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Impacts of Experiential Learning on the Affective Domain: Gaining Insight into How to Broaden Participation in the Geosciences

Meghan Lindsey Cook

University of South Florida

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Impacts of Experiential Learning on the Affective Domain: Gaining Insight into How to 
Broaden Participation in the Geosciences

by

Meghan Lindsey Cook

A dissertation submitted in partial fulfillment of the requirements for the degree of 
Doctor of Philosophy 
School of Geosciences 
College of Arts and Sciences 
University of South Florida

Major Professor: Jeffrey G. Ryan, Ph.D. 
Sarah L. Sheffield, Ph.D. 
Ping Wang, Ph.D. 
Jeffrey R. Raker, Ph.D. 
Todd Chavez, MLIS

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Dedication

I dedicate this work to Mike, Scarlett, Henry, and Gwen. You four are my foundation and greatest joy in life.
Acknowledgments

This dissertation took me ten years to complete. Over those ten years, I married my best friend, had three children, moved seven times, and held five different jobs (I had three at one time)! I would have never completed it if not for the support and patience of my friends, colleagues, and family. My parents, specifically my Mom, gave of their time to watch my children so I could write this dissertation while we were home because of Covid-19. I will forever be grateful to her and her ability to love and care for not only me, but my children as well. Heather Lehto, one of my favorite people on this Earth, offered an endless supply of encouragement and knowledge that guided me on this path. Sara Alvarez provided me with the grounding support that only comes from decades of friendship. FRBs and FWs, you know who you are, were a support network that I constantly relied on to keep going. My Mimi’s Mommas never got tired of hearing me talk about my research and life as a Mom in academia. My USF Libraries tribe: Matt Torrence, Matt Knight, Barb Lewis, Drew Smith, Maggie Trela, Christina Wisz, and Loryn Ragsdale, were like a united pack of support that pushed me towards the “Dr.” goal post. A big thank you to Christy Bebeau who provided me with some much-needed qualitative advice as well as for being a thorough editor of my dissertation. Thank you to Dr. Janet Richards who opened my eyes to the world of discipline-based education research, without which this dissertation would not exist. Thank you to Len Vacher who provided me with guidance, deep thought exercises, and writing advice. Thank you to Mel Rodgers who provided her drone-flying skills and photogrammetry knowledge to assist in the creation of the virtual
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Abstract

Experiential learning exercises, such as field trips, are a common pedagogical practice in geoscience curriculums. Their purpose is to facilitate the transfer of knowledge gained in a classroom or lab setting into a field setting, but can be considered a barrier for entry into the geosciences for those with disabilities, caregiver/employment responsibilities, or financial constraints. Educators have begun to turn to other modalities, such as virtual field experiences (VFEs), to create a more inclusive environment in the geosciences. However, the validity of VFEs as a replacement for, or augmentation to, traditional field trips has yet to be established. The cognitive domain (e.g., knowledge, understanding, and comprehension) impacts of both traditional and virtual field trips on students have been studied extensively (Butler, 2008; Drummond & Markin, 2008; Hurst, 1998; Markowitz et al., 2018; Mead et al., 2019; Mogk & Goodwin, 2012; Whitmeyer et al., 2009), but the impacts to the affective domain (e.g., motivations, emotions, and perceptions) are comparatively sparse. To fully understand the implications of field trips on students, and to gain insight on how to broaden participation into the geosciences, the impacts of both traditional and virtual field trips on the affective domain need to be studied.

In my study, I sought to understand the affective domain implications of a traditional field trip setting as well as a virtual field trip setting by qualitative methods. I used semi-structured interviews along with photographs to gain insight of the affective domain impacts from traditional field trips, and semi-structured interviews only for the virtual field trip. Results from the traditional field trip study indicate students need to be involved in a community of
practice to elicit positive affective domain impacts. Negative affective domain impacts derive from multiple sources such as uncertainty of field trip logistics, lack of accommodations from the instructor in regards to required physical activities, and a student’s lack of preparedness for a day out in the field. Results from the virtual field trip study indicate an overall positive affective domain impact, as every participant stated the experience exceeded their expectations of technological capabilities, user-ability, and interaction with the virtual environment. Participants remarked on the experience as being similar to traditional field trips, which enhanced immersion, and appreciated the iVFT as an option in lieu of a traditional field trip.

The results of my study indicate the affective domain can be dominant in both a traditional and virtual field trip setting meaning educators need to account for a student’s feelings, emotions, and perceptions when creating field trip experiences. Larger implications apply to broadening participation into the geosciences as the validity of VFEs as an option for those unable to attend a traditional field trip is becoming increasingly accepted.
1. Overall Introduction

Experiential learning, such as field trips in the geosciences, are an integral part of the curriculum. However, field trips’ impact on the student affective domain (i.e., motivations, disposition, emotions, values and perceptions) is not well documented, and their requirement as a threshold for attaining a geoscience degree may create an exclusionary environment towards underrepresented populations. This dissertation will discuss the results of two studies geared towards understanding the affective domain impacts of both traditional and virtual field trips in the geosciences, in an effort to help inform educators on how to broaden participation in the discipline.

In the first chapter of this dissertation, I report the results of a photo-elicitation research project, involving semi-structured interviews focused on participant photographs taken on traditional field trips associated with geoscience courses at the University of South Florida (USF). The results from this chapter can help inform best practices on the creation of traditional field trips, which can increase positive affective domain impacts and consequently accommodate a greater participation from underrepresented populations. In the second chapter, I report the results from a qualitative research project involving semi-structured interviews with participants who completed an immersive virtual field trip (iVFT) pilot for the Mineralogy, Petrology, and Geochemistry course at USF. This chapter can help to support the validity of virtual field trips as an option for those unable to attend traditional field trips.
2. Chapter One: Students’ Affective Responses to Geoscience Field Trips as Revealed by Photographs

Coupling traditional field trips with upper-level geoscience courses is a common practice in geoscience pedagogy, that serves the purpose of facilitating an environment where students can put into practice the knowledge learned in a classroom or lab setting. Traditional field trips are immersive environments that captivate all the senses, leading to impacts on both the affective (Gray, 2004; Storbeck & Clore, 2007) and cognitive domains of students. A plethora of researchers (e.g., Butler, 2008; Drummond & Markin, 2008; Garrison & Endsley, 2005; Kelso & Brown, 2009; McKenzie, 1986; Mogk & Goodwin, 2012; Mondlane & Mapani, 2002; Whitmeyer et al., 2009) have reported on the impacts of experiential learning, such as field trips, on student learning, and there is little doubt as to the importance of going into the field to learn in the geosciences. However, there is comparatively sparse literature on the impacts of field trips on students’ affective domain (e.g., motivations, dispositions, emotions, values and perceptions) that report on direct student experiences.

2.1 Statement of the Problem

Learning of geoscience concepts outside of the classroom takes place while on a field trip. However, many of the impacts of field trips lie outside of the cognitive domain and reside in the affective domain, and are less well understood. Pyle (2009) suggests that “affective outcomes that define dispositions or habits of mind are often overlooked because these outcomes are often more implicit and more difficult to measure” (p. 342). As a result, there is a paucity of literature pertaining to the understanding of affective domain impacts of experiential learning on geoscience students. However, the affective domain is an important aspect to consider when
assessing student learning because affect can potentially either enhance or inhibit student cognition (e.g., Ashby & Isen, 1999; Krathwohl et al., 1964; Pessoa, 2008). It is important for geoscience educators to understand the affective impacts of field trips, as a subset of experiential education (DiConti, 2004), for four main reasons: (1) to more fully understand the cognitive impacts of field trips because affect can impede or enhance learning; (2) to inform best practices for field trips; (3) to increase recruitment and retention into the geosciences and (4) to aid in the efforts to increase the diversity of the geoscience community.

2.2 Research Questions

I sought to explore the affective domain impacts of experiential learning, specifically field trips, on geoscience undergraduate students. My main research question is: in what ways do undergraduate geology students’ perceptions of geoscience field trips reveal an impact to their affective domain? I address the research question using two data sources: (1) students’ narratives about their perceptions of geoscience field trips, and (2) students’ narratives about their photographs taken while on a geoscience field trip. I aim to add to the literature on affective responses to field trips to provide a holistic view of the impacts field trips have on students.

2.3 Researcher Epistemology

In qualitative research, the researcher is the instrument of analysis. Therefore, the researcher’s epistemological and ontological posture are important. I have a post-modern epistemology and relativist ontology. I believe everyone has their own truth and that perception is impacted by that personal truth. I believe individuals develop and learn by interacting with others and the environment, and that an individual’s truth can change as their perception changes.
2.4 Background

2.4.1 Review of Affective Domain Impacts from Field Trips

Student affective impacts during a field experience come from factors such as social interaction and group work. For example, Mogk and Goodwin (2012) explain becoming a geologist or studying geology as an immersion into a community of practice. As many researchers note (e.g., Alsop & Watts, 2000, 2003; Fuller et al., 2006; Kempa & Orion, 1996; Marques et al., 2003), a “field setting provides an important interactive social learning environment, and the strong emotions that are engendered by the field experiences deliver cognitive responses that are unique with respect to other learning environments” (Mogk & Goodwin, 2012). Often, during a field trip, students form friendships that last a lifetime, and these bonds positively influence the affective domain with each successive field experience the students share. Numerous researchers (e.g., Crompton & Sellar, 1981; Fuller et al., 2003, 2006; Kempa & Orion, 1996; Kern & Carpenter, 1984; Tal, 2001) have documented the importance of the social aspects of learning in the field and the ability for these shared experiences to create “lifelong memories and friendships, and reduced social barriers” (Mogk & Goodwin, 2012).

Coupled with the social aspect of fieldwork and the influence it has on the affective domain, the beauty and awe that students encounter in natural environments elicits an emotional response that can have a strong impact on student learning (Gagné & White, 1978; Hendrix & Suttner, 1978; Mackenzie & White, 1982). Kaplan (1995) describes human-nature relationships as “components of restorative environments” (pg. 174). Being away (i.e., getting away from one’s everyday setting), fascination (i.e., wonder at natural phenomena), extent (i.e., the vastness of nature), and compatibility (i.e., the ease of navigating through nature versus human-dominated
cities) are components which the human brain digests and internalizes, resulting in strong affective responses (Kaplan, 1995).

2.4.2 Review of Cognitive Domain Impacts from Field Trips

Orion and Hofstein (1991b) cite, “if one were to prepare a bibliography of articles from science journals extolling the possible values of field trips it would no doubt be as long as your arm. Indeed, it might be as long as a dozen arms laid end to end” (Mallinson, 1957, p. 569). Many geoscience scholars consider experiential learning experiences, such as a field trip, to be one of the most effective means for supporting cognitive gains in geoscience education. Accordingly, cognitive gains from field trips are a heavily studied facet of the geosciences (Butler, 2008; Drummond & Markin, 2008; Garrison & Endsley, 2005; Kelso & Brown, 2009; McKenzie, 1986; Mogk & Goodwin, 2012; Mondlane & Mapani, 2002; Whitmeyer et al., 2009).

Additionally, geoscience alumni describe the field experiences as an indispensable piece of their undergraduate geoscience education, and they support the continuity of field camps (Plymate et al., 2005). Fieldwork facilitates higher-order thinking skills (e.g., comprehension, application, analysis, synthesis, and evaluation (Bloom, 1965)) and supports the “deep understanding” of the topics covered (Bransford et al., 1999; Kolb, 1984). Moreover, fieldwork accommodates “direct experiential contact with the raw materials of nature in their full, primal, and complex contexts” (Mogk & Goodwin, 2012). In contrast, laboratory/in-class work presents an out-of-context approach to learning that might limit translation of the importance of the materials being observed (e.g., playing with Playdoh to represent geologic folds in the class versus observing and mapping an actual fold in the field).

The positive cognitive effects of a field experience are not limited to the geosciences. Authors (Baldwin, 2001; Bender & Smith, 2000; Fuller et al., 2006; Gerber & Chuan, 2000;
Gibson et al., 1999; Kent et al., 1997; Manzanal et al., 1999) from other disciplines that contain field instruction as a mode of learning, (e.g., geography, ecology, and archaeology) report similar outcomes related to cognitive gains. Orion asserts that “field trips in themselves do not guarantee higher cognitive gains” (1993a, p. 326). The field experiences must be process-oriented (as opposed to content-oriented) and scaffold student learning from the material/content covered in the classroom environment. It must be delivered in a way the in-classroom experience can never provide (e.g. selecting a rock sample from an outcrop versus given a rock in a classroom), or there is no difference in learning between a classroom-only investigation versus a content-oriented field trip (Orion, 1993a).

2.4.3 Affective and Cognitive Domain Linkage

Field experiences generate strong emotions that can either positively or negatively impact the affective domain. Depending on the nature of these emotional responses, they may serve to heighten (or inhibit) geoscience learning (Alsop & Watts, 2000, 2003; Fuller et al., 2006; Kempa & Orion, 1996; Marques et al., 2003). A positive affect can motivate a student to learn; by the same token, a negative affect can hinder learning (e.g., Glynn & Koballa, 2006). For decades, researchers (Boyle et al., 2007; Eiss & Harbeck, 1969; Iozzi, 1989; Rathburn & Weinberg, 2011; Alison Stokes & Boyle, 2009) reported positive affective responses as precursors to enhanced mental cognition.

Cognition and affect are linked by the idea of novelty space (Orion, 1989, 1993a; Orion & Hofstein, 1991a). In order for learning to occur, the three factors of novelty space (i.e., cognitive, geographic, and psychologic) must be minimized, because “there is an inverse relationship between the size of a student’s novelty space and the ability for that student to maximize learning in a field setting” (Elkins & Elkins, 2007). For example, to minimize the
components of novelty space requires preparing the student for the field trip with maps, background reading material, itinerary, etc. The student’s previous knowledge, as well as their familiarity and comfort before going into the field greatly affects the amount of cognitive gains in a field setting (Orion, 1993a).

2.5 Theoretical Framework and Ontologies

My choices about the theoretical framework that informed the first data source that addressed my research question evolved as I analyzed the data. Qualitative methods are an iterative process where theoretical frameworks or methodologies can change throughout a research project (Patton, 2002). Initially, I considered the Transformative Learning Theory, Situated Learning Theory, Identity Theory, Social Cognitive (learning) Theory, and Communities of Practice Theory. However, after data analysis, I decided it was most beneficial to use only Communities of Practice to inform the research question as it was an all-encompassing theory that explained the data I collected. Furthermore, the Communities of Practice theory accounted for all the main tenets posited by the other theories, thus allowing me to streamline my data analysis.

For the second data source that addressed my research question, I was informed by the research from Patterson et al. (1998) and Pohl, Borrie, and Patterson (2000) as they described interactions with nature and wilderness experiences in broad categories that were informed by a latter defined branch of hermeneutics: environmental hermeneutics approach. Environmental hermeneutics is the use of hermeneutics (i.e., interpretation of meaning) to interpret the meaning of nature through different individual’s perspectives (Clingerman et al., 2013).
2.5.1 Communities of Practice

Lave and Wenger (1991) contend learning is not accomplished on an individual basis, but rather as a collaborative effort involving many individuals. A community of practice is any collection of people who work together for a common goal, e.g., a geoscience class on a field trip, etc. (Wenger, 1998). Communities of practice are defined by the individuals who are engaged in those traditional practices (Wenger, 1998). Participants in a community of practice collaborate by placing themselves as a group with respect to the world around them. “The primary focus of this theory is on learning as social participation” (Wenger, 1998, p. 4). Communities of practice engage in social interactions and practices, and the individuals engaged in those practices construct their identity because of their involvement with the community (Wenger, 1998).

Four main components are encompassed in the Communities of Practice Theory: meaning, practice, community, and identity. “Meaning” describes individual and collective ways of talking about experiences and meanings ascribed to interactions with the world. “Practice” describes how individuals come together while focusing on common actions or practices. “Community” describes the social constructions of individuals who actively participate in groups with other individuals. “Identity” describes the processes that take place while engaging with a community that changes an individual to align with others in that community (Wenger, 1998).

Transformative learning theorists identified social interaction such as those that can occur in a community of practice as “an ideal vehicle for learning” (Kitchenham, 2008, p. 113). As a person begins to self-reflect and create new meaning from their previous knowledge, the discussions between peers in a community of practice aids them in their transformation. Discussion and self-reflection occur extensively in geoscience field trips, in part because the time
involved in traveling between site locations provides opportunities for these activities. For example, riding in a van for hours with peers and professors spawns the perfect environment for students to interact with one another and confer on their findings, likely supporting a transformation in their learning.

2.5.2 Nature and Wilderness Ontologies

A blend of the results reported by Patterson et al. (Patterson, 1998) and Pohl, Borrie, and Patterson (Pohl et al., 2000) on the hermeneutics of nature and wilderness can be ascribed to three distinct categories: (1) connection or closeness with nature, (2) escape from everyday norms and/or opportunities to do things out of the ordinary, and (3) challenge and/or survival. *Connection or closeness with nature* can be described as the awe inspired by the natural beauty of nature. *Escape from everyday norms and/or opportunities to do things out of the ordinary* can be explained as learning a new skill or ability to make decisions that are not typical of everyday decisions. *Challenge and/or survival* can be explained as events or experiences that create a challenge to both the physical and mental realms of an individual. I used these categories to inform the data analysis of the second part of the study where photographs were used to guide the interviews.

2.6 Methods

In my study, I used semi-structured interviews as well as photo-elicitation of field trip photographs taken and provided by the study participants, to address the following research question: in what ways do undergraduate geology students’ perceptions of geoscience field trips reveal an impact to their affective domain? To answer my research question, I broke this study into two parts using different data sources: (1) students’ narratives about their perceptions of geoscience field trips, and (2) students’ narratives about their photographs taken while on a
geoscience field trip. The first part addresses my research question on the perceptions of students using only semi-structured interviews. The second part addresses my second research question on students’ field trip experiences and uses the participant-produced photographs along with semi-structured interviews. My intent to break the study into two parts was to see how students described their field trip perceptions with words-only, and then to see how they described their most recent field trip experience using words and their provided photographs. My choice to have two data sources to answer my research question is a form of triangulation. Triangulation is used in qualitative research to gain an inclusive sense of a phenomena, as well as a way to test validity through the confluence of multiple data points (Patton, 1999).

