Theoretical perspectives on constructing experience through alternative field-based learning environments for students with mobility impairments

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ABSTRACT

Students with physical disabilities encounter challenges in any scientific discipline, yet the geosciences have extremely low participation levels for persons with disabilities. Because of the emphasis placed on field research at the undergraduate level, persons with mobility impairments face limited opportunities for progressing in the geosciences. One strategy to address this is the application of adaptive technologies, such as virtual field trips (VFTs), as a supplement to traditional field instruction. A common goal of VFTs and other adaptive technologies is to promote equal access to undergraduate geoscience curricula for physically impaired students. If the scientific talents of these students are embraced and accommodated, regardless of their physical ability, the overall welfare of the geosciences as a discipline is enhanced.

This paper describes ongoing research into the development of one specific VFT: an electronic re-creation of Mammoth Cave National Park for the Introduction to Cave and Karst Systems field course at the Ohio State University (OSU). This paper focuses on the theoretical processes necessary to conduct qualitative inquiry for the purpose of developing an accessible, alternative field-based learning environment. Grounded theory and critical theory are contrasted as two possible guiding frameworks. Three roles for the researcher are compared: researcher-as-observer, participant-researcher, and action-researcher. Phenomenology is discussed as the preferred methodological choice for this research, and attendant methods are described. Finally, a discussion of validity and reliability issues is provided. This paper is intended to serve as a guide for future researchers embarking on qualitative studies similar to this one.
reside. Adaptive technology may be first implemented as a classroom innovation. The impact of the implemented technology on student learning may then be (quantitatively) assessed. Its application could then be compared to extant pedagogical practice, which itself may be anecdotally considered an idealized baseline condition. For example, a web-based field trip may be designed by an instructor to provide his or her mobility-impaired students with a field-based learning opportunity. Subsequent research into this innovation could address the following questions/objectives: (1) How was it designed and executed? (2) What contribution did the innovation make to student learning? (3) How does it compare as a supplement to—or replacement of—a traditional field trip?

These research objectives would ideally be approached in a mixed-methods manner. Quantitative analyses of outcomes between experimental and control groups of students are appropriate measures of efficacy. Qualitative inquiry provides a deep picture of students’ lived experiences with the innovation, guiding its future applications, and providing an additional illustration of its efficacy. Qualitative inquiry allows the researcher’s role to be presented and understood. This in turn allows the research to be deliberately applied to address a social problem, such as providing equal access to the sciences for disabled students.

PURPOSE OF THIS PAPER AND GENERAL PROBLEM STATEMENT

This paper is intended to serve as one example of the conceptualization of a qualitative study. It does not present a completed study, with a description of methods, data, results, and implications. Instead, it is a theoretical examination of the earliest stages of a research and development project. Guiding theoretical frameworks and roles of the researchers are discussed in detail. Methodological choices are described and justified. Strategies for ensuring reliability and trustworthiness are then outlined.

The basic problem to be addressed by this research is that of improving accessibility to the geosciences for mobility-impaired students, which is defined more deliberately in the population characteristics section of this paper. One avenue to accessibility is the application of adaptive technologies, specifically virtual field trips (VFTs). A desire to understand the utility of VFTs in the context of accessibility generates three specific research objectives to be addressed by the present qualitative inquiry. Prior to a discussion of these three objectives, however, the necessary background on geoscience curricula and mobility-impaired students is provided.

BACKGROUND

In the most recent and thorough study documenting the enrollment of geoscience students with disabilities, it was determined that by the year 2000, total college enrollment in the United States approached 15.3 million persons (NCES, 2008). Of that total, 10.6%, or ~1.4 million students, reported having a disability of some kind (NCES, 1999; Locke, 2005). According to the American Geological Institute (AGI), during the 1995–1996 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 science education addresses the needs of individuals with disabilities. This determination would begin to satisfy the nondiscriminatory 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 for all student populations (Cooke et al., 1997; Norman, 2002).

