned, thought, didn’t know, not what I thought, wrong idea, remember learning, not what I knew*

*Coding Relationships:*
Appendix S: Cave Map Activity

(Credit for underlay map: Cave Research Foundation; Mammoth Cave National Park)