2.6.1 Participants

I recruited participants from multiple upper-level undergraduate geoscience courses at USF that either required or offered an optional multi-day field trip. I visited GLY 3311C: Mineralogy, Petrology, Geochemistry, GLY 3402C Structural Geology and Tectonics, GLY 3104C Sedimentary Rocks and Processes, and GLY 4324C Physical Volcanology during their respective class times to recruit volunteers to participate. Five participants agreed to take part in my study and I used all five as participants. Five participants can be considered a small sample size relative to the number of students who have participated in geoscience field trips, however, I am interested in understanding the essence of affective domain impacts from field trips, not how many participants have participated in field trips (Crouch & McKenzie, 2006).

Each participant sat for two semi-structured interviews (i.e., scripted questions followed by open discussion and follow-up questions (see Appendix A for interview questions). I audio recorded and transcribed the interviews. The first interview occurred before their field trip to
gauge their pre-trip perceptions of field experiences in geoscience courses, and the second, follow-up interview occurred after their respective field trip was completed.

I asked the participants to take photographs as they might normally do on a field trip. I did not give them any direction regarding what they should photograph. I asked each to provide me with at least five of their photographs after they returned from the field trip. In the second interview, I asked each participant to look at the photographs they provided to me and asked them to narrate how their field experiences were represented by the photographs. Two of the five participants chose to submit eight photographs because it was difficult for them to narrow down their selections to five and still represent their field trip experience.

I was granted Institutional Review Board (IRB) (Pro00039034) approval through USF for the study and followed protocols when conducting the study to ensure participant anonymity (see Appendix B and C). Each participant chose a pseudonym for anonymity purposes. No real names are used in this study, and any identifying information has been removed from the transcripts as well as from the pictures.

My original study plan involved two semesters of data collection, but the advent of the Covid-19 pandemic in the USA during the Spring of 2020 resulted in the indefinite suspension of all geology field activities. The data presented in my study comprises one semester of data collection, reflecting student experiences on three distinct field trips.

2.6.2 Data Analysis

Using both the photographs and the participant’s interview transcripts as data sources, I conducted an inductive and deductive thematic analysis. I re-read and compared transcripts to identify common quotes or ideas, and guided by my theoretical framework and ontology, identified themes. I followed best practices to analyze visual data and only attributed the
meaning the participants ascribed to the photographs, not “some inherent property of the images themselves” (Gregory Stanczak, 2007, p. 7).

I compared each participant’s first and second interview to gauge changes in perception. However, because every participant maintained their perspectives from the first interview to the second, I concluded the participants’ perceptions did not change. Therefore, I did not include perception changes in my discoveries. Instead I report on the overall perceptions of field trips using both the first and second interviews.

2.6.3 Photo-elicitation Methodology

I intended to follow an ethnographic methodology for this study, but the Covid-19 pandemic forced the cancelation of geoscience fields trips at USF and without field trips I was not able to observe participants for long enough to gather the data necessary to ascertain the culture of geology; therefore, I changed my methodological approach to a photo-elicitation method. Photo-elicitation is an arts-based method of qualitative study where photographs are used to focus the interview (Collier, 1967). I chose to use photo-elicitation because photographs are a dominate data source and combined with the narrative interviews, would provide triangulation for my discoveries and add to the validity of my research methodology.

Furthermore, geology is a visually-heavy science with geoscience researchers utilizing models, maps, figures, etc. to tell their story (Reynolds et al., 2005). Rudwick (1976) describes geology as having a “visual language” complemented with verbal communication (e.g., a poster presentation); therefore, it seemed only fitting that a study about geologic field trips be visual as well.

Photo-elicitation is a powerful qualitative method because photographs are snapshots of a moment and elicit powerful emotions tied to those moments (Carlsson, 2001). When a researcher
interviews a participant about their photographs, they are gaining an understanding of the participant’s perspective at that moment in time. Leavy states, “…visual imagery does not represent a window onto the world, but rather a created perspective” (2015, p. 224). A deeper understanding of a participant’s experience can be reached using photographs instead of the spoken or written word alone because of the emotions tied to the photographs (Carlsson, 2001). Moreover, visual images tend to come to the forefront of an individual’s brain when remembering a moment in time because they are “powerful and make lasting impressions” (Leavy, 2015, p. 225).

In this study I used participant-provided photographs, which is known as “auto-driven” photo-elicitation (Samuels, 2007, p. 198). The photographs are at the center of the research and the participant interviews are used to tell the story and ascribed meaning of the photographs (Harper, 2002). The photographs act as a key to unlock information and experiences unlikely discovered without the use of photographs (Holm, 2008). Participants take control of the interview as they interpret their photographs, while the researcher takes a passive listener role (Loeffler, 2004).

2.7 Results and Discoveries

2.7.1 Overall Perceptions of Field Trips in Geology Framed within the Communities of Practice Theory

The data I present in this section are a compilation of the first and second interview responses about held perceptions of field trips. I asked participants what their perceptions of field experiences associated with geoscience courses were and if their perceptions had changed in any way because of their recently attended field trip. None of the participants reported any changes in perceptions of field trips after they completed the recent field trip. However, they did report an
intensification of the perceptions they previously held. Therefore, I merged the interview data into one data source to highlight the overall participant-held perceptions of field trips in geology.

2.7.1.1 Theme: Community and Bonding

Every participant mentioned an aspect of community they encountered while attending a previous field trip or recently encountered while on their most recent field trip. The participants described their field trip experiences as environments that evoked a sense of community. For example, “Alex” stated, “there is something about being with like these like-minded people that just brings us together even more because we value nature and we value the world”. “Diane” further elaborated on the feeling of community experienced while on a field trip:

*I really like the field trips because it is a big community experience. Where I have been on a bunch of them and the larger things I got out of them were just that we were doing a lot more group projects and working together more. And you get a better sense of how everyone else is learning in the class than when you're in the actual classroom where nobody nobody's talking.*

Every participant remarked multiple times during their interviews about how field trips facilitate an environment that allows for bonding with their peers, which further intensifies the sense of community. “Prongs” stated:

*I tend while you know, I'm verbose in these [interviews], I'm not so verbose in class. And so, you know, my friends kind of were like, 'nope, you're going to hang out with us and you're gonna have fun'. And I was like ‘okay, that's fine. I can do that’. So, I would definitely say [field trips] deepened my connection to a lot of the classmates I hadn't already talked to.*
The sense of community and bonding that occurs on field trips continues after the field trip is completed, with some participants establishing lasting friendships forged on a field trip. “Diane” describes the social life they now have because of the friendships they made while on a field trip:

I think especially this year after this last set of field trips, the geology major has become incredibly tightknit, like just goofy. Like if you are in the geology major, you now have a social life and you didn't before kind of tight knit...I met both of them [roommates] entirely through the major. The first one I met in my min/pet [mineralogy/petrology] class and went on the field trip with me. The second one I hadn't met until field camp. And I live with both of them now. We just started an intramural volleyball league.

A community of practice contains individuals who work together to solve problems common to all involved. On a geology field trip, the students bond to help each other with the material and concepts discussed. For example, “Iron Man” stated:

so at the end of the day, we'd all come together and like compare notes and be like, OK, ‘hey, like, I didn’t - I missed something. He said, ‘here, did you get that’? ‘Oh, yeah, I got that’. ‘But like, did you get this stop’? Like, I was like, wasn't - I went off to la la land and it's not like I need some information. So, like it was that like teambuilding thing of like, OK. ‘Like, we got to help each other out’.

The bond created between peers while on a field trip was not only useful for ensuring the material and content was fully captured, but also as a means for coping with the logistics and foreign nature (i.e., not normal day activities) of the field trip. “Lestat” remarked that bonding with peers was a means to ‘survive the field trip’:
I was friends with people in the class, but I was only friends with like two people. And I feel like after a field trip, I got to talk to a lot more people. And I had a small relationship at least with everybody, more or less. And then like the next class I've taken, like I know like at least half the people in there, I'm very comfortable talking to them. And they are to me like we're friends. Like even if we only hung out like maybe like part of the days while we're there, it's like I feel like you build a bigger friendship when you're trapped with people for five days straight and all confused and scared and don't know what's going on. And you are all like, ‘oh, let's all be confused and scared together and then it'll be better’ because I feel like that's kind of what happened. Everyone cemented together out of pure like survival, like I'm scared, I'm stressed, they [the instructor] know a whole lot more than I thought that was even possible to understand.

Contrarily, if participants either do not feel a sense of security or do not experience peer bonding, they tend rely more heavily on the instructor(s) and/or teaching assistant(s) (TA) to satisfy the need for a community of practice. For example, “Iron Man” can be considered a “non-traditional” student (i.e., more advanced in age) and struggled connecting with their younger peers:

*It was just a bunch of 18-year olds. So it was hard to really connect with them. Like in sedimentary, I was what, like twenty-four or twenty-five, something like that. And but everybody in there was more around my age. So it was easy to connect with everybody... when you are like eight years older than somebody, you don't connect on that, on an extreme level as you do with somebody that's even five years younger than you are. Or three years. So, it's like, I don’t know, I talked more with our T.A.’s and [the instructor] than I did with them [class peers], you know.*
2.7.1.2 Theme: Role of the Instructor

In a community of practice, all parties involved have a unique and valuable role. Four of the participants remarked the role of the instructor was a positive impact to the community of practice. The participants gave detailed stories about their instructors while on a field trip. For example, “Diane” remarked on how the instructor changed their approachability when in the field, allowing for a more conducive environment to ask questions:

*I very much was just like, this is just a professor and then I went in the field and I was like, you're very pleasant and easy to learn from now. And I really didn't feel like I understood - like I feel like it definitely made it a lot more relaxed and easier to be taught. And at first, when you see your professors in the field, they are much more approachable and easier to ask questions because you're still in that kind of community environment of open discussion.*

“Lestat” noticed a change in their instructors’ behaviors when on a field trip; they seemed to be enjoying the field trip just as much as the students were: “I think a big part is they [instructors] like being out in the field just as much as we want to go out in the field and they're thriving in the field”.

2.7.1.3 Theme: Practice in a Community

Members of a community of practice “interact, do things together, negotiate new meanings, and learn from each other” by the means of active participation and practicing traditions held by the community (Wenger, 1998, p. 102). Two participants remarked on learned field techniques via instructor modeling while in the field. “Prongs” mentioned a time on a field trip where the instructor modeled how to use a rock hammer:
They showed us like the rock hammer, the hand lens, all this other stuff. And then they basically just laid out rocks. And we're like, this is how you hit it. Wear your glasses. Wear gloves.... they modeled it for us. And then after that, we all got to try. They came around one by one and made sure that we were doing it correctly as well.

Two participants remarked the community of practice gave them the support they needed to learn and feel confident in their learning by conducting the same practice. For example, “Diane” measured their own progress, actions, and motivations against that of their peers:

I feel like after these field trips that I have had an incredible amount of – ‘OK, so this is what other people are doing and this is how they treat school’. And it helps motivate me and get better grades and pay attention more because I have people to talk to, explain and we're all kind of doing it as like a larger team, even if we aren’t in the same classes.

Geoscience field trips facilitate peer engagement and allow individuals in a community of practice to learn from each other about traditional practices or techniques, both while on a field trip and beyond into future community interactions.

2.7.1.4 Theme: Identity in a Community

Only one participant remarked on how the influence of the geoscience community that is created on field trips aided in their creation/intensification of their geoscience identity. “Lestat” recognized while on a previous field trip the similar attributes they and their peers all share:

geochemistry was the first field trip where I like bonded with all the other people in my field and I actually got to like see how similar we all were and how equally obsessed with rocks we all were.
An individual in a community of practice creates an identity by the act of participation in a community. “Who we are lies in the way we live day to day, not just in what we think or say about ourselves…” but also in what the community we participate in thinks or says about us (Wenger, 1998, p. 151). It is a surprising discovery that identity was not discussed more by my participants because other researchers (e.g., Mogk & Goodwin, 2012) report identity creation seems to be an important aspect of the field trip experience.

2.7.1.5 Theme: Meaning in a Community

Every participant remarked field trips are an authentic learning environment, and how important that environment is to establish meaning to their in-class learning. “Alex” stated that field trips allow them to apply knowledge learned in a classroom environment and that it scaffolds them to new knowledge:

*I think it's [attending a field trip] more of like an application of skills. But you - I think it is a whole new like set of skills that you do gain, like the actual identification process and like being able to look at different features and put them together with things like that's a new skill that you learn on your own rather than just studying I feel like in a book.*

Participation and the idea of reification (i.e., turning abstract ideas into concrete things) act in tandem to help individuals in a community of practice devise meaning. “Any community of practice produces abstractions, tools, symbols, stories, terms, and concepts that reify something of that practice in a congealed form” (Wenger, 1998, p. 59). Field trips facilitate the process needed for students to see the ‘bigger picture’, to place knowledge learned in a classroom into a proper geological context. Students can to reify an abstract idea into a concrete element. For example, “Iron Man” stated:
there's the aspect of going out there and seeing it firsthand and ... seeing how each layer is like precipitated or like deposited and like perfectly at seeing that like - you see a picture, it's like a one-dimensional photo, like you can't really get the scope of like the angles and everything in there. Seeing that was like, 'oh like this makes sense. I get this now'.

2.7.2 Photo-elicitation of Undergraduate Geology Students’ Field Trip Experiences

In this section, I present data obtained through photo-elicitation of participants’ photographs they produced while on their most recent field trips. To obtain the data in this section, I asked participants to explain the meaning, importance, and memories associated with each picture they provided to me, whereas, in the previous section I gained an understanding of how the participants perceived field experiences through their narrative responses to semi-structured interviews. In this section, I will weave the stories told by the participants about their photographs with results of previous research (Patterson, 1998; Pohl et al., 2000) to visually showcase the types of impacts field trips have on participants. I did not analyze the photographs themselves, but I focused my analysis on the stories the participants ascribed to their photographs.

2.7.2.1 Theme: Connection and/or Closeness with Nature

Photographs coded into the Connection and/or Closeness with Nature theme were of picturesque landscapes, locations that engaged more than one sense, and fine details of nature. Participants submitted these photographs to my study because the connection with nature meant something deeper to them. The connection with nature helped to define their experience on the field trip.
Field trips inherently immerse students in nature, and this immersion in the environment activates all the senses (Millar & Millar, 1996), soliciting a strong affective response (Mogk & Goodwin, 2012). For example, the smell of sulfur or the touch of extremely cold water immerses the participant in nature, connecting them to that moment and impacting the affective domain. “Alex” referenced immersive features in their photograph while on the Physical Volcanology field trip and how the experience ascribed to the photograph was strong enough that viewing the picture brought them back to that moment:

we had to do like a huge hike to get to where like these hot spring sort of sulfur spots were. And I guess this picture just like truly puts me back in the moment because I can see the gas and it’s almost as if I can still smell the sulfur because it was a very strong, overpowering smell (Figure 2.7.1).

Figure 2.7.1. A photograph that exemplifies the Connection and/or Closeness with Nature Theme. Taken by “Alex” while on the Physical Volcanology field trip.
“Alex”, “Iron Man” and “Diane” remarked on the vastness or greatness of a landscape. “Iron Man” described the memory associated with their photograph taken on the Mineralogy, Petrology, and Geochemistry field trip as: “we were just walking down the mountain ... I like mountains, so I like to take pictures of the mountains and try to get a sense that you are in them” (Figure 2.7.2). Students who have attended field trips often include an aspect of landscape descriptions and their appreciation for the landscape in their anecdotes. An appreciation for a landscape induces a positive affective domain response in the students.

![Figure 2.7.2](image)

Figure 2.7.2. A photograph that exemplifies the Connection and/or Closeness with Nature Theme. Taken by “Iron Man” while on the Petrology, and Geochemistry field trip.

“Prongs” was the only participant to remark on the appreciation of nature and the aesthetics of biological specimens: “… [I] followed a set of tracks through the sand ... and it led to this little guy and he was exactly in the middle of the ripple mark like as the Sun was ... and I was like, he's such a cutie. And he was tiny, teeny, tiny, less than the length of my pinky” (Figure 2.7.3). “Prongs” is pursuing a double major in both biology and geology so it is not surprising this participant was the one to highlight natural or biological aspects of the field trip. Carlson
(1981) asserts that the appreciation of nature is influenced by a proper understanding of the scientific information behind it (i.e., scientific cognitivism). If a viewer has a proper understanding of nature, then they are able to see nature as a positive aesthetic.

**Figure 2.7.3.** A photograph that exemplifies the *Connection and/or Closeness with Nature* Theme. Taken by “Prongs” while on the Sedimentary Rocks and Processes field trip.

“Alex” described their photograph taken while on the Physical Volcanology field trip and connected the memory to a spiritual connection with nature:

*So, this one is the beautiful Mount Shasta and just at first sight, seeing it was just I don't know, I felt like some like spiritual connection almost with it. And like, I know a lot of people say that there are like spiritual things going on. They say it's like the Root Chakra. And like, I'm not a very spiritual person, so, like just seeing it and like having that feeling just like truly was powerful, I guess, because just the span of how big it really is and everything was just really beautiful to see* (Figure 2.7.4).

“An experience of landscapes, especially of very scenic landscapes in good viewing conditions, is often compared to an almost religious experience” (Benovsky, 2016, p. 327). A spiritual
experience engenders feelings of something greater than one’s self but does not necessarily have to be tied to a religious affiliation. “The experience gives meaning to one’s life and helps to define who one is in relation to the world” (Schroeder, 1992, p. 25). A spiritual connection is a strong positive affective response facilitated by a field trip experience.

Figure 2.7.4. A photograph that exemplifies the Connection and/or Closeness with Nature Theme. Taken by “Alex” while on the Physical Volcanology field trip.