Challenges and Opportunities of Field-Based Education

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 and Elkins, 2007; Maskall and Stokes, 2008; Riggs et al., 2009). The basic method of classroom instruction is not enough; no analog exists for traversing a landscape (Riggs et al., 2009). First-hand observation and construction of field knowledge, which are associated with the aspect of “embodied field work” (Nairn, 1999), are especially important for a novice geology student with limited field knowledge and experience, regardless of their physical ability (Elkins and 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. It is depicted by the ways in which 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 and Mogk, 2009). Additionally, geoscience field-based coursework offerings in most geology and earth science departments are reappearing nationwide (AGI, 2009; Whitmeyer and Mogk, 2009). This suggests a potential revitalization of the importance of field instruction in the geoscience curriculum that had been on a slight decline in recent years, and, therefore, an increased need for accessibility.

A student’s identity within the geosciences may also be profoundly shaped by field study. 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, and excluded from traditional geoscience fieldwork (Nairn, 1999; Hall et al., 2004; Hall and Healey, 2005). Based on the findings of Hall et al., an assertion can be made that students with physical disabilities should not be treated as fragile students, 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 complete participation by all students will limit the difficulties to overcoming these barriers through the course design process (Healey et al., 2002). It is therefore imperative to develop innovative learning environments that will transform and improve learning experiences for all students. So, in order to accommodate students with mobility impairments who primarily face the physical barriers of field-based coursework, adaptive technologies must be designed and developed.

## Adaptive Technologies in Field-Based Education

Fieldwork is primarily designed as a physical experience; students go to the field, traverse the landscape, take measurements, collect rock samples, and make observations of the geology by navigating through it. This experience engages multiple senses, yet the overall sensory experience is narrow, relying heavily on the physical abilities of the student (Hall et al., 2002). The traditional field-based learning experience is predicated on a given level of mobility. Therefore, mobility impairments negatively impact the field learning experience. This is a barrier to students with disabilities, especially if no modified methods of field instruction exist.

Visualization technologies, such as virtual field trips (VFTs), are not only a practical supplement to traditional field methods, but they are also a potential alternative instructional method for all students requiring improved accessibility to a field experience. VFTs range from simple and static narratives: hot-linked web pages or animations, to dynamic and complex interactive experiences (Spicer and Stratford, 2001; Qiu and Hubble, 2002). Interactive VFTs are capable of analyzing students’ conceptualizations of the environment through the development of mental models of environmental scenarios (Shepardson et al., 2007), three-dimensional computer-based simulations, visualizations, and computational modeling (McKinney, 1997; Schwert et al., 1999; Barab et al., 2000; Bakas and Mikropoulos, 2003; Saat, 2004). Such environments have been developed to inform students on reducing potential hazards in a natural field environment, serve as a supplemental resource to enhance instruction and interpretation skills both before and after a field trip, or completely replace trips to a location that may be inaccessible or not longer in existence. In addition, the realism and effectiveness of VFTs continue to improve with the advancements of technology and visualization. The three-dimensional displays of stereographic representation, surround display of Cave Automatic Virtual Environment (CAVE) systems, supercomputer-based computational modeling and immersive virtual reality (VR) including the potential for real-time tele-presence visualization, a real-time synchronous interaction between two live users within two different locations, provide effective alternatives to field courses without the need to enter the field (Jackson and Winn, 1999; Lascara et al., 1999; Tan and Subramaniam, 2003; Stredney et al., 2008).

Alternative field environments, however, should not be considered superior to traditional field courses. It is not the intent for technology to replace traditional field studies, but rather enhance them by increasing accessibility for persons with mobility impairments who would otherwise be potentially excluded from the field excursion. However, opportunities for alternative field-based education would offer utilities that are an advantage to all students (Cooke et al., 1997; Norman, 2002). It is also reasonable to assume that virtual field studies will provide alternative ways to enhance existing geoscience field courses by supplementing pretrip content knowledge acquisition or post-trip review of concepts (Holt, 1996; Spicer and Stratford, 2001; Qiu and Hubble, 2002). These virtual programs are finding respect within several geoscience programs as a supplement of virtual and hypermedia materials and resources for pre- and post-field-trip activities (Spicer and Stratford, 2001). Through strong instructional design, these supplementary materials could reduce the duration of the field study as well as increase the informational transfer while in the field (Qiu and Hubble, 2002). Also, supplementary information to the filed content would potentially boost the confidence of novice geoscience students, allowing them to refresh the material during a post-trip review. The greatest potential impacts of VFTs, however, are the opportunities presented to students who do not have access to the field because of mobility impairments.

## DESIGN AND DEVELOPMENT OF THE VFT

As stated already, virtual field environments can take on a variety of formats, from low-technology text and image-based, self-paced field reference guides to high-technology, complete visual immersion field trips. Additionally, task-specific activities contained in a large number of VFTs found on the internet have
a wide spectrum of content and quality variance (Qiu and Hub- 
ble, 2002). However, recent studies have determined that higher 
levels of immersion in virtual environments have increased ben-
efits of spatial understanding and a correlation to natural reality 
(Schuchardt and Bowman, 2007; Stredney et al., 2008). Through 
three-dimensional display, geographic distances and sizes of 
comparable objects can be realistically rendered. The added 
scenery promotes a more accurate content acquisition than cur-
rent desktop systems (Schuchardt and Bowman, 2007).

We investigated a process aimed at developing a complete 
immersive, multidimensional, abstract re-creation of a natural 
cave environment. An immersive technology environment expe-
rience is being conducted in order to test the multimodal aspects 
of different VR environments, and to determine the best envi-
ronment to address the learning objectives and create a realistic 
field experience. Deliberately broad, the goal is to narrow down 
the type of visualization technology based on effectiveness of re-
creation and participant usability. The aspects of modality include, 
but are not limited to, seamless and realistic image rendering, 
visual movement within the virtual environment, and interac-
tivity of the user-simulation interface design. This investigation 
looks at three separate, virtual environments, two of which have 
been developed during former studies at Ohio State University, 
and are available to be utilized for this specific purpose. The first 
of the two virtual environments was developed as a re-creation 
of a hazardous scenario using farming equipment in which the 
virtual re-creation allows for an enhanced level of safety and con-
trol for the user (Stredney et al., 2008). The other is a complete 
re-creation of archaeological ruins that are no longer accessible 
to public visitors: an interactive model of an ancient sun-dial cal-
endar site in Chaco Canyon, New Mexico (Nicoli et al., 2008). 
The rationale for using these predeveloped environments is that 
they are readily available on site with the required equipment and 
software needed, and will provide a diverse representation of the 
VR options needed for the initial design of the pilot VR model.

The first environment is a more visually immersive agricul-
tural simulation; users wear a full, head-mounted display inter-
face and have the ability to visualize their own hands within the 
environment through wrist-tracking devices. This simulation pro-
vides a significant amount of user-environment interface inter-
action that controls their experience within the fully rendered, 
interactive virtual environment. This simulation also boasts ele-
ments of motion from the simulated objects within the environ-
ment that are independent of the user.

The second environment is a full re-creation of a real archae-
ological site using a high-resolution 10′ × 6′ stereoscopic three-
dimensional (3-D) display; the user is capable of interpersonal 
interactions with other users, while controlling 360° of visual 
 mobility around the virtual site. The medium is a rear-screen 3-D 
projection system where the user wears polarized glasses.

The third simulation will be a real-time tele-presence 
experience also using technology available at OSU. This two-
dimensional (2-D) user-to-user environment will allow a 
laboratory/field student exploration team (one student user in the 
interface laboratory while the other student user is exploring the 
interior of the building) to work in tandem in a field exploration 
experience. The laboratory student will receive visual imagery 
through a monitor or projection display from the perspective of 
the explorer and be able to have full vocal interaction with the 
explorer. The laboratory student will have control over the envi-
ronment to the extent that the explorer responds and obliges. The 
intention will be to then begin translating this into an interactive 
virtual explorer, controlled by the laboratory student.

The three VR environments differ significantly from each 
other in scope of technology, display, interactivity, and percep-
tion. Utilizing the personal experiences of the students, we will be 
able to determine which features of the simulation are most effec-
tive for them and develop a completely innovative and interactive 
design for the final VFT. The students involved in this investiga-
tion will assist in assessing the capability of the virtual field envi-
ronment to represent geologic content, and they will provide an 
interactive presence and an accurate visual perspective.