2.7.2.2 Theme: Escape from Everyday Norms and/or Opportunities to do Things Outside of the Ordinary

Photographs coded into the Escape from Everyday Norms and/or Opportunities to do Things Outside of the Ordinary Theme were of activities carried out by the participants that could not have been carried out without the environment created by a field trip or of a new perspective gained because of a unique opportunity afforded to the participants by the field trip. Participants submitted these photographs because the activities, exercises, and new perspectives were accomplished only while in the unique field trip environment. The act of doing or seeing something extraordinary was impactful and resonated with the participants.

Every participant provided a photograph that had a memory attached to it that involved an activity they normally would not do in their daily lives, elicited a new perspective, a fun experience, or an escape from things they do every day. “The outdoors is an optimal
environment for invoking a change in perspective because it offers a change in routine and an escape from daily life” (Loeffler, 2004, p. 548). “Prongs” provided a photograph that was taken from a vantage point very few have experienced while on the Sedimentary Rocks and Processes field trip and explained the importance of this moment, which was captured in the photograph:

“This picture I think was my favorite from the whole trip. It was beautiful… so I delved into as many little caves and nooks and crannies as I could find and then crawled my way through one and came out here. And I immediately went like, holy shit… So I just thought it was such a cool little outcome of putting myself near spiders and tarantulas and grossness and dirt and then coming out and finding this is really, really awesome [spot]…There was no way to get to it [the view] apart from through the cave. It was only two of us [students who saw this view] (Figure 2.7.5).

The importance ascribed to this moment by “Prongs” is clearly very impactful and positively impacted their affective domain. The activity performed by “Prongs” in order to attain this photograph is unique to this field trip experience.

“Iron Man” provided a photograph that captured a moment on their Mineralogy, Petrology, and Geochemistry field trip where the whole class was looking for a specific mineral in the rocks, and it was explained akin to a scavenger hunt:

*it's everybody in the class on these rocks. It's like we were climbing in the rocks, like to get a better look at what minerals were in them and stuff like that. So, it's like you get to actually climb up these things and like have a bunch of people around you doing it...we were looking at some granite... we were looking for biotite in these rocks and like we couldn't find them like further down. So, we had to climb up these rocks. Just like climbing up the rocks and like finding that biotite (Figure 2.7.6).*
The memory tied to “Iron Man’s” photograph is of an activity not commonly performed outside the context of a field trip. The field trip facilitated an environment that allowed “Iron Man” to use their knowledge gained from in-class activities (i.e., how to identify minerals) as geologists use them in the field.

“Diane”, “Lestat”, and “Alex” provided photographs that had a fun memory attached to them. Fun activities elicit a positive impact on the affective domain, and can promote problem-solving, and facilitate bonding in groups (Fredrickson & Joiner, 2002). “Diane” provided a photograph taken on the Physical Volcanology field trip where they did cave surveying, and they explained how the photograph represented a fun time where they learned how cave surveying is accomplished:

we were doing a cave surveying activity ... it was super fun. It was probably my favorite thing we did the entire trip ... was the cave surveying ... this lady [park ranger] was
super nice and did all of this like technical cave surveying, showed us how to cave survey and told us a lot about how they do their cave surveying ... That was a really good activity and I felt like I just love this photo (Figure 2.7.7).

Figure 2.7.6. A photograph that exemplifies the Escape from Everyday Norms and/or Opportunities to do Things Outside of the Ordinary Theme. Taken by “Iron Man” while on the Mineralogy, Petrology, and Geochemistry field trip. The individuals in this photograph are blurred to protect their identities and preserve anonymity.

“Diane’s” photograph carried two meanings: it represented a fun activity and their appreciation of how they felt and looked in this photograph.

“Lestat” provided a photograph taken while on the Sedimentary Rocks and Processes field trip of a large hand sample of gypsum (Figure 2.7.8). The photograph represents a fun time for the participant while they were hammering on rocks to collect rock samples:
that's just a giant piece of gypsum and we went to a mine and ... we were allowed to like dig through and pick up pieces and stuff ... we broke chunks of gypsum ... which was really fun. We were all walking around just smashing gypsum like crazy because it was a mine and they just had a lot of chunks they didn’t want out there. Everyone was like pulling pieces apart, trying to, like, get the perfect square.

**Figure 2.7.7.** A photograph that exemplifies the *Escape from Everyday Norms and/or Opportunities to do Things Outside of the Ordinary* Theme. Taken by “Diane” while on the Physical Volcanology field trip. The participant is blurred in this photograph to protect their identity and preserve anonymity.
The University of South Florida is based in Tampa, FL within a metropolitan area, which draws in students who live nearby. The field trips provided by the USF School of Geosciences typically require travel outside of the state of Florida, to areas unfamiliar to students who live in Florida. “Alex”, a Florida resident, provided a photograph taken while on the Physical Volcanology field trip of a location and activity that is not common to their normal day-to-day lives; playing with snow:

*during our lunch stop we ... found like big piles of snow and we were just having a ball. I honestly felt like a kid that day because we were having snowball fights. We all made like different snowmen, obviously, and we were just playing with the snow, throwing it around. And it was a really fun day. So, I think that was probably like one of my favorite days on the trip just because of, you know, the silliness that we did* (Figure 2.7.9).
Figure 2.7.9. A photograph that exemplifies the *Escape from Everyday Norms and/or Opportunities to do Things Outside of the Ordinary* Theme. Taken by “Alex” while on the Physical Volcanology field trip.

Four out of the five participants submitted photographs that contained specific geological element through which they gained a new perspective. “Prongs” provided a close-up photograph that elicited a memory of insight about the study of geology on their Sedimentary Rocks and Processes field trip (Figure 2.7.10). “Prongs” stated:

> [the instructor] called the stop an enigmatic contact because ... they don't know why those two canyons are meeting in that one spot ... And I thought it was just really cool because, especially with geology, sometimes it feels like a lot of it's all known already because it's all been around for billions of years. So, it was really cool - like here, ... we can see it, we can touch it ... We still don't understand how in the world it got here ... we have a lot of living mysteries right now that there's still potential for research and study.
This newly gained perspective by “Prongs” allowed them to adjust their understanding of the field of geology and to understand there is still much about the science that is not known.

2.7.2.3 Theme: Challenge and/or Survival

Photographs coded into the Challenge and/or Survival Theme were of participant memories that centered on a challenge or of stories where the participant struggled to survive the field trip. Participants submitted these photographs to my study because the challenges they faced on the field trip negatively impacted their affective domain. Field trip-induced, self-induced, and instructor-induced increases in novelty space have a negative impact on a participant’s field trip experience.

Four out of the five participants provided photographs that depicted a challenge or survival memory associated with it. The challenges they described all reside in the idea of “novelty space”. Novelty space, or familiarity index, of a student participating in a field trip is
defined by their (1) level and type of knowledge and skills before they go into the field, (2) acquaintance with the field trip area, and (3) psychological preparation (Orion & Hofstein, 1994). An increase of novelty space, meaning the student is not prepared for the field trip in the aforementioned three areas, leads to a decrease in concentration and learning, and a decrease of novelty space can help to boost concentration and learning (Orion & Hofstein, 1994). “Diane” provided a photograph of themselves standing on a geologically important area on the Physical Volcanology field trip, however, the main memory tied to this picture is not of the geology, but of the trip logistics and their lack of information surrounding where and when they were stopping:

sometimes we’re just like ‘what are we doing next?’ And then it will be a really cool thing that will kind of like motivate you to be enthusiastic about the trip again. After you have been doing all this getting in and out of the van and driving. You don't know how long you're gonna drive for. This obsidian was just so so pretty ... We got to visit this super pretty geologic thing. And it's all over the place and we're kind of driving up on it. And they were like, ‘don't worry, we're gonna keep going on purpose - we're not like passing up this good obsidian’ (Figure 2.7.11).

“Diane” was unsure of what the trip agenda was and therefore the logistics of getting in and out of a van to drive to different locations was wearing on them. This increase in novelty space is induced by the logistics of the field trip.
Figure 2.7.11. A photograph that exemplifies the Challenge and/or Survival Theme. Taken by “Diane” taken while on the Physical Volcanology field trip. The participant is blurred in this photograph to protect their identity and preserve anonymity.

Another example of a logistics-induced increase in novelty space is the loss of freedom students feel while on a field trip. Students in college are adults who might live on their own and make their own decisions; however, when engaged in a geology field trip, students are sometimes required to follow a strict schedule and are limited in their choices of food or lodging. “Lestat” provided a photograph they took while on the Sedimentary Rocks and Processes field
trip while they were in a cave, but the memory associated with the photograph lead to lunch plans after they left the cave and how they were given a choice of hot food to eat that day:

*I had to have a picture of the cave because the cave was really cool...and we got to eat food there, which was cool. Got hot food for lunch. ... like a hot meal for lunch just made you feel more human again. Because like the trips are so cool but it's like, you lose ... that sense of having control over your own food intake, when you're going to eat, where you're going to go ... So, it's nice when you get those points where you get to feel like you're in control even though you're not* (Figure 2.7.12).

*Figure 2.7.12. A photograph that exemplifies the Challenge and/or Survival Theme. Taken by “Lestat” while on the Sedimentary Rocks and Processes field trip.*
“Iron Man” provided a picturesque photograph of a mountain stream taken on the Mineralogy, Petrology, and Geochemistry field trip, yet the memory recalled when viewing this picture was of a self-induced novelty space issue:

that was a bad day, I was not having a good time. So, we like walked a few miles down this mountain ... we get to the bottom and [the instructor is] like ‘All right, now walk all the way back up, and then even further but stop at every rock you see and see what it is and if it's a different kind of rock mark it on your paper and we're gonna map this whole thing’. And it was like, okay. And the biggest issue is like, I smoke. So, and my vape that I had, I had burned it out accidentally. So, ... I did not have access to nicotine and I was not happy ... So like ... I was cranky and like not having a good time (Figure 2.7.13).

Figure 2.7.13. A photograph that exemplifies the Challenge and/or Survival Theme. Taken by “Iron Man” while on the Mineralogy, Petrology, and Geochemistry field trip.
“Iron Man’s” memory clearly demonstrated an increase in novelty space and a loss of concentration on the activity at hand. This student was not prepared for the day and ran out of nicotine, which derailed the day in the field.

“Lestat” and “Prongs” both provided photographs that triggered negative memories of their field trip, (they both attended the Sedimentary Rocks and Processes field trip), associated with the increase of novelty space induced by the instructor. They noted that the role of the instructor could be a negative impact on the field trip experience, especially in cases of when a physical activity is required, such as hiking. They remarked on how some students might have difficulty keeping up with the instructor and/or class and how that can impact them negatively. For example, “Prongs” provided a photograph of a fossil imprint, however the memory associated with the photograph was of staying back to assist a friend in need:

    so my friend was having some issues climbing a mountain in general and kinda breathing heavily. And just I was just staying with [them] cause like, I know how it is. Like sometimes when you can't do something physical, you're like, ‘oh, I just want somebody to walk with me, like be a friend kind of thing’...I worked as a summer camp nature hike person like that was literally my job. And the number one rule is you go by the pace of the slowest person. And [my friend] wasn't the slowest. So, there were people behind us. But then the whole group was up with [the instructor] and we didn't get to hear anything that [the instructor] said...And I was like, we're missing all this information and just kind of felt like maybe [the instructor] should have slowed down a little (Figure 2.7.14).
“Prongs” was not the student who had difficulty with the hiking aspect of a field trip, but chose to stay with a friend who was having a difficult time. Students who have difficulty with physical aspects of field trips miss out on valuable information if the instructor lectures when they are not present. Furthermore, if other students decide to stay with individuals who are having a difficult time, the impact of a student having a difficult time with the physical activity expands to more than just the student who is having the direct issue.

2.8 Discussion

2.8.1 Communities of Practice

The data I presented in the first part of this study supports the assertion that a feeling of community dominates the overall participant perspectives of geoscience field trips. Field trips facilitate a community of practice, and the students and instructors/TAs all have a unique role to play in the community to perpetuate the community and its practices. Participation in a

Figure 2.7.14. A photograph that exemplifies the Challenge and/or Survival Theme. Taken by “Prongs” while on the Sedimentary Rocks and Processes field trip.
community of practice incites feeling of belonging and positive affective responses. The social interactions that take place on field trips appear to be an integral part of the experience and have life-long effects. “Shared experiences in the field form a basis for strong social and professional networks that may last a lifetime” (Mogk & Goodwin, 2012). Bonding with peers is important for helping to establish a geoscience identity and promotes social learning. The positive feelings surrounding peer to peer connections on field trips can also carry to student/mentor relationships (Mogk & Goodwin, 2012). Positive affective responses to a connection made to an instructor while on a field trip can strengthen a mentor/student relationship and allow the community of practice to extend beyond only peers. Alternatively, as demonstrated by “Iron Man”, if a student does not feel a bond to a community while on a field trip, a negative affective response can occur, causing an unpleasant experience. However, it depends on when in the sequence of field trips in the geoscience curriculum the student feels the lack of community because, as explained by “Iron Man”, they knew the lack of community they felt on their most recent field trip was not the norm because they had participated in previous field trips where a strong sense of community was felt.

Field trips are a type of supportive community. Supportive communities “are created when there is an emergence of conditions such as: working with nature, experiencing the outdoors because of an appreciation of the environment, and safety and sharing with a focus on group members' strengths” (Berman & Davis-Berman, 2005, p. 20). A field trip experience facilitates a supportive community because it immerses students in an environment that requires action and practice. Students work together to solve a problem and the instructors facilitate and add meaning to the experiences. Peers help to bolster each other, while the instructors are useful in modeling behavior to train a new generation of geologists. Argamon et al., (2008) describe
scientific fields as “discourse communities”, meaning groups of like-minded people who use unique language to convey ideas and evaluate others in their field. The participation in a field trip brings together like-minded people and facilitates an environment where instructors can pass on their knowledge to their students in the way they were taught. “…communities of practice reproduce their membership in the same way that they come about in the first place. They share their competence with new generations through a version of the same process by which they develop” (Wenger, 1998, p. 102). Having like-minded peers surrounding you while you are all completing a task has a strong affective domain impact.

2.8.2 Community as the Identity

An interesting discovery in this study was the lack of data to support the creation of an identity while on a field trip. Other researchers (e.g., Mogk & Goodwin, 2012) have placed a higher importance on the role of field trips in an individual’s identity creation, but this did not appear as strongly in this study. Only “Lestat” directly stated a perception of identity, while the other participants briefly or did not mention an aspect of personal identity creation while on a field trip. I did not collect data on the curricular context for the participants to use as a basis for speculation about the lack of identity creation in my data. However, it is possible that the feeling of community felt by the participants supersedes individual identity creation, and that the identity of the community is synonymous with individual identity. Tenets of the Communities of Practice Theory support this idea: membership in a community of practice “constitutes our identity” and identity creation of a member in a community of practice “is an experience and a display of competence that requires neither an explicit self-image nor self-identification with an ostensible community” (Wenger, 1998, p. 152). In other words, participants in a community take on the identity of the community by simply being a part of a community of practice, and as such
developing or maintaining a separate self-identity is not a requirement. I theorize that participants did not explicitly talk about field trips and their relation to self-identity because as a member of this community, it was their identity.

2.8.3 Community of Practice Not Represented in Photographs

The feeling of a community was the overarching theme present in the data from the first part of my study. However, this theme was not as prevalent in the part of my study focused on participant-provided photographs. “Iron Man” was the only participant to submit a photograph of a group of people (on purpose; another participant remarked on how they did not want people in their photograph, but the people would not move). All the other participants mentioned a memory associated with their photographs of community or a group activity that supported a community of practice, but this was not demonstrated in the photographs themselves. I do not take the absence of people in photographs to mean that the community of practice was not viewed as important by the participants, but rather as a limitation of this study. I directly asked the participants why they did not submit pictures with people in them, and the participants remarked on the anonymity aspect of this study and that they were unsure if submitting a photograph without receiving permission from the person(s) in the photograph was an acceptable thing to do, so they erred on the side of caution and withheld submitting those photographs. It was further uncovered when asked if there were photographs the participants wished they had taken, that they wish they took more photographs of people, such as group photographs along with the many nature or geologic pictures they had taken. I can confidently say that the feeling of community was present in the photo-elicitation part of my study, but was exhibited in the data at a much lesser degree than what was exhibited in the overall perceptions held by participants of geoscience field trips. Participants talked about their peers (e.g., the term “we” is used in the
participants’ descriptions of their photographs), but their peers were not included in their photographs. Perhaps clearer instructions from myself on the types of photographs that could have been submitted would have resulted in a different outcome, and the feeling of community would have been showcased through the participants’ photographs.

2.8.4 Aspects of a Field Trip Outside of a Community of Practice That Positively Impact the Affective Domain

The photo-elicitation part of my study painted a different picture of the perceptions of field trips than did the pre-trip interviews. Along with the feeling of community, as observed in the first part of this study, immersion in nature, having fun, and viewing things from a new perspective all positively impacted students’ affective domain. On the other hand, the increase of novelty space induced by different factors was not a theme that appeared in the data from the first part of the study, though it was dominant in the photographs.

An immersion and connection to nature is a large component of the positive impacts to a student’s affective domain while on a geoscience field trip. Researchers (e.g., Kaplan, 1995; Loeffler, 2004) have posited that interactions with nature carry benefits such as finding inner clarity and an increased sense of contemplation. The participants in this study provided numerous photographs that showcased a connection with nature and described how that connection impacted them positively. The landscapes in the photographs are aesthetically pleasing, and are perceived according to the viewers’ background knowledge (Benovský, 2016). Geologists have an appreciation for landscapes as they have a deep understanding of how landscapes are formed (i.e., a “science-based view of aesthetic appreciation of landscapes”, Benovský, 2016, p. 328). They can understand why mountains are where they are, and why volcanoes can change entire landscapes.
The ability to have fun or do an activity that is outside of daily activities while on a field trip was remarked on by every participant in this study. The broaden-and-build theory (Frederickson, 1998; Fredrickson, 2001) suggests that the more positive experiences you have, the more they add up and have a future impact. The USF School of Geoscience’s curriculum has multiple field trips associated with upper-level major courses, and if every field trip has a fun aspect to it or an event that is out-of-the-ordinary component to them, those experiences will compound and create a holistic view of positive emotions around field trips. During the interviews, all participants referenced other field trips they had taken with other courses and the memories they shared were of positive, fun experiences. Therefore, the aspect of fun built into a field trip can have longer temporal impact on the affective domain.