Context of the Field Site

Mammoth Cave National Park can be described as one of 
the world’s most fascinating places for detailing Earth’s his-
tory 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 of America. This is a location that is utilized 
by many research and educational institutions for the vast learn-
ing opportunities it possesses. In fact, Mammoth Cave National 
Park, and the surrounding region, is the primary focus for one of 
the field courses at The Ohio State University in cave and karst 
processes within the School of Earth Sciences. However, like 
many field-intensive courses, there is an accessibility issue with 
this excursion, which excludes many mobility-impaired students 
from taking part in the course. The extremely limited access to 
the park’s resources and challenges of descending stairs and very 
narrow passages further reduce the likelihood that these students 
would consider taking part in this field course.

The VFT will be a virtual recreation of portions of the 
cave’s interior—an innovative solution to improve accessibil-
ity to the park’s extensive resources. This project is facilitated 
through collaboration between the Ohio Supercomputer Center, 
the Advanced Computing Center for Arts and Design, Mammoth 
Cave National Park, and Ohio’s STEM Ability Alliance, and it is 
supported by National Science Foundation funding (NSF GEO-
0939645).

SETTING THE STAGE FOR THE PRESENT STUDY:
THEORY AND LOCATION IN QUALITATIVE INQUIRY

Quantitative inquiry and scientific empiricism are both predic-
ted on the notion of a measurable, objective reality and the 
ability to replicate experiments and observations. Geoscientific 
investigators have a unifying purpose: to discover the “truth”
about a phenomenon and how it works. By contrast, qualitative inquiry considers problems that are much more “messy” in nature. Attitudes, perceptions, and individual communicated truths are the data generated by qualitative inquiry (Mason, 2002; Feig, this volume). These data do not lend themselves well to experimental manipulation, numerical analysis, or external judgments of validity.

Researchers addressing geological problems, such as the structural history of a region, the age of a pluton, or the evolution of a landscape, are working wholly within the theoretical framework of scientific empiricism. They do not need to consciously reflect on their purpose and their role as the researcher, and then choose a theoretical framework in which to conduct their work. To understand a natural process, to verify or reject a hypothesis about that process, and to apply a model of that process across settings are empirical and logical procedures, based on experimentation and replication.

Researchers addressing educational problems through qualitative inquiry, however, have a choice of theoretical frameworks. Their choices are based on their purpose in conducting the research, as well as their place within it. The options for theoretical frameworks and the researchers’ place in qualitative study are described next, and the choices made for the present study are outlined.

Choosing a Theoretical Framework

Qualitative researchers may choose from a variety of theoretical frameworks, including quasi-empiricism, behaviorism, symbolic interactionism, grounded theory, or critical theory, depending upon their motives and goals. A common approach in geoscience education research is a blend of behaviorism and grounded theory. Behaviorism is predicated on the notion that human behavior is a set of responses to stimuli that follow basic rules and patterns (Skinner, 1953). Grounded theory is a data-driven approach to building a systematic model, or other type of theoretical construct (Creswell, 1998). This model should have some applicability beyond the study that generated it. The model is constructed by means familiar to geoscientists: recognition of patterns (concept indicators), unifying explanations of a phenomenon, and the outlining of visual, stepwise sequences in a process. One example of grounded theory in geoscience education research is that of Riggs et al. (2009). These workers equipped students in a field mapping class with global positioning system (GPS) transmitters that recorded their movements in the field. These movements were subsequently overlain on a geographic information system (GIS) grid. Riggs, Leader, and Balliet then identified navigation paths and coded them to produce consistent models of student performance as a function of land navigation. The outcome of their study was a new tool (model) for gauging student performance in geologic field problem solving.

By contrast, critical theory is an approach suitable for those researchers seeking to affect social or educational change (Mayo, 2007). In this context, “change” means addressing the social and educational problems of equal access (e.g., Freire, 2000), power relationships (e.g., Gould, 1993), or race- or sex-discrimination (e.g., Haymes, 1995; Barton, 1998). In the geosciences, an example of research informed by critical theory is that of Williams and Semken (this volume) and Semken and Brandt (2010). The former workers 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 workers take on broader societal issues of cultural sustainability and ecojustice. They approach these problems by calling for the integration of Euro-American science with indigenous knowledge. Semken and Brandt (2010), through applications of place-based geoscience education, seek to give Native American peoples and their knowledge a voice.