2.8.5 Aspects of Field Trips That Negatively Impact the Affective Domain

Novelty space, or the ambiguity surrounding a person’s relationship to geographic location, geologic context, tasks at hand, and personal comfort, is an important concept to consider when conducting a field trip (Orion & Hofstein, 1994). “No significant learning can occur when students are unsure about where they are, what they are supposed to do, what the expectations are for learning outcomes, or if they have concerns about their personal comfort or safety” (Mogk & Goodwin, 2012). In the participant-provided photographs each participant described a memory associated with the photograph that increased their novelty space and therefore inhibited learning and created an undesirable experience.

For the instructor-induced increase of novelty space, students remarked on how the instructor was too fast while hiking, and it forced students to focus on trying to keep up and if they failed to keep up, they missed hearing important information from the instructor who was lecturing without the whole class in attendance. The field trip logistic-induced increase in
novelty space negatively impacted students because they were too focused on trying to figure out what the next steps of the field trip were that they were not as engaged with the content of the field trip. The student-induced increase in novelty space can hinder students if they are not prepared for each day’s events. For example, students who might need to snack between meals, have a medical condition that requires them to carry a certain amount of medicine per hour out in the field, or students who smoke need to have the proper amount of nicotine available to them to be able to focus on the field trip. Field trips impact both the cognitive and affective domain and if the affective domain is impacted either negatively or positively, cognition will follow (McConnell et al., 2011).

2.9 Implications

The results from my study have implications for students, instructors, recruitment and retention for geoscience departments, and diversity in the geoscience community. Below are my suggestions from the results of my study as well as from other researchers on how field trips can be planned and constructed following best practices as well as how field trips can be changed to increase recruitment, retention and diversity in the geosciences.

2.9.1 Implications for Instructors

Instructors who lead field trips need to consider a range of issues when planning field experiences. Field trips should be inclusive and student-centered. Mogk and Goodwin (2012), assert that “there is a concomitant need to attend to student’s needs, motivations, prior experiences, scholarly preparation, and learning styles” (pg. 152). Instructors need to be more cognizant of the physical, cognitive, and affective needs of their students and do their best to facilitate positive field experiences. Important practices include providing students with field trip agendas, including information on bathroom breaks and what facilities will be available to them
(Greene et al., 2020), as well as information on limitations (e.g., availability/likelihood of convenience stores or like resources for purchasing nicotine during the trip), so students can prepare appropriately for their field days. In this regard instructors need to be aware of the limited experiences of their students with field activities, and have in place plans for obtaining alternative/emergency supplies. Students need to have as much control as is possible over their food options, ideally with the freedom to make their own food choices. Instructors should include pre-activity instruction/training on how to use equipment in the field, as this may help decrease novelty space, allow for greater learning gains, and offer an overall more pleasant field trip experience (Orion, 1993b; Orion & Hofstein, 1994).

Instructors can make positive efforts to foster the development of a community of practice among their trip participants before, during, and after their field experiences. Results from my study indicate that the bonds fostered between peers has broader impacts outside of the field trip. Among the positive actions instructors can make to support the development of community are to encourage group work, to plan for time in the field trip schedule for group discussions, and to be present and available after the field day is complete to have informal conversations with their students.

Instructors need to become aware of the range of physical abilities of their students so they can attempt to make accommodation for those with limitations. Doing this can be associated with obtaining privileged medical information from students, something that many institutions, including USF, de facto require in order to meet student health and safety guidelines. Making accommodations involves a careful consideration of the sites for field activities to ensure acceptable access for those with limitations (Atchison et al., 2019; Carabajal et al., 2017). In cases where accommodations cannot easily be made, instructors need to plan an alternative
activity or partner that student with a TA or another student who can provide vicarious access, or otherwise share the information (Atchison et al., 2019; Carabajal et al., 2017). Instructors must ensure that the students pick their own partner as it will further enhance the community of practice. If a student is unable to find a partner, an instructor or TA should consider becoming their partner because the instructor/TA are a part of the community of practice as well.

2.9.2 Implications for Students

To get the most out of field trips educationally, participating students need to be prepared for these experiences, so as to minimize their potential for novelty space issues during the trip. They need to confirm with their instructors on issues such as the weather and terrain, so as to have the correct clothing, shoes, etc. As well, they should be forthright about any concerns they have regarding the likely physical demands of the trip, informing their instructors as early as possible of any limitations they may face. On the trip, the students need to be present and open to the natural surroundings. They should seek to engage with their peers as well as the instructor/TA toward becoming immersed in the developing community of practice. Students need to take responsibility for their learning, be alert to what the instructor is saying or highlighting, and ask questions or request assistance when they require it. If they find they are falling behind on hikes or other physical aspects of the trip, they should alert their instructors, so they can slow down. Students need to take advantage of the free time built into the field trip to engage with peers and the instructor/TA to debrief the day.

2.9.3 Diversity Implications

The geosciences are considered one of the least diverse STEM disciplines (Dutt, 2020). This lack in diversity is attributed to a long-standing culture of exclusion towards populations such as women, LGBTQ+ individuals, Black, Indigenous, and People of Color (BIPOC), and
disabled individuals (Dutt, 2020). The role of field trips in the culture of exclusion is actively being debated; however research does suggest that required field trips exclude populations such as those with financial struggles, or physical disabilities (e.g., Carabajal et al., 2017; Pickrell, 2020).

As presented in my study, there were multiple participants that remarked on the physical requirements of field trips and how that impacted them or those around them. Individuals with physical disabilities may not be able to attend required field trips, thus preferentially sorting out those unable to complete a degree in the geosciences. Furthermore, the culture surrounding field trips tends to put a negative light on the inclusion of those disabled, increasing discrimination against that population. Researchers have developed guidelines for the creation of inclusive field trips (e.g., Atchison et al., 2019; Carabajal et al., 2017); however, negative opinions from peers and potential employers persist and cause disabled individuals to actively choose to not pursue a career in the geosciences (Atchison & Libarkin, 2016).

2.9.4 Recruitment and Retention Implications

A myriad of researchers (Karabinos et al., 1992; Kern & Carpenter, 1984, 1986; Manner, 1995; McKenzie, 1986; Salter, 2001) “assert that well-designed field experiences are an effective means to recruit students to the earth science majors” (Mogk & Goodwin, 2012). Fieldwork in the geosciences aids student learning (Orion, 1993a), as well as potentially affording strong positive affective responses. Thus, if facilitated correctly, field experiences are a powerful teaching and motivation tool (McConnell et al., 2011). Conversely, a poorly constructed field experience can de-motivate students and “turn them off” to the geosciences.

The affective domain appears to strongly influence many decisions individuals make in life (McConnell & van Der Hoeven Kraft, 2011), and we thus need to understand student
affective responses, and their origins, if we wish to understand why students choose to become geoscience students. Singer et al., (2012) states that if we want to understand what works” in the recruitment and retention of students into science”, we need to examine both the cognitive and affective responses of students (p. 162).

2.10 Conclusions and Future Work

In this study, I presented the lived experiences of students on field trips through their narratives, and a photo-elicitation method. I documented, using student perspectives, in what ways do undergraduate geology students’ perceptions of geoscience field trips reveal an impact to their affective domain. This study is unique in that it provides a first-hand perspective of the students’ experiences by virtue of the participant-provided photographs taken while on a field trip.

I discovered that the dominant positive affective domain impacts of field trips on undergraduate geoscience students are a feeling of community. Students who interact with their peers and instructor/TA while on a field trip, and engage in practices that are unique to that environment develop a sense of community that defines who they are, i.e., identity. Communities of practice was not as evident in the photo-elicitation part of this study, but the memories shared related to the photographs contained language that inferred that community was just as much there, if not represented in the photographs. To a lesser degree, connection with nature and opportunities to do extraordinary tasks while on a field trip positively impacted a student’s affective domain. Conversely, increases in novelty space induced by either the field trip, the instructor, or self-induced actions negatively impacted the affective domain.

The evidence provided in this study can inform best practices for inclusive field trip creation to ensure positive affective domain impacts occur. Students undergo many emotions,
feelings, etc. while on field trips and those emotions and feelings are directly linked to their learning. Professors need to be aware of the broader impacts of field trips on students to properly facilitate a positive learning and emotional experience for all. Furthermore, impacts to students while on a field trip has the potential to exclude certain populations, thus professors should take into consideration how to best serve students to foster an inclusive experience.

For future work, I would like to take a broader view of field experiences as it relates to the culture of the geosciences. As I stated previously, I had originally intended on performing an ethnographic study, but was forced to switch methodologies because of the Covid-19 pandemic; therefore, I would like to continue on with that goal of gaining a holistic understanding of the geosciences. Moreover, with the recent social unrest and impacts of Covid-19, geoscience programs have been assessing their curriculums and dropping requirements such as the Graduate Record Examination (GRE) to decrease barriers for underrepresented populations in the geosciences. I want study the impacts of abandoning the GRE as an admission requirement to further help inform decision-making for future geoscience program changes

2.11 Limitations

I am a geoscientist and I have attended numerous field trips; therefore, I have my own personal feelings towards geoscience field trips. These feelings form a bias, which could have come through during the data analysis and interpretations. I bracketed my bias through peer debriefing to ensure my feelings were not portrayed onto the study. My sampling was essentially a convenience sample of participants from one university, over a small number of field trips, so the results may not be generalizable to other students who may not have engaged with a field trip to the same degree as the study participants. Had I sampled differently from a wider selection of participants and universities I might have obtained different results. Participants could have
remembered their experiences incorrectly or could have been unwilling to tell me certain stories about their experiences. It became evident that directions needed to be clearer in regards to photograph submissions from the participants as several participants remarked on not submitting pictures that they would have, but chose not to because of ambiguity reasons. The lack of photographs with groups of people in them could have skewed the data.
Field experiences to enhance classroom learning in the geosciences are a “tradition” that dates back to the beginning of the science. Most, if not all, upper-level undergraduate and graduate geoscience courses require some kind of field component (Drummond & Markin, 2008). By the time an undergraduate student graduates and is ready for the workforce, they should have efficient field skills and be able to problem-solve in a complex environment (Mosher & Keane, 2021). Traditional field experiences allow students to practice necessary skills required to work as a geologist such as spatial cognition, teamwork, problem solving, and geoscience synthesis, and are the preferred method to teach field-based measurement and interpretive techniques (Mosher & Keane, 2021).

3.1 Statement of the Problem

There is a broad consensus that field trips enhance geoscience classroom learning (Butler, 2008; Drummond & Markin, 2008; Elkins & Elkins, 2007; Garrison & Endsley, 2005; Kelso & Brown, 2009; Mogk & Goodwin, 2012; Semken et al., 2017; Whitmeyer et al., 2009). However, at the same time requirements for such experiences as part of a geoscience degree may serve to exclude, limit, or dissuade some students from pursuing a major in the geosciences. Traditional geology field trips often require students to complete activities, such as hiking or camping, that may be difficult for some populations to accomplish because of a physical/mental disability. Field experiences often also call for students to be away for extended periods above and beyond dedicated class time, and there is often the expectation that students will need to financially
support their travel, meals and lodging in the field. In addition, it is typically expected that students purchase of their own field gear: at least their hammers, hand lenses, field books and field shoes, if not also camping gear, and gear for working in inclement weather. Because of these expectations, individuals with disabilities, those who have caregiver or job responsibilities, or those who are of a low socioeconomic means often cannot participate in required field trips (Giles et al., 2020; Pickrell, 2020; Science Education Resource Center (SERC), 2020).

Without another viable field experience option, such students may drop out of, or choose not to enroll in geoscience courses, and/or eschew a geoscience major. Attendees at the Summit on Future of Undergraduate Geoscience Education, as documented in the recent Vision and Change in Geoscience Education report indicated a growing support for alternative modes of learning, such as virtual field trips, to educate students about field techniques and skills (Mosher & Keane, 2021).

3.2 Virtual Field Experiences in the Geosciences

Virtual Field Experiences (VFEs) are rapidly gaining popularity in the geosciences as possible augments or replacements for field learning. VFEs can potentially provide field experiences to excluded populations (Atchison & Feig, 2011; Dolphin, Dutchak, Karchewski, & Cooper, 2019; Hurst, 1998; Stainfield, Fisher, Ford, & Solem, 2000). However, creating a truly immersive and transformative field experience is complex, and involves more than a basic visual encounter with the subject matter. Anecdotally, students speak of transformative cognitive and affective experiences occurring on traditional field trips (e.g., identifying a mineral in hand sample for the first time, or conquering an arduous hike), suggesting that both learning and emotion are important considerations when creating an immersive field trip (See Chapter 1). Studies suggest positive feedback on VFEs as an augmentation, but a less positive response
when a VFE is chosen in lieu of going on a traditional field trip (e.g., Arrowsmith, Counihan, & McGreevy, 2005; Poland, Baggott, & Nichol, 2003; Stokes et al., 2012). The lack of an understanding of the affective impacts of VFEs has been a major hurdle to the use of this technological intervention. Aspects such as the feeling of “being there,” with head-tracking capabilities and a scaled, immersive environment are crucial to providing a similar, physical world experience (Klippel et al., 2019; Moore & Gerrard, 2002). Only if VFEs can provide the same levels of student agency as traditional field trips will VFEs ever be considered sufficiently robust to be a viable option for students to learn aspects of field science without visiting the field (Klippel et al., 2019; Lenkeit Meezan & Cuffey, 2012).

3.3 Research Question

In this study, I helped develop and I qualitatively assessed the perceived impacts of a “plus” immersive virtual field trip (iVFT) pilot on students’ affective domain (Klippel et al., 2019, p. 4). Although qualitative studies are needed to formulate a deeper understanding of students’ affective responses to VFEs, the number of such qualitative studies is comparatively low as compared to those primarily focused on measuring cognitive gains (e.g., effectiveness of learning). It has been demonstrated that cognition and affect are linked by the idea of “novelty space” (Orion, 1989, 1993a; Orion & Hofstein, 1991a); therefore, to fully understand the learning that may occur on a virtual experience the affective domain needs to be studied.

To inform future development of the pilot into a complete one-to-one replication of the traditional field trip, I asked participants what was their perceived alignment of the traditional field trip learning goals with the iVFT experience and if they had any suggestions to enhance the virtual experience.
3.4 Researcher Epistemology

In qualitative research the researcher is the instrument of analysis, therefore, the researcher’s epistemological and ontological posture are important to acknowledge. I have a post-modern epistemology and relativist ontology, whereas I believe everyone has their own truth and that perception is impacted by that personal truth. I believe individuals develop and learn by interacting with others and the environment, and that an individual’s truth can change as their perception changes. As I helped to create the iVFT, my epistemology guided my decisions in regards to how virtual material was to be displayed and how the participants would interact with the virtual material in the both the real and virtual environment.

3.5 Background

3.5.1 Virtual Reality Usage in Place-Based Learning

The exciting and ever-changing nature of VR technology has allowed for rapid advancement of its use in place-based educational settings (e.g., Pirker et al., 2019; Won et al., 2019; Zackoff et al., 2019), yet its effects are not studied in sufficient detail to affirm or refute the utility of VR as a viable resource in field-based disciplines (e.g., geosciences) (Bowman & McMahan, 2007; Klippel et al., 2019; Makransky et al., 2017; Markowitz et al., 2018). Dede (2009) verified the efficacy of VR for use as a learning tool in educational settings, and other researchers have established connections between VR approaches and well-established educational theories, such as situated learning theory (Lave & Wenger, 1991), and constructivism (Piaget, 1967). Nonetheless, the geoscience education community has yet to assay the full impacts that an iVFT can have on a student, and how those are manifested in the students’ affective domain. Researchers suggest both immersion and interaction are crucial components in a VFT for eliciting a positive affective response (Corter et al., 2011; Joel et al.,
however, they are unclear about the level of immersion needed, or when or whether students reach cognitive overload (Wu et al., 2013). Education researchers have not yet established VR best practices or appropriate theoretical frameworks for its educational use (Fowler, 2015; Johnson-Glenberg, 2018; Mikropoulos & Natsis, 2011). There is a need for research to deepen our understanding of how to properly create and assess an iVFT experience.

Researchers (Bursztyn et al., 2017; Kamarainen et al., 2018; Makransky et al., 2017) have conducted studies to show the impact, both negative and positive, of immersive technologies in the geosciences. However, these studies primarily used quantitative means of data gathering, such as surveys or pretests/post-tests, and as such provide only a partial picture of the impacts on a student interacting with a VFT. Dolphin et al., (2019) reported using researcher observations and teaching assistant comments as data sources for their study on VFTs, but did not report direct student perspectives. Minocha et al. (2017) conducted semi-structured interviews with science educators, but did not gather data that provides insights about the direct experiences of the students. Researchers in disciplines such as the medical and educational fields, have explored student perceptions of immersive technology based on Likert scale responses (e.g., Zackoff et al., 2019), but thus far there are no studies in the geoscience education literature focused on students reporting directly on their experiences or interactions with immersive technology. This study aims to fill this gap by exploring geoscience students’ perceptions of immersive technologies, through analyzing their direct responses to their experiences with a pilot iVFT.
3.5.2 Diversity and Inclusion in the Geosciences

The geosciences are the least diverse of the STEM disciplines (Bernard & Cooperdock, 2018; Dutt, 2020; Huntoon et al., 2015). Approximately 85% of PhDs awarded since the early 1970s in ocean, atmospheric, and earth sciences have been to white or non-Hispanic persons, and men are awarded doctorates at a greater rate than women, although the gender gap has decreased over time (Bernard & Cooperdock, 2018). Within the geoscience workforce, individuals with disabilities constitute 9% of the population, and in all of STEM, LGBTQ+ persons are underrepresented (Carabajal et al., 2017; Freeman, 2018). A diverse geoscience community has the benefit of diverse perspectives, innovative thinking and the production of a well-rounded population for the workforce (Atchison & Libarkin, 2013, 2016; Bernard & Cooperdock, 2018; Huntoon et al., 2015; Velasco & De Velasco, 2010).

My research has potential impacts on three populations that might be excluded from traditional geoscience field work: individuals with disabilities, persons with caregiver or job responsibilities, and persons with low socioeconomic status (Atchison & Libarkin, 2016; Giles et al., 2020; P. J. Stokes et al., 2015). I describe the characteristics of the three excluded populations in the following sections. The most recent geoscience education and field science literature has primarily focused on increasing inclusiveness for the disabled community, and does not necessarily address care-giver or socioeconomic status populations. As an individual, I personally identify with two out of the three excluded populations and have struggled to attend field trips. My intent with this study is to add to the growing literature on best practices for traditional field trip alternatives. Furthermore, I aim to support the use of alternative field trips for those who are unable to join the geoscience community because of the barriers present to them.
3.5.3 Individuals with Disabilities

Individuals with disabilities face both physical and non-physical barriers in the geosciences. Physically, individuals may not be able to access a field site required for a field trip, or use certain kinds of lab equipment in a classroom. To try and address accessibility issues with field trips, researchers (Carabajal et al., 2017; Clark & Jones, 2011) have recommended instructors choose their field sites carefully (i.e., less rugged terrain, limit light and sound interferences) and incorporate their accessibility office for compliance of ADA requirements. Such solutions are necessarily limited by issues such as vegetation coverage and driving access to key sites. However, even with incorporating changes to improve inclusivity in a field trip, some students can be dissuaded from the geosciences because of negative experiences or their distaste for field work in any capacity (Giles et al., 2020; Pickrell, 2020).

Individuals with disabilities make up the largest minority group in the United States (Olkin, 2002), making them a significantly untapped population for the geosciences (Carabajal et al., 2017). Sixty-one million or 26% of adults living in the United States have a disability, with nearly 14% of them living with a serious mobility disability and nearly 11% of them living with a cognitive disability (Centers for Disease Control and Prevention, 2020). In postsecondary education, nearly 20 percent of all undergraduates have a reported mental or physical disability (U.S. Department of Education & National Center for Education Statistics, 2019). In the geoscience workforce, an estimated 10% of employed scientists and engineers report having one or more disabilities ranging from hearing and vision difficulties, to self-care challenges (i.e., difficulty dressing or bathing) (National Science Foundation, 2019). A large disparity exists between the national percentage of persons living with disabilities and postsecondary education and geoscience workforce percentages. However, only within the last decade have geoscience
education researchers begun to study accessibility and inclusion issues faced by individuals with disabilities in the geosciences (Adams et al., 2011; Atchison & Martinez-Frias, 2012; Atchison et al., 2019; Atchison, 2011; Carabajal et al., 2017; Feig et al., 2019; Gilley et al., 2015; Hendricks et al., 2017; A Stokes & Atchison, 2015).

The majority of the published literature about individuals with disabilities in the geosciences has centered around best practices of inclusive field trips (Atchison & Feig, 2011; Atchison & Gilley, 2015; Atchison, 2011; Collins et al., 2016; Cooke et al., 1997; Gaved et al., 2010; Alison Stokes et al., 2019). Literature about alternative sources for field trips such as VR is not as prevalent but is emerging as the technology advances and as virtual field trips for excluded populations gains promise (Carabajal et al., 2017).

With a VFE, changes to field sites are not required. Students can choose to sit down or stand up while participating, and those who need more time or exposure can replay parts of the trip for better comprehension. There are no necessary time limitations on using a VFE, supporting students who may need to work at a slower pace. Camping or hiking is not required for a VFE, and students continue to have access to modern conveniences/necessities such as electricity, air conditioning, and Internet. Moreover, a VFE records for posterity a field site at a particular point in time, so subsequent changes to a site (e.g., fires, landslides, construction issues, etc.) are not a concern for future users of the VFE.

Non-physical barriers, such as discrimination or prejudice towards individuals with disabilities, can have a much larger impact on retention than physical barriers (Atchison & Libarkin, 2016). Synchronous remote field trips have proven successful; however, they can create new non-physical barriers of exclusion by highlighting the distance between the student in the field and the student with a disability not in the field (Atchison et al., 2019). A VFE in which
multiple students participate concurrently might allow the students regardless of disability to feel
connected and in a community of learning.

3.5.4 Individuals with Caregiver or Employer Responsibilities

Geoscience students (and all college students) increasingly exhibit “non-traditional” (i.e.,
young adults arriving immediately from secondary education) attributes, such as having a job or
a family with dependents (U.S. Department of Education & National Center for Education
Statistics (U.S. Department of Education & National Center for Education Statistics, 1993), the
largest increases over the past years to a more non-traditional student population have been seen
in two-year colleges, and primarily represent women of color.

Because of their non-academic commitments, non-traditional students do not have the
flexibility to spend additional time beyond dedicated class time on school activities. Therefore,
field trips as a requirement for some courses can deter non-traditional students from majoring in
the geosciences, therefore exacerbating the diversity problem. Specific to this inquiry, students
who have children, take care of elderly parents, or have a job, may not be able to leave for
geoscience field trips (Giles et al., 2020). Furthermore, people who are pregnant or breastfeeding
are impacted much more so by required field work because they must account for factors such as
frequent feedings, pumping breaks, and/or coordinating with child care services if unable to take
child(ren) into the field (Lynn et al., 2018). This overwhelmingly impacts women and gender
minorities. Furthermore, if a woman does decide to have a child during their undergraduate
tenure, their return back to their program occurs at a lower rate than the father (if both parents
are in school) because of these aforementioned considerations (Lynn et al., 2018).
3.5.5 Individuals with a Low Socioeconomic Status

The price to attend a traditional field trip can reach into the hundreds or thousands of dollars once airplane flights, gear, food, and hotel accommodations are considered (Giles et al., 2020). Field trip costs (travel, lodging, food) were historically covered at least in part by institutions, but with the decrease in discretionary funding to geoscience departments over the years, more and more of the financial burden has transferred to the student [J. Ryan, personal communication, 2021]. A few universities still subsidize part or most of the costs required to attend a field trip (e.g., University of Michigan). However, even subsidized students who are new to the geoscience major still need to buy hiking boots, warm clothes, rain clothes, and other personal camping gear and field equipment that is of good enough quality to weather the elements, which are not funded by the university. The culture of the geosciences that often leads students to purchase specific expensive or presumed ‘quality’ brands (e.g., Patagonia, or North Face) can increase the financial burden as students try to “fit-in” (Pickrell, 2020). Students who are pressed for money and for whom field trip expenses might prove detrimental often forgo some purchases, or choose options that don’t meet basic needs regarding durability, or rain protection, etc. If students attend a field trip but are not properly prepared for it, they are more likely to have a negative affective experience and may thus have a limited uptake of new knowledge (Giles et al., 2020). Other options for field trips that might provide students with a similar experience as the traditional field trip, such as VFEs, are important if they can allow those without the financial means to have similar kinds of learning experiences.
3.6 Theoretical Framework

In this study, I sought to understand in what ways a pilot iVFT impacted students’ affective domains. Multiple theories intersect to inform this study: situated learning theory, communities of practice, transformative learning theory, and distributed intelligence theory.

3.6.1 Situated Learning Theory

Beyond using authentic tasks occasionally in classrooms, some scholars have argued that all learning must be understood as situated in realistic contexts (e.g., Bereiter, 1991; Greeno, J.G., Smith, D.R., & Moore, 1992). Lave and Wenger (1991) describe Situated Learning Theory as “legitimate peripheral participation in communities of practice” (p. 30). In other words, legitimate peripheral participation enables a student to engage social practice where learning is an intrinsic part. Legitimate peripheral participation should not imply a negative connotation, but rather a positive one; the student is not on the outskirts of the activity but rather in the “center” and “fully involved” (Lave & Wenger, 1991). As fully involved participants, students are affected by and learn from social participation and in turn affects the social construct that aided in the initial learning (Bleiler, 2015; Lave & Wenger, 1991).

Applying Situated Learning Theory in the current educational system affords a number of challenges. In order to meet the criteria for an authentic situation, the situation must involve real-life problem solving, an opportunity for the detection of relevant versus irrelevant information, and an opportunity to engage in collaborative interpersonal activities (Young & McNeese, 1995). It can be daunting for an educator to create an authentic learning environment within the traditional constraints of today’s education system, and some authentic tasks cannot be recreated in a classroom, (e.g., learning to fly a jet plane). However, simulations or VR interfaces can be used to closely mimic the authentic task.
3.6.2 Communities of Practice

A Community of Practice is defined as any collection of people who work together for a common goal, e.g., a reading group, a softball team, a geoscience class on an iVFT, etc. (Wenger, 1998). Participants in a Community of Practice collaborate by framing themselves as a group with respect to the world around them. To be considered a member in a Community of Practice an individual (1) has interest in the discipline at hand (in this inquiry, an iVFT), (2) must be engaged in the community via actions and discussions, and (3) use their knowledge gained from social interaction to problem-solve (Wenger, 1998). The transformative theorists identified social interaction like those that occur in a Community of Practice as “an ideal vehicle for learning” (Kitchenham, 2008, p. 113). As a person begins to self-reflect and add new meaning to their previous knowledge, the discussion between peers in a Community of Practice aids them in their transformation. Additionally, Wenger (1998) argues for allowing students to have experiences where they take charge of their own learning (i.e., student-centered instruction) instead of an instructor-centered environment. Rather than having a curriculum that follows content, educators should focus on transformative events placed in the context of a community of learning. By construct, an iVFT follows the tenets of Communities of Practice and allows for students to take charge of their learning while in a community of peers.

3.6.3 Transformative Learning Theory

Mezirow (1978) describes transformative learning as a change in how a person views themselves and their relationships with others. A transformative shift in learning can occur because of a memorable event, or from a series of minor events that all follow the same epistemological adjustment (Mezirow, 1978, 2000; Taylor, 2008) The right conditions are required to promote an individual’s transformative learning (Richards, 2015). For example,
Mezirow (1991) suggests the facilitation of an environment that allows for an unbiased, nonpartisanship conversation where all individuals are allowed to reflect on their assumptions, and identify and create new knowledge with new information freely without consequence. A geoscience iVFT can provide the conditions necessary for transformative learning to occur, but it is critical for the instructor to entice open discussion and reflection (Richards, 2015).

3.6.4 Distributed Intelligence

Distributed Intelligence piggybacks on the ideals of Communities of Practice, whereas the learning is shared and collective, but unlike Communities of Practice, Distributed Intelligence places a high demand on utilizing external resources to help solve the problem at hand (Pea, 1993, 2002). For example, Parker (Parker, 2008) describes these external resources as entities, such as humans, computers, robots, etc., collaborating to learn and problem solve.

Pea (1993), suggests learning should be done in communities using new and cutting-edge technology (e.g., VR). He divides Distributed Intelligence into two categories: social and material. The social aspect of distributed intelligence involves social activities or collaboration towards a common goal, whereas the material aspect of distributed intelligence involves incorporating a material object or artifact, like a computer. A VR experience with multiple users utilizes Distributed Intelligence principles allowing for learning to be among individuals while using tools.

3.7 Immersive Virtual Field Trip Development and Research Methods

3.7.1 Immersive Virtual Field Trip Development and Description

The iVFT is centered around rock exposures at Elk Garden Ridge in the Mount Rogers area of southwest Virginia, USA. I conducted my MS research at this field site therefore I was familiar with the geology of the area. The virtual experience is derived from activities that
constitute part of a live, traditional field trip conducted as part of the Fall semester course GLY 3311C (Mineralogy, Petrology, Geochemistry) taught at the University of South Florida (instructor: Dr. Jeffrey Ryan). Although the iVFT is a limited pilot and does not incorporate every location visited on the multi-day traditional field trip, it is equivalent to most of a full day in the field.

I collaboratively developed the virtual pilot field with Dr. Mel Rodgers (a USF School of Geosciences research faculty member who, as a licensed drone pilot, oversaw much of the imagery acquisition as well as coordinated undergraduate student work on data processing), and the USF Advanced Visualization Center (AVC), an entity funded by the University of South Florida’s Information Technology (IT) office. The AVC worked closely with me and Dr. Rodgers to integrate high-resolution digital photography, GoPro© videos, Google Earth© overlays, and 3D models created using structure-from-motion (SfM) methods in Agisoft© from ground-based and drone photographs, placing them in proper context within a fully immersive digital environment. AVC staff used the program Unity3d© to create the digital environment. My role was to oversee the project to ensure the field trip was grounded in pedagogical theories for maximum immersion and approximation to traditional field trips.

Students taking part in the iVFT used HTC Vive© headsets to display and interact with the digital environment. Students can stand or sit, and have a VR headset completely covering their eyes that is tethered to a computer. Their movement is limited because they are tethered, but they can move a few feet in each direction. They hold controllers in their hands that they use to transport around the digital environment and to interact with the materials (Figure 3.7.1).
Figure 3.7.1. A photograph of participants while completing the iVFT. The photograph displays two participants completing the iVFT at the same time, but they cannot engage with each other in reality or the VR environment. Participants wear a VR headset tethered to a computer that runs the iVFT program. The participant in the forefront bends down to interact with the iVFT materials. In the background on a table are hand samples and a petrographic microscope with thin sections for participant use. Permission to use photograph given by the participant.

To begin the iVFT, students viewed a Google Earth® introduction video to orient themselves to the overall trip. The video begins at the university, where the traditional field trip departs, and provides a broad overview of the geology along the way to the final destination in southwestern Virginia. Upon arrival at the field site, a hologram of the instructor delivers an overview of the reasons why the students were visiting this location, and its geologic importance. Once the video and hologrammatic presentation were complete, students were able to interact and explore the digital environment.

Undergraduate interns working with me and Dr. Rodgers created three, 3-D models of important outcrops from the field area that are discussed and highlighted as part of the traditional
field trip. AVC staff then placed these models in their appropriate locations in the virtual environment, scaled to the appropriate proportions. Students in the iVFT choose the order in which they explore the outcrops, similar to how field instruction is done. Located over each outcrop is a colored beacon to signify it as a distinct outcrop to visit, as well as to allow the students to better keep track where they had already been in the virtual field environment. Students navigated the virtual space using controllers that allowed them, via clicks, to move around and explore the digital environment.

Once at an outcrop, students pause to listen to the instructor give a short, audio-only description of the outcrop, mentioning to look for important geologic features (e.g., jointing, mineral assemblages). Then, the students are free to explore and manipulate the outcrop. High-resolution photos, identified by yellow bubbles, are located around each outcrop that give a real image of the outcrop from that respective view (Figure 3.7.2). The software provides a virtual rock hammer tool at each outcrop, which students can digitally use (Figure 3.7.3). Students can reach down, pick up the rock hammer, and physically swing it at the outcrop to expose 3-4 hand samples. Students can then retrieve the hand samples to examine them, which activates their other VR controller into a magnifying tool to reveal multiple thin section images and/or videos that include labels for important minerals (Figure 3.7.4). Using the swipe feature on the VR controller, the students are able to view the thin sections in both plane polarized and cross polarized light. The rocks shift to a red color after the student has viewed its respective thin sections. After every outcrop is visited and every rock, thin section, and picture are viewed, an exit video leaving the field site plays, along with a closing hologram video from the instructor (Figure 3.7.5).
After completing the iVFT, students are invited to explore the physical hand samples and thin sections that they saw modeled in the VR environment and geological maps of the field site. Petrographic microscopes are available for thin section study, and students are directed to bring their hand lens for use in viewing the real hand samples.

Figure 3.7.2. A screenshot taken from inside the iVFT from the participant’s perspective. The screenshot displays one of the three, 3-D modeled outcrops and one of the associated high-definition photographs. The participant accesses the high-definition photographs by reaching into the yellow bubbles located on the outcrop with their hand/VR. Permission to use image given by the USF Advanced Visualization Center.
Figure 3.7.3. A screenshot taken from inside the iVFT from the participant’s perspective. The screenshot displays one of the three, 3-D modeled outcrops with a virtual rock hammer, held by a participant in their hand/VR controller, and multiple 3-D modeled hand samples (outlined in yellow). The yellow bubbles represent locations on the outcrop where students can reach in with their hand/VR controller and access high-definition photographs of the outcrop. Permission to use image given by the USF Advanced Visualization Center.
Figure 3.7.4. A screenshot taken from inside the iVFT from the participant’s perspective. The screenshot displays one of the three, 3-D modeled outcrops, with a magnifying glass and 2-D thin section photograph associated with a hand sample. To activate the thin section photographs the participant moves their left hand/VR controller, which switches to look like a magnifying glass, over the hand sample held in their right hand/VR controller. The yellow bubbles represent locations on the outcrop where students can reach in with their hand/VR controller and access high-definition photographs of the outcrop. Permission to use image given by the USF Advanced Visualization Center.
Figure 3.7.5. A screenshot taken from inside the iVFT from the participant’s perspective. The screenshot shows an exit scene from a GoPro® video, leaving the virtual field site. Once participants view all materials associated with the three outcrops, the exit video plays followed by a hologrammatic video of the instructor delivering a concluding large-scale description of the geology of the area the participants just visited, along with setting up the next part of the field trip to a different geologic location, which is outside of the scope of this pilot. The iVFT then ends. A maroon beacon can be seen at the top of the image. Permission to use image given by the USF Advanced Visualization Center.

3.7.2 Methods

In this immersive virtual field trip (iVFT) pilot study, I used semi-structured interviews to address the following research question: In what ways do undergraduate mineralogy/petrology students perceive participating in a pilot iVFT impacted their affective domains? In addition to the impact on affective domain, I wanted to evaluate – through the perspectives of the
participants - how closely the design of the iVFT aligned with the learning goals of the
traditional field trip. Then, I asked what modifications the participants perceive might improve
the virtual field trip experience.