In this study, we ultimately seek improved accessibility within the geosciences for a previously marginalized population; this is a challenge to the status quo preconception that some students can “do” geology, while others cannot. An eventual outcome of this research will be the development of a generalizable model of effective student-VFT interfaces. However, the main thrust of the present study is to challenge current geoscience field-based accessibility. Therefore, this present study is to be conducted in the framework of critical theory. We, as authors, are critical theorists.

CHARACTERISTICS OF THE STUDY POPULATION

As with most qualitative studies, the population size of the present investigation will be small ($n = 20$). Half of the participants ($n = 10$) within this study population are mobility impaired; the rest ($n = 10$) are trained personal assistants for the mobility-impaired students, who will not be compared to the students, but rather be observed working with and interacting with them throughout the learning experience. For the purpose of this study, the term mobility impairment represents any physical condition that prevents an individual from performing a key life activity through movement; conditions that limit their ability to use stairs or traversing rough terrain, not due to sensory or psychological impairment. The rationale for this study is to determine how experience in a geologic field environment assists in the overall construction of knowledge. Given this idea, most traditional field environments are inaccessible to mobility-impaired students. The data gathered from these individuals will be necessary for the development of an alternative field environment that will permit students to experience the field site virtually, within a controlled facility, learning within the field environment without the physical or emotional stress of negotiating the natural field site.

Participants were identified through the assistance of the Office of Disability Services (ODS) at a Midwestern research university, as well as the Project Coordinator for Ohio’s STEM Ability Alliance (OSAA). All participants in this study are to be enrolled in an introductory cave geology course within the Earth and Environmental Sciences department entitled Introduction to
Cave and Karst Systems, which is only being offered to students registered with ODS and their personal assistants. The principal investigator will gain access to these students as a result of being a co-instructor for the geology course.

Factors to determine participant eligibility include the following:

1. mobility impairment, registered with the University Office of Disability Services (ODS) OR a personal assistant to a student registered with ODS;
2. must be in good academic standing; and
3. enrollment in EES 199, Introduction to Cave and Karst Systems.

LOCATING THE RESEARCHERS

The location in time of this study is the present; it is not a historical or longitudinal study. The spatial locations of this study are the face-to-face (F2F) classroom and field site at Mammoth Cave National Park, as well as the interface laboratory at the Ohio Supercomputer Center for the study of the virtual environments associated with this investigation. In a qualitative study, the researcher must also describe his or her role in the research. Ultimately, the questions that must be answered are, “Who is the researcher, and why is she or he conducting this research?” Such questions are highly relevant in qualitative inquiry (Feig, this volume; Mason, 2002; Wolcott, 1999) because they reveal the purpose of the study. Three possibilities exist for a researcher’s location: the researcher-observer, the researcher-participant, and the action-researcher. These are discussed in detail in Feig (this volume), but a brief overview is included here.

The researcher-observer documents, among other things, how students cope with novel situations, how they respond to a teaching innovation, and how they navigate tangible or intangible barriers. This researcher generates data either by passive observation, or active processes such as interviewing participants. Clary and Wandersee (this volume) are researcher-observers. They engaged in direct observation of verbal and nonverbal behaviors to document student reaction to, and experience in, an informal learning environment.

Researcher-participants study their own classrooms. These are the instructors who have created a classroom innovation, and wish to document its efficacy and impact. They often seek to refine the innovation, or expand its application beyond their setting. The instructor is not only a researcher, but is also a participant in the research, because she or he is studying his or her own students, and is using the results to improve and apply the innovation in his or her future classes. The researcher-participant moves back and forth between the roles of “detached” observer and active participant in the research.

Action-researchers seek to address social problems through their research. This can be a reflexive process, as when an instructor seeks to modify his/her own praxis (Hunter, 2007); alternatively, the researcher may be working on an external social/educational problem. For example, research that is meant to broaden participation in geoscience by underrepresented groups (e.g., Riggs, 2005), or promote environmental activism and stewardship (e.g., Smith and Williams, 1999) is action research. Action-researchers are typically critical theorists, because they are issuing a call to action or a challenge to the status quo, beyond understanding or modeling a process. The present study is best categorized as action-research, because the overarching goal is to increase geoscience access to a commonly marginalized population at the study institution. This is a direct challenge to current educational practice, compelling educators to evaluate and, as necessary, rethink their preconceptions of the educational ability of mobility-impaired students.

In the present study Atchison, as the principal investigator, is a critical theorist, and has a location as an action-researcher. He is seeking to solve the educational problem of mobility-impaired students being excluded from traditional field-based education opportunities. The “call to action” here is for instructors to see the application of a VFT as a viable educational opportunity for this population of students in particular, and ultimately all geoscience students.

RESEARCH OBJECTIVES

The general research problem of improving access to fieldwork with VFTs generates three specific research objectives for qualitative inquiry. First, successful application of VFTs as an adaptive technology for mobility-impaired students requires an understanding of how students construct geological knowledge in the face of field-related barriers. Second, evaluating VFTs as a supplement to field instruction requires an understanding of how students interface with their environment, i.e., understanding their lived experience with (and within) a traditional field site. Third, the overall effectiveness of a VFT must be documented in terms of learning outcomes and other measures of student achievement. This documentation will begin to determine how the virtual re-creation adequately promotes an authentic interaction with the natural environment.

Critical theory is the consistent guiding framework in which each of these objectives will be addressed. Another consistent factor is the location of the authors as action-researchers. The variable, however, is the methodology and methods used for each objective, as well as the processes of ensuring reliability and trustworthiness. For the sake of convenience, these variables are grouped as the “mechanics” of each research question, and are discussed accordingly. Figure 1 provides a process map listing each research objective, applied methods and methodologies, and expected outcomes.

Research Objective 1: The Construction of Geological Knowledge in the Face of Field-Related Barriers among Mobility-Impaired Students

Substantial work has been conducted on student learning in the field (Thrift, 1975; McKenzie et al., 1986; Orion, 1993;
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Garrison and Endsley, 2005; Elkins and Elkins, 2007; Potter et al., 2009; Thomas and Roberts, 2009). Much less work has been done on students with disabilities attempting to learn in the field (Cooke et al., 1997; Hall et al., 2004; Healey et al., 2002; Locke, 2005; Hall and Healey, 2005), and even fewer on field-based education with students with mobility impairments (Norman, 2002; Stokes and Boyle, 2009). In terms of specific challenges of the field environment, 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 aspects of novelty space with respect to field-based learning environments. However, many studies on field-based education assume a situation in which the learners are physically able-bodied. As a result, the documentation of knowledge construction did not take into account the physical and psychological barriers that are significant to learners with mobility impairments that are evident in Orion’s concept of novelty space.

This first research objective addresses this issue by seeking to discover the exact nature of the potential barriers related to the Mammoth Cave National Park field site, and how mobility-impaired students negotiate them in the learning process. In terms of qualitative inquiry, this is an objective of the “essence” (Creswell, 1998; Mason, 2002) of a particular experience. An appropriate methodology here is phenomenology, which is a meticulous documentation and understanding of the essence of a lived experience (Schwandt, 2001; Feig, 2008). Understanding comes through the process of extracting meaning from data, and relevant data include behaviors, feelings, choices, attitudes, personal accounts, and interpersonal interactions (Feig, this volume). As such, this methodology is appropriate for the objective of documenting how students construct knowledge through experience.

The methods used to generate these data include individual and focus group interviews, attitudinal and motivational surveys, student journaling, and observations. The interviews may be unstructured, semistructured, or highly structured, depending on the researcher’s intentions (Wolcott, 1999). For example, in their work to refine the “Geoscience Concept Inventory,” Clark and Libarkin (this volume) asked novices and experts specific questions about tectonic processes in order to document their conceptions of how the process worked. Their questioning was directed, but it allowed participants to guide the discussion wherever it might go. Clark and Libarkin did not know what the specific conceptions would turn out to be, and so they allowed the conceptions to emerge naturally through conversation. This is an example of semistructured interviewing. In the present research, a semistructured interview process will be applied to generate discussion about potential barriers to learning and the participants’ negotiation of those barriers, while allowing thick descriptive data to emerge naturally through conversation.