3.7.3 Participants

I recruited participants from an upper-level undergraduate mineralogy/petrology class at
USF (GLY 3311C: Mineralogy, Petrology, Geochemistry) that required a multi-day field trip. I
visited the course during class time to solicit volunteer participation. A few students chose to
take the iVFT instead of the traditional field trip because of job responsibilities or monetary
constraints. However, none identified a disability as the reason for participating in the iVFT
instead of the traditional field trip. The participants were eight geoscience majors who completed
the iVFT over the course of two days, with no more than two individuals at a time in the same
room. All participants were interviewed for this study.

There were five categories of participants:

1. students who were currently enrolled in the mineralogy/petrology course, were unable
to attend the traditional field trip, and had never been on a traditional geoscience field
trip before (n=2),

2. students who were currently enrolled in the mineralogy/petrology course, were unable
to attend the traditional field trip, but had been on a previous traditional geoscience
field trip (n=3),

3. students who were currently enrolled in the mineralogy/petrology course, and
participated in both the traditional field trip and iVFT (n=1),
4. students who were not currently enrolled in the mineralogy/petrology course, but
participated in the traditional field trip with the same instructor during a different
semester (n=1), and
5. students who were not currently enrolled in the mineralogy/petrology course, but
participated in the traditional field trip for the same course with a different instructor
and different location (n=1) (Table 3.7.1.).

I interviewed the participants shortly after they completed the iVFT to gain their
perspective on the experience. Per USF IRB-approved protocols (Pro00037627, see Appendix D
and E) for the study, each participant chose a pseudonym for anonymity purposes, and interview
transcripts were edited to remove any identifying information. I asked each participant several
open-ended questions about their experiences with the iVFT, as well as their thoughts on
coverage of learning goals for the traditional and iVFT field trip (see Appendix F) for interview
questions). I employed constant comparative analysis techniques (Glaser, 1965) to analyze the
interviews. I examined each participant’s data individually, as well as compared all the
participants’ data as a whole, and guided by the theoretical framework I determined overarching
themes from common ideas and perceptions.

I analyzed the five categories of participants as one body of aggregated data, as I was not
interested in discerning differences between traditional field trips and the iVFT. I primarily
sought to understand how the iVFT impacted the participants; therefore when, where or if they
took a field trip associated with the course was irrelevant. However, in the results section, I
identify the participants’ categories when necessary to provide necessary context.
Table 3.7.1. Categories of Participants in the Virtual Reality Study

<table>
<thead>
<tr>
<th>Category of Participant</th>
<th>Participant pseudonym</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Currently enrolled in the mineralogy/petrology course</td>
<td>• Al</td>
</tr>
<tr>
<td>• Did not attend the traditional field trip</td>
<td>• Lee</td>
</tr>
<tr>
<td>• Had never been on a traditional geoscience field trip before</td>
<td></td>
</tr>
<tr>
<td>• Currently enrolled in the mineralogy/petrology course</td>
<td>• Frodo</td>
</tr>
<tr>
<td>• Did not attend the traditional field trip</td>
<td>• Joe</td>
</tr>
<tr>
<td>• Had been on a previous traditional geoscience field trip</td>
<td>• Gabby</td>
</tr>
<tr>
<td>• Currently enrolled in the mineralogy/petrology course</td>
<td></td>
</tr>
<tr>
<td>• Participated in both the traditional field trip and iVFT</td>
<td>• Banner</td>
</tr>
<tr>
<td>• Not currently enrolled in the mineralogy/petrology course</td>
<td></td>
</tr>
<tr>
<td>• Participated in the traditional field trip with the same instructor during a different semester</td>
<td></td>
</tr>
<tr>
<td>• Not currently enrolled in the mineralogy/petrology course</td>
<td>• Blue</td>
</tr>
<tr>
<td>• Participated in the traditional field trip for the same course with a different instructor and different location</td>
<td>• Chad</td>
</tr>
</tbody>
</table>

3.8 Results and Discoveries

3.8.1 Overall Reaction to the immersive Virtual Field Trip

The results indicate an overall positive reaction to the pilot iVFT as every participant stated the experience exceeded their expectations. “Chad,” who had not been on the traditional trip, but
took a similar trip with a different instructor, stated; “I thought it was really amazing how you can literally crouch down and you can actually get towards the plants closer.” “Frodo,” who had been on a geoscience field trip before, but did not go on the traditional field trip associated with this course stated:

So, I was just sort of expecting like that - actual thing blew me away because..., definitely way more detailed than what I was expecting. Like very expansive especially with the little trigger marker that you could just go around to different elevations. I mean, I wasn't really expecting that. I was just expecting like dropping you off in one area, so to see that, I expect it was way more extensive than what I originally thought.

3.8.2 Theme: Situated Learning

A dominant theme involving authentic tasks and situated learning emerged from the data. Seven out of the eight participants remarked on how the iVFT allowed them to do physical things they would do on an traditional field trip, or that similar processes were followed as if they were in the field. For example, “Al,” a participant who had never been on any geoscience field trip, connected the activities in the iVFT to what they could imagine could be done on a field trip:

Like I can watch a lecture, I can look at a picture, but the minute I actually reach down and grab something, my brain just connects that in a way and I am like okay this is something very, very grounded, and I am like okay I can see how this will translate really well to like practical field experience with it.

“Blue,” who was not enrolled in the current course, but had taken the traditional field trip with the same instructor during a different semester, stated:
I did, I did like the rock hammer thing! I really like how you can't pick it up until the professor stops talking. I think that's very applicable in the field. Don't be banging rocks as they are trying to lecture, please. I like that.

Every participant mentioned the potential value of including some kind of sensory exercise to heighten the authentic experience to make it more approximate to the traditional field trip. For example, “Chad” mentioned incorporating some weather aspects; “what would make this even more immersive if you know where you're going, and you know the temperatures that are going to be there – you should make them go through the cold!” “Lee” also stated that, “you should show [laughter] all the hiking and the students having to break down bushes and shrubbery to get to where they need to go because that's all part of it.” “Banner” mentioned how on the traditional field trip, one of the outcrops they remembered in the iVFT had thorn bushes all around it that had to be pushed down in order to view the outcrop properly. One of the participants mentioned incorporating a virtual animal to make it feel like you were really on the traditional field trip. “Frodo” told a story relayed them by one of their peers that went on the traditional field about a field area that had ponies, and remarked; “yeah like an actual - adding like a pony in just to prove to you when you're at a certain outcrop like that could be good.”

3.8.3 Theme: Communities of Practice

Social learning and engagement with peers, as outlined in communities of practice, emerged as a negative feature, i.e., the socialization aspect was missing from the iVFT and participants noted feeling alone, or wishing they had others in the experience at the same time to interact with. For example, “Joe,” who was currently enrolled in the course, but unable to attend the traditional field trip, and had been on a traditional geoscience field trip before stated:
It felt kind of lonely. It felt as if it was more akin to an office hours sort of set up where it's just you and the professor and the professor is talking at you and not really a setting where you are, you know, with a class. And it was very different. I don't really know how to describe it. And I'm not going to - I don't really think it was either good or bad. It was just very different.

However, three out of the eight participants had positive comments involving community. “Joe,” the same participant from the example given above, liked the videos with other students in them, they stated:

I got to see, you know, especially with the videos that were filmed at the spot [field trip area]..., it showed the professor and there were like cars and stuff in background, there are some kids coming out of the woods – it - it gave me like 75% of the experience of actually being there because I got to again see other people and it felt - it very much felt like I was out with some sort of team... even if those people were just walking out of the woods in the background of the video, you know, it made it better than just a hologram of the professor standing next to me.

“Gabby,” who was unable to take the traditional field trip because of financial reasons commented:

It [the VFE] definitely gave me a good idea of what my classmates were looking at on the trip, which is cool. ...my alternative was just like write an essay about another trip. But then this one was more like I actually got to see what my classmates were doing, ...I could of like done the actual trip and like followed, like I don't know, been kinda of doing the same thing as my classmates instead of like something else.
3.8.4 Theme: Transformative Learning

My goal for the study was not to explicitly determine how much or what kind of learning occurred because of the iVFT; however, six of the eight participants mentioned a transformative learning event that led to new knowledge. The new knowledge ranged from gaining a better understanding of the content for those who had gone on the traditional field trip to understanding the usefulness of VR as a learning tool as well as to reach underrepresented populations in the geosciences.

“Banner,” who attended the traditional field trip, had trouble paying attention on the traditional field trip – “I wasn't paying attention as much as I should have there [on the traditional field trip]...I'm not really learning a lot as much as I should have....” – so the iVFT helped them revisit the area and relearn the content. “Al” stated, “I wouldn’t mind if in like the future I could like, I don’t know, I am doing research work on paleontology and I could have like a 3D model of a dinosaur in front of me. I would love for it to be like 1-to-1 scale, you know the most gorgeous looking graphical representation...” “Banner” mentioned, “I mean like it [virtual field trips] seems like a good alternative if like you're physically cannot go on these field trips, it's like at least you've got something there”.

3.8.5 Theme: Distributed Intelligence/Usefulness of Tools

Half of the participants remarked on the usefulness of having different tools (i.e., VR and digital representations) to help learn the field trip content aside from lectures, or physical materials such as maps or hand samples (physical maps, hand samples and thin sections were provided at the iVFT site). “Gabby” gained clarity about the material the instructor lectured about in class before the rest of the class embarked on the field trip. They state, “And I learned more about the different zoning [physiographic provinces] and stuff like that that they [the
instructor] were talking about before they [the class] went on the trip. That I didn’t really understand. So, it's nice to see, like have a visual and have it in my ear”.

“Lee” mentioned the importance of the labeled thin section photos, as they helped them identify minerals that they were unable to in a classroom environment:

*I liked the thin sections. That was probably my favorite part because you don't get it as much in class like you're looking at things, but don't have like a reference to what that [minerals] looks like. And there were pointed - like there was epidote here and you could see how that interacted with like polar and cross polar light. That was neat.*

### 3.8.5.1 Use of Physical Materials

An interesting outcome that emerged from my data analysis concerns the choice of students to interact with the physical hand samples, maps, and thin sections available to them after they completed the iVFT. Only two out of the eight participants chose to look at the physical materials. The other six stated that there was no motivation to look at the physical materials because they were not being evaluated on it (e.g., “Because they weren't really getting tested on it, I guess and I don't know if any student is like, I'm going to learn this because I need to know in the future. Everybody is like, this isn’t on a test, get that out of my face” – “Chad”), or that they did not see the physical materials even though the materials were clearly present and it was announced before the iVFT began that physical materials were available to view (e.g., “Oh, I didn't see those” – “Banner”). “Frodo”, who chose to examine the physical materials stated:

*So, you couldn't rotate the thin sections in the VR, but you could rotate the ones here to look for any like birefringence or any isotropic mannerisms in it. So, I just thought it was nice to like you see what it [thin sections] looks like as an overview [in the iVFT] and then actually seeing it for different properties.*
3.8.6 Appreciation for the Immersive Virtual Field Trip

Participants stated that having an option to take an iVFT in lieu of a field trip was much appreciated for those students who could not attend the field trip for varied reasons. As I mentioned previously, “Gabby” was unable to attend the field trip and appreciated having the iVFT instead of the alternative assignment. “Lee” was unable to take the traditional field trip because of work responsibilities, and stated, “I think it’s awesome that we are doing this because I didn't even think because ... you know, this is really cool for the kids that have full time jobs and can’t do these things”.

Participants who took both the traditional and iVFT welcomed a second source to help them understand the material in more depth and to review the information learned on the field trip. “Banner,” who had done both the traditional and iVFT, suggested using the iVFT as a refresher for engaging with the content again:

> *It was a nice little supplement. Like you could go on the normal field trip and then be like if you ever say you have like an assignment or a paper or something to write on, be like, well ... I don't really remember a lot. And if these VR trips were available, you could be like okay, well let me sign up [to take the iVFT] and do it and I'll be like, okay, refresher. And I have this stuff brought back to your brain.*

3.8.7 Learning Goals Coverage

Every participant was asked about the four learning goals for the traditional field trip, not to gauge what they learned as compared to the traditional field trip, but to determine if that content was present in the iVFT and to what degree. This information is important to know to ensure the iVFT pilot covered the learning goals of the traditional field trip. The learning goals are:
The student should:

1. Be able to identify primary and secondary mineral assemblages in volcanic igneous and associated sedimentary rocks, based on hand sample observations and the students’ understanding of petrologic/sedimentologic mineral associations.

2. Be able to resolve among the various mafic and felsic volcanic rock types based on mineralogy and other hand-sample scale features.

3. Be able to recognize macro-scale features in volcanic igneous rocks (vesicles/amygdules, flow banding, lithophysae, pillow lavas, etc.) and understand their significance in terms of eruptive conditions.

4. Be able to use variations in grain size and mineral assemblages in sedimentary and volcanogenic sedimentary rocks to make inferences about their environment of deposition.

As the learning goals listed above reflect the entire, multi-day traditional field trip, therefore, the pilot, which encompassed approximately one day in the field did not cover sufficient content for all these learning goal to be considered relevant or fully covered. Specifically, the pilot explicitly did not include content targeting learning goals #2 or #4.

3.8.7.1 Learning Goal #1 *Be able to identify primary and secondary mineral assemblages in volcanic igneous and associated sedimentary rocks, based on hand sample observations and the students’ understanding of petrologic/sedimentologic mineral associations*

Half of the participants ("Al", "Chad", "Banner", and "Lee") did not remember or have an example to reference to concretely say learning goal #1 content was present in the iVFT ("I don’t think that was covered too well..." – "Al"). However, the other half of the participants did
remember or could give a specific example to verify that learning goal #1 was covered and was important. “Frodo” stated:

Yes. In the beginning, [the instructor] was giving a general overview of the area, like all the volcanic processes that go into making those rocks in the first place. And then with each outcrop like you see the hand sample, you can see the bigger mineral around it. And then those are classified with a caption. And then you can see all the smaller ones with that. Like you might have like the big calcium feldspar, but also like chlorite and epidote too. So I feel like that defines like you can clearly see the primary just from the overview of the area, like what's to be expected, but also just having that inclusion of other stuff you see that's an indication of secondary.

3.8.7.2 Learning Goal #2 Be able to resolve among the various mafic and felsic volcanic rock types based on mineralogy and other hand-sample scale features

Half of the participants ("Al", "Blue", "Chad", and "Frodo") were able to recall information given in the iVFT relating to learning goal #2. According to “Chad”, “It’s just, I mostly remember most about formations - on how the things were forming among those outcrops, so that's where maybe I picked up the most was about structurally how things are there and why they're there”. “Gabby” had difficulty recalling if learning goal #2 content was present because the concepts covered were difficult to understand; “yeah, no, I don't think so really because I don't even necessarily know what that means. I mean I understand the wordage and everything, but like... I can't really think of a time when I was doing that that I can think about”. This learning goal was not explicitly covered in the pilot iVFT so the participants that recalled information related to this learning goal might have guessed, conflated the traditional field trip with the iVFT, or felt pressure to give a positive answer to the interviewer.
3.8.7.3 Learning Goal #3 Be able to recognize macro-scale features in volcanic igneous rocks (vesicles/amygdules, flow banding, lithophysae, pillow lavas, etc.) and understand their significance in terms of eruptive conditions

Learning goal #3 content was by far the most “visible” during the iVFT with every participant remembering the material and able to give detailed examples from their experience. “Joe” states:

Oh yes... the pictures were very helpful there - they very clearly showed the different features that you just listed and being able to see the specific angles to see those while [the instructor] was talking about that was very nice. And that is one of the positive things about having the pictures there is that, in my opinion, you get a more curated view of this specifically is of a pillow lava, you know. While with a regular trip, you know, if you're looking at the wrong thing and you're like, yeah that I think that's what [the instructor] is saying. And then later you find out that it wasn't that, that problem wasn't there, because the picture showed exactly what [the instructor] was trying to talk about.

3.8.7.4 Learning Goal #4 Be able to use variations in grain size and mineral assemblages in sedimentary and volcanogenic sedimentary rocks to make inferences about their environment of deposition

Half of the participants (“Blue”, “Frodo”, “Joe”, and “Chad”) were able to recall information given in the iVFT relating to learning goal #4. “Banner” stated, “I don’t really remember that. I know that from other classes, but I don't remember seeing that in the [virtual] field trip”. “Blue” recalled the thin sections as helping them remember the content covered for learning goal #4; “This goes back to the thin sections and pointing out the different crystals”. As with learning goal #2, the participants might have guessed, conflated the traditional field trip
with the iVFT, or felt pressure to give a positive answer to the interviewer as this learning goal was not explicitly covered in the pilot.

3.8.8 Student Suggestions for Improvement

All participants gave suggestions as to how to improve the iVFT to attain a more realistic, or user-friendly environment. They suggested adding more interactive activities, improving the orientation of materials, and incorporating forced breaks from the immersive experience to engage with physical materials (e.g., notebook, hand samples, thin sections).

“But it would definitely be nicer if there was more movement happening” – “Joe.”

“More like I guess - like less like listening and more just like activities” – “Gabby.”

Half of the participants wanted orienting features so students could know where to look while the instructor was talking or labels on rocks or outcrops to improve student understanding of the geologic processes of the location.

“... the very beginning intro video and he's like talking about the different formations, like having something light up or point at them to be like - he's like, ‘yeah, we're going into this range’ and it's like ‘bing’ and you are like OK that’s where that is and then that one and that one” – “Banner”.

“... it was just kind of like a vague - like this whole area has this thing. And I didn't know what to really look at while [the instructor] was talking” – “Lee.”

Five out of the eight participants mentioned a notebook and their desire for a chance or a forced break to take notes. “...it's a forced break, you can take notes and then you maybe have the time to sit and reflect on the notes before resuming” – “Chad”. “Blue” stated that part of their learning style requires taking notes, and not having notes did not help them learn fully: “... the
thing was I wish I had ... be able to pause mid lecture or something like that. Take some notes or have a virtual notebook or something like that. Because I know myself like too much information at once just kinda goes in and out ... like ah, I need to be able to take notes”!

3.9 Discussion

3.9.1 Theme: Situated Learning

The choice to pursue a “plus iVFT” (Klippel et al., 2019) with 3-D models and full immersion appears to have been a worthwhile decision, as students indicated that they felt like they were at the field site, situated in their learning and carrying out authentic science tasks.