Research Objective 2: Understanding Student Interactions with Their Environment

This research objective considers mobility-impaired students in the context of both the natural and virtual field-trip experiences. Phenomenology is again an appropriate methodology, since the objective is to carefully document the essence of individual experiences with the VFT. The methods used would also include observation and structured interviews both before and after using the VFT. These methods allow participants to be guided through the process of reporting and reflecting on their experiences. The data of interest here include accounts of using
the VFT, students’ perceptions of the VFT, and changes in conceptions as a result of interaction with the VFT, all while relating it to the natural field location. Participants will be interviewed about their understanding of cave formation, cave features that are used to assist the interpretation of that formation, and the physical accessibility issues associated with the natural environment. One potential outcome of this procedure is the construction of a model that describes student interaction with the natural environment, either holistically or as progressive stages, that can be mimicked in a virtual environment. This model would be useful to other instructors and applicable to groups of student-users beyond those studied here. The chosen strategy lays a foundation for a descriptive portrait of an individual’s perspective and lived experience. Without having a documented, first-person account of the experience, researchers are left to detail an event through hearsay or second-hand evidence, i.e., describing one’s perspective without having the experience to do so.

Research Objective 3: Effectiveness of an Actual VFT in Engaging Mobility-Impaired Students

The effectiveness of the VFT within the given student population may be assessed both qualitatively and quantitatively. In a qualitative process, a phenomenological methodology would be applied to document effectiveness in the form of individual “successes,” including evolving conceptions and so-called “Aha! moments.” The appropriate methods here are individual and focus group interviews, student journaling, a survey of motivation in science learning, and direct observation in order to build a narrative of the VFT as an effective strategy to remove barriers to learning. Applying these methods will allow participants to narrate their experience with the VFT, identifying threshold concepts of the content, and the ways in which, in detail, using the VFT altered their conceptions. The generated data will be in the form of oral and written narratives.

This research objective is also well suited for quantitative study. For example, student outcomes in the study population can be measured against criterion-referenced learning outcomes. In the Mammoth Cave field course, these learning outcomes include the ability to conduct scientific measurements and observations, formulate interpretations, and present findings based on gathered evidence and newly constructed knowledge. This is an empirical methodology, and two strategies for methods may be applied. In the first, a pretest of field skills or content knowledge is applied to the study population before they interact with the VFT, and a subsequent post-test is administered. The two tests may then be compared statistically for significant differences. In the second method, the study population may be compared against a control group (mobility-impaired or otherwise) who did not use the VFT. Alternately, the study population could be compared with a non-mobility-impaired group who also used the VFT. If such empirical measurements were to be conducted simultaneously with the qualitative inquiry, this would be a true mixed-methods study, with the same question being addressed by different methods.

ENSURING RELIABILITY AND TRUSTWORTHINESS

Raw qualitative data will include field notes written by an observer, transcripts of recorded interviews, and journal entries provided by participants. In phenomenological methodology, meaning is extracted by applying coding processes to these data. The coding process breaks data into manageable segments (Schwandt, 2001) and groups them by category. The categories may emerge naturally as the researcher looks for concept indicators, or the researcher may specify categories beforehand. An example of the latter would be sorting data into the two categories of “Dependent on student mobility” and “Independent of mobility.” One common coding process is the constant comparison method, developed by Glaser and Strauss (1965). In this process, data from one interview/observation are grouped as themes, and then compared to the themes from other interviews/observations. It is the across-group comparison that allows the researcher to parse meaning and relationships. The reader is referred to Creswell (1998) for further examples of constant comparison techniques applied across different studies. Without some process for ensuring reliability and trustworthiness, any emergent themes remain anecdotal. Three processes will be applied in this study to establish reliability and trustworthiness: triangulation, participant review, and providing excerpts of raw data.