“Banner”, who had been on the traditional field trip stated, “Yeah, I remembered all three of them [outcrops]. And especially the pillow lava one [they were] talking about like it looked like pillow lava and it looked like the outcrop that we were messing around with...”. The pilot was designed to allow students the freedom to roam around a virtual environment and mimic behaviors seen and done on an traditional field trip (Steinicke et al., 2013). Strictly guided VFEs (i.e., field trips that are linear and follow only one path) have been shown to illicit negative affective reactions due to the lack of user freedom (i.e., students not given a choice to explore) and their digression from the structure of an traditional field trip, where students are free to choose their method of approach (Dolphin et al., 2019). “Al” stated:

_I certainly think it was interesting to actually have like a free go at like whatever was available to me in the experience. I feel like if it was more like uh ‘go here, look at this sample’, I would kinda get like this feels less of a trip and more like a scripted like I should, I don’t know how to put this like a very scripted experience. Like I feel like that would take away from the actual like me, there was no incentive for me to look at the samples but I chose to look at them I guess because I had the freedom to look at whatever_
quarry I wanted to look at whatever um uh whatever sample I wanted to look at first like you know there was no real, I created my own structure rather than the structure being laid out for me

In the iVFT, the unique ability to see the entire process from outcrop to hand sample, to thin section in a short period of time helped the students connect depositional environments of rocks to their mineral assemblages. Boundy and Condit (2004) report similar results from their Dynamic Digital Maps resources, which integrate geologic maps, analytical data, digital images, field-based movies and animations within a map interface, allowing students to interact with all if these data in real-time. The VR thin section feature provided immediate feed-back to students, whereas on a traditional field trip a thin section is created days or weeks after the hand-sample is collected from the outcrop. Therefore, the VR participants could make connections between the rock and thin section in ways not available on the traditional field trip. “Joe” said, “I got to see you know, I got to see at - look at the thin section and say, OK, this thin section is this rock and there's this stuff going on in this rock and all of that stuff that is very pertinent to the class”.

The participants indicated that more sensory engagement would heighten the iVFT experience. The ability to replicate wind or rain while in an immersive experience would prove to be technically challenging (Hurst, 1998). Moreover, the experience of cold or rain may be considered a positive sensory experience for some, but for others it may be a deterrent. A desired aspect in the pilot that I was not able to implement because of resource limitations was the addition of more videos to further immerse the participants. Sounds of insects buzzing and tall grass swaying in the wind are all forms of sensory engagement that might be easily implemented in a VR environment. Although there are studies that support integrating multiple senses to achieve a greater level of immersion (Clark & Jones, 2011; Hutchins & Renner, 2012; Lakoff &
Johnson, 1999; Shapiro, 2011), researchers have thus far not reported data related to the impacts on learning if more senses are engaged in an iVFT. Studies focused on the interaction of multiple senses in an iVFT are absent in the extant literature.

The suggestions provided by participants aimed at making the iVFT more engaging and enriching were similar to findings reported by other researchers (e.g., Klippel et al., 2019). Students want more interactive experiences, more opportunities to interact with their peers and/or instructor, and a chance to take notes for reflection and better information retention. With current technological capabilities, implementing these changes would not require a substantive overhaul of the pilot. In fact, the iVFT was designed as a pilot field trip with the explicit purpose of understanding what features needed to be changed before effort was put into creating a full virtual one-to-one replica of the traditional field trip, therefore a redesign is expected.

3.9.2 Theme: Communities of Practice

A major drawback to VR is the participant’s feeling of isolation, and several participants remarked on this. A community of practice is important to establish on a field trip as learning is socially constructed, and is a major driver of positive affective student response to such experiences (see Chapter 1). Other researchers have showed that the interactions between peers and instructors in the field are not easily replicable in VFEs (Bailey et al., 2012; Çalışkan, 2011; Stumpf et al., 2008). In the pilot, students were engaging with the iVFT in a room with others, but the inability to see other students in the VR experience resulted in a negative affective reaction, which might negatively impact learning. “Blue” knew they were in a room with others, however, not seeing them in VR impacted their affective domain (e.g., “I’ve never done VR before, so I didn't realize it was really stepping into this whole other world type of thing. We couldn't see anything, it kind of felt like no one could see you, but that's not true”). Although, the
videos with students in them helped with the feeling of loneliness, the lack of interaction with the other students and the instructor in VR needs to be addressed in some way to reach similar levels of agency afforded to students while on an traditional field trip. “Joe” recommended that, if synchronous interaction in VR was not available, then create a “railroaded” experience where multiple students go to the same locations at the same time so “knowledge was there that we are all experiencing the same thing”.

3.9.3 Themes: Transformative Learning and Broadening Participation in the Geosciences

An interesting discovery in the student responses were the participant remarks on their views on how this kind of VR experience might benefit non-traditional student populations and those with financial hardships populations in the geosciences. Participants stated that having an option to take an iVFT in lieu of a field trip was much appreciated by those who could not attend the field trip for a number of different reasons. As mentioned earlier, “Gabby” was unable to attend the field trip and appreciated having the iVFT instead of the alternative assignment. “Lee” was unable to take the traditional field trip because of work responsibilities, and stated, “I think it’s awesome that we are doing this because I didn’t even think because ... you know, this is really cool for the kids that have full time jobs and can’t do these things”.

Participants recognized that not only is another alternative needed for students who cannot attend traditional field trips because of financial constraints or work/caregiver responsibilities, but also for those with physical or mental disabilities that make it untenable for them to attend. “Chad” stated:

I think it's [the iVFT] great. And I hope, like, you know, if this thing starts to heat up even more, I'd like to see where it goes... I just had a conversation with another student - they were talking about, you know, nobody who is disabled or has certain conditions ever -
I've not seen any single person like that in the geology program. And so, you know, yeah, well they go ‘well that’s part of the job, you got to be able to get up there on top of the mountain’, and now it kind of tells you, no, you don't. Because not everybody wants to be a field geologist, you know

I see statements such as those made by the participants above as evidence of a welcome side benefit of VFEs because, as mentioned previously, populations who are underrepresented in the geosciences not only face physical barriers, but also non-physical barriers. The one significant way to decrease the non-physical barriers is to change the culture surrounding field work in the geosciences.

3.9.4 Theme: Distributed Intelligence/Usefulness of Tools

While I made physical materials (maps, hand samples, thin sections) available to students as part of the iVFT experience, only 25% of the participants used the materials either before or after the iVFT. However, the choice to not use the materials did not seem to be detrimental, as “Lee” states; “... then you can go look at the maps if you wanted to, and that's good for like referencing... I thought that was a really good idea ... I think that should stay ... for sure because we need to look at those things. We want to be geologists”. If the iVFT were implemented as a course-based requirement, I would recommend requiring students use these materials to gain a proper understanding of the geology of the field area.

Furthermore, my study supports the addition of VR technologies as a tool to add to the traditional geoscience “toolbox” of rock hammers, maps, Brunton© compasses, etc. used in field education. Participants enjoyed engaging with the technology, and some remarked on previous interactions with VR in their social lives, indicating a familiarity that could be used by instructors to scaffold students to new experiences. The addition of VR into geoscience
pedagogy might answer the needs of the ever-changing, technology-dependent world and be another tool instructors use to educate future generations of geoscientists.

3.9.5 Learning Goals

The pilot, by construct, did not explicitly address learning goal #2 (e.g., resolving among the various mafic and felsic volcanic rock types, based on mineralogy and other hand-sample scale features) or learning goal #4 (e.g., using variations in grain size and mineral assemblages in sedimentary and volcanogenic sedimentary rocks to make inferences about their environment of deposition). Therefore, it was not surprising that few participants expressed perspectives about the iVFT materials that support those goals.

The pilot did include material supporting learning goal #1 (e.g., identifying primary and secondary mineral assemblages in volcanic igneous and associated sedimentary rocks, based on hand sample observations and their understanding of petrologic/sedimentologic mineral associations) and learning goal #3 (e.g., recognizing macro-scale features in volcanic igneous rocks and understand their significance in terms of eruptive conditions). All of the participants remembered or could recall learning goal #3. Unfortunately, the participants largely did not perceive that materials clearly supporting learning goal #1 were present. The lack of student uptake on those materials supporting learning goal #1 will need to be addressed as the iVFT undergoes further development, with appropriate attention to choosing and providing visually compelling and useful imagery samples and thin sections. For the pilot, the choices of hand samples and thin sections were partly based on convenience, as they were part of an existing collection of hand samples and thin sections, related to past course activities and my M.S. research, and thus did not require creation of new thin sections. Different hand samples and thin
sections that better highlight the textural and mineralogical features of the rocks from this site may better support learning goal #1 for future iterations of this project.

As well, because the iVFT experiences for the participants did not include reflective exercises (i.e., assignments reviewing and considering the provided samples and their field contexts), an activity important in transformative learning theory, they may not have properly learned the material that supports learning goal #1. My findings thus suggest that reflection-focused activities should be a part of a refined iVFT. However, given that my intent was to explore the participants’ perceptions of the virtual field trip experience and how it impacted their affective domain, I did as such not assess student’s cognitive gains or the extent to which they understood the targeted geologic concepts.

3.10 Implications

My study results inform the development and use of VFEs for three populations of stakeholders: instructors, the geoscience community, and the three populations identified in my study as potentially reaping the most benefit from VFEs (disabled, those with caregiver/job responsibilities, and individuals that have a low socioeconomic status).

Instructors who create VFEs must make informed choices about the types of activities they include in their virtual environments to ensure positive affective impacts for their students. Students must be able to manipulate 3-D models, have some level of autonomy to make choices and interact with virtual tools (e.g., rock hammer) while in a virtual environment to provide an immersive experience that will elicit positive affective responses. Ensuring positive affective responses are necessary if instructors want their students to learn while engaged with a VFE, as cognition and affect are linked. Instructors need to be aware of the aspects of VR that can negatively impact the affective response, in particular the lack of human interaction. As noted in
this and previous studies of field experiences, developing a feeling of community is crucial to positive affective impacts among students. Instructors can facilitate social activities either within the virtual environment (e.g., student and/or instructor avatars), or plan for breaks from the VFE to do group work (e.g., a hand sample and thin section group activity with the physical samples).

The geoscience community can benefit from the use of VFEs by their potential to make field trips available to populations unable to attend traditional field trips. Persons such as those with disabilities can access field work with VFEs and engage with materials and content similar to their peers. During a lifetime, individuals have a higher chance of changing their disability status (either permanently or temporarily) as compared to other forms of diversity (e.g., it is impossible to change race or ethnicity). Therefore, the availability of a VFE option may be important for a much larger population than might be anticipated. For example, a 20-year-old has a one in four chance of becoming disabled by the time they reach retirement age (Social Security Administration, 2020). From the other side of the instructional dynamic, instructors may become permanently or temporarily disabled. If a VFE is available as a substitute for a required field trip, then instructors whose disabilities preclude leading field experiences could continue to fully contribute instructionally in courses with traditional field components, and students would have VFE’s as a resource to continue their course curriculum with minimal interruption. With the advancement and validation of VFEs, the three populations addressed in my study may have the potential to engage more fully with the field aspects of the geosciences and thereby more readily become a part of the geosciences community. The option of VFEs for these populations not only paves a path for them to join the geoscience community, but my study supports the idea that VFEs can transform the views and biases held by the privileged population (e.g., those who are not disabled, do not have care-giver/work responsibilities, or are higher in
their socioeconomic status). Perhaps the use of VFEs with a new generation of geoscientists might lessen prejudice towards those seen as being on the outside, allowing these populations to persist in their studies, consequently helping to diversify the geosciences.

3.11 Conclusions and Future Work

In this study, I presented lived experiences of students that participated in a pilot iVFT for a mineralogy/petrology course. I documented, using student perspectives, in what ways an iVFT impacted students’ affective domains. Students overall enjoyed the experience and reported positive affective responses. Authentic tasks such as picking up a rock hammer, swinging it to hit a rock to produce hand samples evoked the feeling of “being there”, which was crucial in impacting the affective domain positively. Conversely, the lack of social interactions with peers and the instructor negatively impacted the participants’ experiences, indicating the importance of some kind of human-to-human interplay while participating in a VFE.

My study provides evidence on how to inform best practices for VR usage in educational settings, and as well as contributes to multiple educational theoretical frameworks for future studies in this area. As my research utilized a pilot virtual field trip, this pilot trip can itself serve as a foundation for future work. Future investigators can implement some or all of the suggestions offered by the study participants toward improving the iVFT experience. Key improvements include:

1. Forced breaks from the VR experience need to occur for students to take notes and/or to reflect on their experiences.

2. Social interactions with peers and/or the instructor while in the virtual environment are necessary to facilitate positive experiences for students.
3. Create as much interaction as possible with digital materials, as this allows students to feel involved and immersed in the virtual experience.

4. Create an environment where students can explore and choose their own approach to interacting with the VFE.

VFEs provide opportunities for those excluded from traditional field work. Students who are unable to attend field trips because they cannot take time off work, have caregiver responsibilities, might endure financial hardship, or are physically/mentally incapable, still have the ability to experience field work. In this study, I posit students can have positive experiences in a virtual environment and populations who are excluded from the geosciences, because of the tradition of field work, can have an avenue to engage with field geology. VFEs have the potential to broaden participation and diversify the geoscience community. VFEs can help shift the culture around field work in the geosciences, allowing for historically excluded groups to feel included in the geoscience community.

The future work on this project includes application of participant suggestions as the pilot is expanded, to align the affective domain impacts from the VFE more closely to those encountered on a traditional field trip. Eventually, the iVFT will cover all the geologic concepts and field areas visited on the traditional mineralogy/petrology field trip as well as involve more immersion and socialization with peers and/or professor. Although more immersion and social interaction is necessary in VFEs to reach the full agency afforded to those who attend traditional field trips, my research supports that, with proper pedagogy and the advancement of technology, VFEs are close to achieving the same goals as traditional field trips: that is, to positively impact a students’ affective domain to enrich geoscience learning.
3.12 Limitations

I chose the field site (Elk Garden Ridge at Mount Rogers, VA) because of familiarity and convenience of materials (i.e., hand samples and thin sections). I collected hand samples and thin sections during my M.S. thesis work (2007-2008) and chose to use them for convenience rather than for their ability to support the learning goals. Furthermore, the field site is located on a relatively open field with minimal obstacles on the outcrops that were modeled. It is possible that not all field locations can be modeled and turned into an iVFT.

The participants either volunteered or were required for course credit to take the iVFT, therefore responses could be considered subjective. However, this was the population available to the researcher and subjectiveness is a part of personal perception. A few of the participants completed both the traditional and iVFT and could have conflated the two experiences. Also, memory distortion can have an impact on a participant’s ability to remember the experience clearly. I did not perform member checking; therefore, it is possible I misinterpreted the data to not reflect the participants’ true perceptions.

I performed the data analysis. It is possible another researcher who has a different epistemology, ontology, or worldview, and experiences might analyze the data and reach different outcomes. I am a geologist and feel strongly about field work. I had to bracket my bias to not project my feelings about field work on to the participants. I acknowledge that the novelty of VR might have had an influence on student’s perceptions since some were not familiar with the technology, therefore any references to the novelty of the experience were intentionally disregarded while coding to attempt to negate that aspect in the results.
4. Concluding Comments

The affective domain is important to understand as it is intimately linked to the cognitive domain, and can either heighten or inhibit learning if impacted positively or negatively, respectively. Geoscience undergraduates are exposed to numerous field experiences in the curriculum that impact them both affectively and cognitively. The cognitive impacts from field trips have been documented extensively and there is little doubt that a field trip increases learning and skills, however, the affective impacts are not as documented because feelings, emotions, and perceptions are difficult to measure. Moreover, required field trips create a barrier for underrepresented populations, such as disabled persons, financially deficient individuals, or those with caretaker or employment responsibilities. In an attempt to broaden participation in the geosciences, alternatives to field trips such as virtual field trips are being created, but again, the affective domain impacts are not as well documented.

I presented two studies in this dissertation that will add to the extant literature on the affective domain impacts of both traditional and virtual field trips on undergraduate geoscience students, expanding our knowledge on how to construct field trips in a way that facilitates positive affective and consequently, cognitive gains. Furthermore, my studies help geoscience educators to understand how students perceive their experiences of traditional and virtual field trips so geoscience educators are informed when creating alternatives for those unable to attend traditional field trips. Geoscience educators need to foster a community of practice and attempt to decrease novelty space in order to facilitate a positive affective experience for students that attend both a traditional or virtual field trip.
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Appendices
Appendix A: Semi-structured Interview Questions for Chapter 1 Study

Pre-Field Trip Interview Questions:

1. What is your name? Please choose a pseudonym.
2. What year are you in for your undergraduate degree?
3. What other geoscience courses are you enrolled in right now?
4. What do you plan to do after you graduate with your bachelor’s degree?
5. How many field trips (experiential learning exercises) associated with a geoscience course have you been on?
6. What are your perceptions of field experiences in geoscience courses?
7. What are your perceptions of the upcoming field trip associated with your geoscience course?

Post-Field Trip Interview Questions:

1. What is your name? Please use your same pseudonym from before.
2. Now that you have taken the fieldtrip associated with a geoscience course, in what ways have your perceptions of fieldtrips associated with geoscience courses changed, if any?
3. Using pictures taken by the participants:
4. Why did you choose this subset of pictures over others to represent your field experience with the geoscience course?
5. What is/are the meaning(s) (importance) you have ascribed to your experience in this picture?
6. What is the value of the photograph in explaining your field experience?
7. What are the memories you have associated with this picture?
8. Were there any pictures you didn’t take that you wish you took? Why or why not?
9. In what ways did you find that going on a field trip in this class (or any geoscience class) affected you?
Appendix B: Institutional Review Board Approval for Chapter 1 Study

June 20, 2019

Meghan Cook
Library
4202 East Fowler Avenue
LIB122
Tampa, FL 33620

RE: Exempt Certification
IRB#: Pro00039034
Title: Effects of experiential learning on undergraduate geoscience students

Dear Ms. Cook:

On 6/19/2019, the Institutional Review Board (IRB) determined that your research meets criteria for exemption from the federal regulations as outlined by 45 CFR 46.104(d):

(2) Research that only includes interactions involving educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior (including visual or auditory recording) if at least one of the following criteria is met: (i) The information obtained is recorded by the investigator in such a manner that the identity of the human subjects cannot readily be ascertained, directly or through identifiers linked to the subjects; (ii) Any disclosure of the human subjects’ responses outside the research would not reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects’ financial standing, employability, educational advancement, or reputation; or (iii) The information obtained is recorded by the investigator in such a manner that the identity of the human subjects can readily be ascertained, directly or through identifiers linked to the subjects, and an IRB conducts a limited IRB review to make the determination required by 45 CFR 46.111(a)(7).

As the principal investigator for this study, it is your responsibility to ensure that this research is conducted as outlined in your application and consistent with the ethical principles outlined in the Belmont Report and with USF HRPP policies and procedures.

Please note, as per USF HRPP Policy, once the exempt determination is made, the application is closed in ARC. This does not limit your ability to conduct the research. Any proposed or anticipated change to the study design that was previously declared exempt from IRB oversight must be submitted to the IRB as a new study prior to initiation of the change. However,
administrative changes, including changes in research personnel, do not warrant an Amendment or new application.

We appreciate your dedication to the ethical conduct of human subjects research at the University of South Florida and your continued commitment to human research protections. If you have any questions regarding this matter, please call 813-974-5638.

Sincerely,

Melissa Sloan, PhD, Vice Chairperson
USF Institutional Review Board
Appendix C: Institutional Review Board Consent Form for Chapter 1 Study

Informed Consent to Participate in Research Involving Minimal Risk

Information to Consider Before Taking Part in this Research Study
Title: Effects of Experiential Learning on Undergraduate Geoscience Students
Pro # 00039034

Overview: You are being asked to take part in a research study. The information in this document should help you to decide if you would like to participate. The sections in this Overview provide the basic information about the study. More detailed information is provided in the remainder of the document.

Study Staff: This study is being led by Meghan Cook who is a Ph.D. candidate in the USF School of Geosciences. This person is called the Principal Investigator. She is being guided in this research by Dr. Jeffrey Ryan. Other approved research staff may act on behalf of the Principal Investigator.

Study Details: This study is being conducted at the University of South Florida and is supported/sponsored by the USF School of Geosciences. Core major geology courses require a field trip component to accompany and intensify in-class learning. A field trip component has long been a requirement for geology courses and their cognitive impacts have been studied heavily. However, research into the affective impacts on students in response to a field trip are less studied. The purpose of this study is to find out what broad impacts an experiential learning exercise (a field trip) has on an undergraduate declared major geology student enrolled in a geoscience course that has a required field trip component. This is determined by means of photographs taken by the participants while on a field trip. There will be two interviews: one before the field trip, and one after that will be approximately an hour each.

Participants: You are being asked to take part in this study because you are enrolled in a geoscience course that has a required (or optional) field trip component, as well as a declared geology major.

Voluntary Participation: Your participation is voluntary. You do not have to participate and may stop your participation at any time. There will be no penalties or loss of benefits or opportunities if you do not participate or decide to stop once you start. Your decision to participate or not to participate will not affect your student status, course grade, recommendations, or access to future courses or training opportunities.

Benefits, Compensation, and Risk: We do not know if you will receive any benefit from your participation. There is no cost to participate. You will not be compensated for your participation. This research is considered minimal risk. Minimal risk means that study risks are the same as the risks you face in daily life.
Confidentiality: Even if we publish the findings from this study, we will keep your study information private and confidential. Anyone with the authority to look at your records must keep them confidential.

Why are you being asked to take part?

Study Procedures:
The Principal Investigator (PI) will set up a time via email that is convenient for you to be interviewed before you take your field trip with your geoscience course. This interview will take no more than an hour and will be held outside of the USF School of Geosciences to protect your anonymity. After you complete your required field trip, the PI will arrange another interview via email that is convenient to conduct a second interview that will take no more than an hour and will be held outside of the USF School of Geosciences to protect your anonymity.

At each visit, you will be asked to:
- For the first interview, nothing is required of you. The purpose of the first interview is to get a baseline before you take the field trip.
- For the second interview, you will be asked to email the PI 5 representative photographs that you took while on the field trip. The photos you take will be at your discretion and there are no guidelines as to how or what you choose to photograph. These photographs will be the basis for the second interview and will be used in any publications that arise from this research. All identifying features in pictures will be removed before publication.
- The PI will conduct the interviews and ask semi-structured, and open-ended questions. The PI will ask what level you are in your schooling and what your thoughts are on field trips in the geosciences.
- The interviews will be digitally audio recorded and stored on a private drive (USF Box drive) for 5 years after the Final Report is submitted to the IRB per the IRB policy. Only the PI will have access to the recordings and only pseudonyms will be used during the recording. After 5 years, the recordings will be destroyed by erasing the digital data.

Total Number of Participants
About 50 individuals will take part in this study at USF.

Alternatives / Voluntary Participation / Withdrawal
You do not have to participate in this research study.

You should only take part in this study if you want to volunteer. You should not feel that there is any pressure to take part in the study. You are free to participate in this research or withdraw at any time. There will be no penalty or loss of benefits you are entitled to receive if you stop taking part in this study. Decision to participate or not to participate will not affect your student status or course grade.
Benefits
You will receive no benefit(s) by participating in this research study.

Risks or Discomfort
This research is considered to be minimal risk. That means that the risks associated with this study are the same as what you face every day. There are no known additional risks to those who take part in this study.

Compensation
You will receive no payment or other compensation for taking part in this study.

Costs
It will not cost you anything to take part in the study.

Conflict of Interest Statement
There are no known conflicts of interest with this study.

Privacy and Confidentiality
We will do our best to keep your records private and confidential. We cannot guarantee absolute confidentiality. Your personal information may be disclosed if required by law. Certain people may need to see your study records. These individuals include:

- The research team, including the Principal Investigator and other research staff.
- Certain government and university people who need to know more about the study. For example, individuals who provide oversight on this study may need to look at your records. This is done to make sure that we are doing the study in the right way. They also need to make sure that we are protecting your rights and your safety.
- Any agency of the federal, state, or local government that regulates this research. This includes: the Office for Human Research Protection (OHRP).
- The USF Institutional Review Board (IRB) and its related staff who have oversight responsibilities for this study, and staff in USF Research Integrity and Compliance.

We may publish what we learn from this study. If we do, we will not include your name. We will not publish anything that would let people know who you are.

You can get the answers to your questions, concerns, or complaints.
If you have any questions, concerns or complaints about this study, contact Meghan Cook at 813-974-7427. If you have questions about your rights, complaints, or issues as a person taking part in this study, call the USF IRB at (813) 974-5638 or contact by email at RSCH-IRB@usf.edu.
Appendix D: Institutional Review Board Approval for Chapter 2 Study

10/9/2019

Meghan Cook
Library
4202 East Fowler Avenue
LIB 122
Tampa, FL 33620

RE: Exempt Certification
IRB#: Pro00037627

Title: Virtual Reality (VR) Field Trips for the School of Geosciences: A Pilot Qualitative Study of the Mineralogy/Petrology Field Trip

Dear Ms. Cook:

On 10/7/2019, the Institutional Review Board (IRB) determined that your research meets criteria for exemption from the federal regulations as outlined by 45 CFR 46.104(d):

(2) Research that only includes interactions involving educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior (including visual or auditory recording) if at least one of the following criteria is met: (i) The information obtained is recorded by the investigator in such a manner that the identity of the human subjects cannot readily be ascertained, directly or through identifiers linked to the subjects; (ii) Any disclosure of the human subjects’ responses outside the research would not reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects’ financial standing, employability, educational advancement, or reputation; or (iii) The information obtained is recorded by the investigator in such a manner that the identity of the human subjects can readily be ascertained, directly or through identifiers linked to the subjects, and an IRB conducts a limited IRB review to make the determination required by 45 CFR 46.111(a)(7).

As the principal investigator for this study, it is your responsibility to ensure that this research is conducted as outlined in your application and consistent with the ethical principles outlined in the Belmont Report and with USF HRPP policies and procedures.

Please note, as per USF HRPP Policy, once the exempt determination is made, the application is closed in ARC. This does not limit your ability to conduct the research. Any proposed or
anticipated change to the study design that was previously declared exempt from IRB oversight must be submitted to the IRB as a new study prior to initiation of the change. However, administrative changes, including changes in research personnel, do not warrant an Amendment or new application.

We appreciate your dedication to the ethical conduct of human subjects research at the University of South Florida and your continued commitment to human research protections. If you have any questions regarding this matter, please call 813-974-5638.

Sincerely,

[Signature]

Kristen Salomon, Ph.D., Chairperson
USF Institutional Review Board
Appendix E: Institutional Review Board Consent Form for Chapter 2 Study

Informed Consent to Participate in Research Involving Minimal Risk

Information to Consider Before Taking Part in this Research Study
Title: Virtual Reality Field Trips for the School of Geosciences: A Pilot Study of the Mineralogy/Petrology Field Trip
Pro # 00037627

Overview: You are being asked to take part in a research study. The information in this document should help you to decide if you would like to participate. The sections in this Overview provide the basic information about the study. More detailed information is provided in the remainder of the document.

Study Staff: This study is being led by Meghan Cook who is a Ph.D. candidate in the USF School of Geosciences. This person is called the Principal Investigator. She is being guided in this research by Dr. Jeffrey Ryan. Other approved research staff may act on behalf of the Principal Investigator.

Study Details: This study is being conducted at the University of South Florida and is supported/sponsored by the USF School of Geosciences. Core major geology courses require a field trip component to accompany and intensify in-class learning. Some students become faced with a hardship to attend a required field trip because of financial burden or a physical/mental disability. With recent advances in technology, virtual reality field trips are becoming readily available for use in classroom settings. Virtual reality trips have the possibility of becoming an option for students to take instead of going on an actual field trip. However, research into the cognitive and affective impacts on students in response to a virtual reality field trip is sparse. The purpose of this study is to understand the cognitive and affective responses of an undergraduate student to a virtual reality pilot field trip associated with the Fall 2019 Mineralogy/Petrology course. There will be one interview after the virtual reality pilot field trip has been completed. The interview will take approximately an hour.

Participants: You are being asked to take part in this study because you are enrolled in GLY 3311C Mineralogy/Petrology during the Fall 2019 semester.

Voluntary Participation: Your participation is voluntary. You do not have to participate and may stop your participation at any time. There will be no penalties or loss of benefits or opportunities if you do not participate or decide to stop once you start. Your decision to participate or not to participate will not affect your student status, course grade, recommendations, or access to future courses or training opportunities.

Benefits, Compensation, and Risk: We do not know if you will receive any benefit from your participation. There is no cost to participate. You will not be compensated for your
participation. This research is considered minimal risk. Minimal risk means that study risks are the same as the risks you face in daily life.

Confidentiality: Even if we publish the findings from this study, we will keep your study information private and confidential. Anyone with the authority to look at your records must keep them confidential.

Why are you being asked to take part?

Study Procedures:
The Principal Investigator (PI) will set up a time via email that is convenient for you to be interviewed after you take the virtual reality pilot field trip associated with the Fall 2019 Mineralogy/Petrology course. This interview will take no more than an hour and will be held outside of the USF School of Geosciences to protect your anonymity.

At each visit, you will be asked to:
- For the one and only interview, nothing is required of you to prepare. The purpose of the interview is to get an understanding of your perceptions of the actual field trip compared to the virtual reality pilot field trip.
- The PI will conduct the interviews and ask semi-structured, and open-ended questions. The PI will ask what your perceptions of the actual field trip are and what your thoughts are on the virtual reality pilot field trip.
- The interviews will be digitally audio recorded and stored on a private drive (USF Box drive) for 5 years after the Final Report is submitted to the IRB per the IRB policy. Only the PI will have access to the recordings and only pseudonyms will be used during the recording. After 5 years, the recordings will be destroyed by erasing the digital data.

Total Number of Participants
About 35 individuals will take part in this study at USF.

Alternatives / Voluntary Participation / Withdrawal
You do not have to participate in this research study.

You should only take part in this study if you want to volunteer. You should not feel that there is any pressure to take part in the study. You are free to participate in this research or withdraw at any time. There will be no penalty or loss of benefits you are entitled to receive if you stop taking part in this study. Decision to participate or not to participate will not affect your student status or course grade.

Benefits
You will receive no benefit(s) by participating in this research study.
**Risks or Discomfort**
This research is considered to be minimal risk. That means that the risks associated with this study are the same as what you face every day. There are no known additional risks to those who take part in this study.

**Compensation**
You will receive no payment or other compensation for taking part in this study.

**Costs**
It will not cost you anything to take part in the study.

**Conflict of Interest Statement**
There are no known conflicts of interest with this study.

**Privacy and Confidentiality**
We will do our best to keep your records private and confidential. We cannot guarantee absolute confidentiality. Your personal information may be disclosed if required by law. Certain people may need to see your study records. These individuals include:

- The research team, including the Principal Investigator and other research staff.
- Certain government and university people who need to know more about the study. For example, individuals who provide oversight on this study may need to look at your records. This is done to make sure that we are doing the study in the right way. They also need to make sure that we are protecting your rights and your safety.
- Any agency of the federal, state, or local government that regulates this research. This includes: the Office for Human Research Protection (OHRP).
- The USF Institutional Review Board (IRB) and its related staff who have oversight responsibilities for this study, and staff in USF Research Integrity and Compliance.

We may publish what we learn from this study. If we do, we will not include your name. We will not publish anything that would let people know who you are.

**You can get the answers to your questions, concerns, or complaints.**
If you have any questions, concerns or complaints about this study, contact Meghan Cook at 813-974-7427. If you have questions about your rights, complaints, or issues as a person taking part in this study, call the USF IRB at (813) 974-5638 or contact by email at R SCH-IRB@usf.edu.
Appendix F: Semi-structured Interview Questions for Chapter 2 Study

VR Field trip Interview Questions:

1. What is your name? Please choose a pseudonym.
2. Did you go on the actual mineralogy/petrology field trip to Mt. Rogers?
3. What were your perceptions of the field trip?
4. Did you take the VR pilot field trip of Mt. Rogers?
5. What were your perceptions of the VR field trip?
6. Comparing the actual field trip to the VR field trip, please describe any similarities between the two.
7. Comparing the actual field trip to the VR field trip, please describe any differences between the two.
8. Please describe any challenges you encountered while on the actual field trip.
9. Please describe any challenges you encountered while taking the VR field trip.
Appendix G: Photographic Release Form for Photographs of Participants While in Virtual Reality

STANDARD USF PHOTOGRAPHY & VIDEO RELEASE

CHECK APPROPRIATE BOX:  ☑ For an adult  ☐ For a minor under age of 18

I, the undersigned, hereby grant to University of South Florida (USF), to those acting on its behalf with USF’s permission and authority, and to USF’s licensees, successors and assigns, the absolute, irrevocable, royalty-free, perpetual right and permission to use any and all photographs, videotape, likeness, biographical information, home town, voice, or other recordings of me ("Materials") in connection with my participation in or attendance at the [Mineralogy, Petrology, and Geochemistry pilot virtual reality field trip scheduled for November 15, 2019. ("Event").

I understand that all such Materials, including film, photographic prints, digital files, or video, are USF’s exclusive property and to the fullest extent permitted by law, I grant to USF the unrestricted right to use – including, without limitation, copyright, publish, re-publish, broadcast, transfer, alter, distribute, display, perform, reproduce, and incorporate into other works – the Materials in any medium now known or in the future invented, including without limitation, print, digital, radio and/or television and Internet, for any purpose, including without limitation, trade, solicitation, promotional, advertising, and marketing, without compensation or further permission from me.

I am fully aware that my likeness may appear in materials available to students, parents, faculty, or staff of USF, and individuals outside of the USF community. I further understand that USF is under no obligation to use the Materials and has made no representations to me in this regard. I hereby waive the right to inspect or approve the finished images, videotape, digital recording, sound track, advertising copy, printed matter or other content including advertising copy or printed matter, incorporating any Materials or otherwise in which they may be used or to any eventual use. I further hereby waive any and all rights to any compensation associated with USF’s use of the Materials.

I hereby release any and all claims, demands, damages, and causes of action of any nature that I have or may hereafter have against USF, its affiliates, officers, directors, employees, and agents arising out of or in connection with my participation or attendance at the Event or USF’s use of the Materials, including, but not limited to, any claims for defamation, invasion of privacy, invasion of right of publicity, misappropriation of likeness, infliction of emotional distress, negligence, any right, title or interest in the Materials, or any other physical or monetary injury.

Without limiting the foregoing, I understand that any distribution of the images will be fully compliant with USF policies, statements and values. I release USF and those acting under their authority from any liability related to the alteration, intentional or otherwise, that may occur in connection with the processing, editing, transmission, display or publication of the images, and understand that images may be cropped or altered for purposes of illustration.

____________________________  ______________________________
PRINT NAME (PHOTO SUBJECT)  DATE

____________________________  ______________________________
PRINT NAME PARENT/GUARDIAN  AGE (IF MINOR) USF CLASS LEVEL (IF APPLICABLE)

____________________________  ______________________________
SIGNATURE  TELEPHONE  EMAIL
Meghan Cook  813-310-6569  mlcook3@usf.edu

PHOTOGRAPHER/VIDEOGRAPHER  TELEPHONE  EMAIL

DESCRIPTION OF SHOOT (LOCATION AND PURPOSE)
Photographs were taken at the Advanced Visualization Lab in the SCA building located at USF, Tampa when participants were completing the Mineralogy, Petrology, and Geochemistry VR pilot field trip. Photographs will be used for the exclusive purpose of showcasing the VR environment in Meghan L. Cook’s Ph.D. dissertation as well as any subsequent publications from the dissertation.

Reviewed for Legal Form and Sufficiency by USF Office of the General Counsel – November 2021