In the triangulation process, the researcher subjects the themes and inferences he or she identifies to the analysis of other experts (Lincoln and Guba, 1985; Denzin, 1989; Schwandt, 2001; Seale, 1999), be they geologists, social scientists, or cognitive scientists. Coded data from this study and subsequent inferences drawn from them will be examined by multiple experts from multiple points of view in order to establish the validity of the inferences. In the participant review process, the original researcher presents a transcript (or summary of observations), together with the emergent themes, to the participants for their review. Usually the context of this conversation is along the lines of asking the participants if these themes correspond to what they meant to say, or their actual experience. The subsequent discussion either clarifies the themes, allows new ones to emerge, or, frequently, both. In the excerpting process, the researcher presents to his or her audience (as “results”) emergent themes and interview quotes, or summarized observations, to support the identified themes.

EXPECTED RESULTS AND IMPLICATIONS

We argue that the culture of geologic fieldwork 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), or labeling, of students who do not fit the persona of a young, able-bodied (and in good cardiovascular shape) person as being “disabled” for most field-based educational experiences. This must be transformed from the discriminatory notion that there is a problem with the student, to there being an issue with the field
environment. To do so, it is necessary to include the first-hand perspective (lived experience) of students with mobility impairments in the development of supplementary, alternative field-based learning environments that will be used to accommodate them. This investigation is designed as an ethnographical needs assessment for the development of an effective, supplement to the cave and karst system course curriculum and the field-based component at Mammoth Cave National Park. Constructed to acquire the perspective of the participants, it is anticipated that this investigation will assist in obtaining a deeper understanding of the accessibility needs of students with mobility impairments. Additionally, through the direct experience of the students, this study will begin addressing the aspects of potential geographical, cognitive, and psychological barriers that students with mobility impairments may encounter. It is also expected that this work will further inform the broader research community on understanding the importance of the qualitative aspects of field-intensive coursework design for nontraditional students.

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). VFTs have the potential to enhance the geoscience curriculum by focusing on technology-based interpretation of new and archived geoscience data sets. Cooke et al. (1997) suggests that most modern geoscience careers utilize laboratory-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, it could therefore be argued that it is possible to become an expert geoscientist without direct, traditional fieldwork experience. A future vision of field-based geoscience curricula could suggest that this advanced, technology-based interpretation track be geared toward career-minded students with mobility impairments.

SUMMARY

This paper presents a research project in its early stages, as a model for conceptualizing qualitative inquiry from the ground up. The issue of accommodating mobility-impaired students is a significant area of inquiry in geoscience education, and lends itself well to qualitative inquiry. In order to begin developing an alternative learning environment that will accommodate students with mobility impairments, three specific research objectives have been proposed: (1) document how mobility-impaired students construct knowledge in the face of field barriers; (2) describe student experience and interaction within the physical environment; and (3) investigate the overall effectiveness of a VFT to virtually mimic one’s interaction with the natural environment. We propose that these objectives are best addressed in the framework of critical theory by workers who locate themselves as action-researchers. The preferred methodology is phenomenology, with an excursion into empirical (quantitative) inquiry. The selected methods will be individual and focus group interviews, attitudinal and motivational surveys, student journaling, and observation; empirical methods will include statistical analysis of student outcomes. Reliability and trustworthiness will be established by triangulation, participant review, and excerpting of data together with coded themes. The expected outcome of this research is improved access to the geosciences for mobility-impaired students via adaptive technology, as a challenge to current educational praxis.

ACKNOWLEDGMENTS

This research is currently being conducted at the Ohio State University in collaboration with the Schools of Teaching and Learning and Earth Sciences, Ohio Supercomputer Center, Advanced Computing Center for Arts and Design, National Multiple Sclerosis Society Buckeye Chapter, Mammoth Cave National Park, and the National Cave and Karst Research Institute. This work is funded through the National Science Foundation GEO Directorate, Opportunities for Enhancing the Diversity in the Geosciences, Planning Grant 0939645. Chris Atchison wishes to thank Jill Karsten, Karen Irving, Garry McKenzie, and Scot Danforth for their support and thoughtful suggestions. Anthony Feig wishes to acknowledge the assistance of Alison Stokes and Steven Semken.

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**Manuscript accepted by the society 23 June 2010**

**Printed in the USA**