2016

Exploring Meteorology Education in Community College: Lecture-Based Instruction and Dialogue-Based Group Learning

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Exploring Meteorology Education in Community College: Lecture-based Instruction and Dialogue-based Group Learning

by

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Dissertation Submitted in Partial Fulfillment

of the Requirements for the Degree of

Doctor of Philosophy

Educational Studies, Adult Learning and Development Program

Lesley University

August 2016

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ProQuest Number: 10251653

Abstract

This study examined the impact of dialogue-based group instruction on student learning and engagement in community college meteorology education. A quasi-experimental design was used to compare lecture-based instruction with dialogue-based group instruction during two class sessions at one community college in southern California. Pre- and post-tests were used to measure learning and interest, while surveys were conducted two days after the learning events to assess engagement, perceived learning, and application of content. The results indicated that the dialogue-based group instruction was more successful in helping students learn than the lecture-based instruction. Each question that assessed learning had a higher score for the dialogue group that was statistically significant (alpha < 0.05) compared to the lecture group. The survey questions about perceived learning and application of content also exhibited higher scores that were statistically significant for the dialogue group. The qualitative portion of these survey questions supported the quantitative results and showed that the dialogue students were able to remember more concepts and apply these concepts to their lives.

Dialogue students were also more engaged, as three out of the five engagement-related survey questions revealed statistically significantly higher scores for them. The qualitative data also supported increased engagement for the dialogue students. Interest in specific meteorological topics did not change significantly for either group of students; however, interest in learning about severe weather was higher for the dialogue group. Neither group found the learning events markedly meaningful, although more students from the dialogue group found pronounced meaning centered on applying severe weather knowledge to their lives. Active engagement in the dialogue approach kept these students from becoming distracted and allowed

them to become absorbed in the learning event. This higher engagement most likely contributed to the resulting higher learning. Together, these results indicate that dialogue education, especially compared to lecture methods, has a great potential for helping students learn meteorology. Dialogue education can also help students engage in weather-related concepts and potentially develop better-informed citizens in a world with a changing climate.

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Acknowledgments

My journey from deciding to pursue a doctorate to finishing my dissertation has been amazing and memorable. After landing a full-time position at a community college, I knew I wanted to increase my knowledge of adult learning and development to help improve the teaching of meteorology-related sciences. Even though the road was tough at times, I am grateful that I made this choice to further my education. I have many people to thank for my success.

First, I would like to thank my committee members who have had infinite wisdom, patience, and insight. Dr. Christine Ersig-Marcus was instrumental in helping me understand how diverse student bodies at community colleges learn and become engaged in the classroom. Dr. Linda Pursley introduced me to dialogue education and helped me fall in love with Jane Vella's adult learning principles and practices. Dr. Pursley's support in my pursuit to explore quasi-experimental designs was pivotal in my successful completion of this dissertation. Dr. Terry Keeney was a tremendous senior advisor and role model. He applied adult learning strategies to help guide my research and provide the perfect amount of support.

Of course, I could not have conducted my research without the graciousness of Dr. Erin Hayes who helped recruit students to participate in my research. I must also acknowledge her students for their willingness to participate and provide important feedback for my study. Dr. Noble Eisenlauer was also an important resource for guiding the implementation of my research design and informing my understanding of how community college students learn.

I must thank my amazing Lesley University Cohort of 2013 who helped me get this far without feeling alone. Although I was nearly 3,000 miles away from most of them, I never really felt that far away. In particular, I want to thank my friends Stacy Atkinson and Kathryn Hix who stayed in contact with me almost every day, inspiring me to work on my doctoral studies despite my busy work schedule. We also shared fun memories while traveling all over the country to work and attend conferences and residencies.

I must also extend my deepest gratitude to my family. My parents and siblings were always supportive, even when I had to work while visiting them from out of state. I can even blame my mother for teaching me about the weather when I was five, resulting in my passion for meteorology and my meteorology-focused dissertation. At the same time, I could not have done this work without the full support of my husband, David. He was so tolerant during so many long nights of my writing and not always being present during weekends and vacations. I cannot thank him enough for his unconditional love and guidance that were crucial to my success. Lastly, I must express my love and appreciation for my beloved Labrador Retriever, Dori, who was often by my side (nudging my arm) while I worked long hours.

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Chapter 1: Introduction

Changing weather patterns have forced people to consider the effects of global warming. It has never been more imperative to understand the mechanisms behind weather and climate around the world. Regrettably, students in California community colleges often lack the skills and motivation necessary to learn fundamental principles of scientific disciplines such as meteorology, but weather and climate affect everyday activities, the economy, and the health of most living things on this planet (Lutgens & Tarbuck, 2013). This is true even in southern California where the weather is relatively mild and generally has a minimal impact on people's everyday lives. Since community college students make up nearly half of all undergraduate students in the United States (American Association of Community Colleges, 2014), it is crucial to reach out and engage them in a discussion about factors that are certain to touch their lives and those of their loved ones. Meteorology is a fascinating and important field, and if more students were introduced to it, they might choose to deepen their understanding and ultimately get involved in addressing some of the most pressing issues of our times.

In this chapter, I introduce my research by discussing the context of the problem, beginning with the urgent need to understand climate change and its effects on the weather as evidence that community college students need to learn meteorological and related scientific material. I will then discuss the primary research problem, which is the lack of published research on meteorology education in community colleges and the use of non-lecture-based methods to help community college students learn science. Based on this problem, I discuss the research question by focusing on the potential impact of dialogue education on enhancing student learning and engagement in meteorology education. Lastly, I describe the assumptions and challenges that are linked to my epistemological framework and the application of dialogue education principles.

Background and Context

When I was a community college student majoring in meteorology, I was strongly motivated to learn weather-related science and math. However, throughout my seven years of teaching meteorology to community college students in California, I have had difficulties engaging non-science-majors with concepts of meteorology. Although I have highlighted the importance of learning about weather and climate in my lectures, community college students in southern California find it difficult to relate to the material. They become especially disinterested when abstract atmospheric concepts are taught. My animated lectures, which make considerable use of audio and visual technologies, sometimes inspire highly motivated students. However, the majority of my students are passive learners who struggle with the course material. Their struggle may be related to their belief that concepts of weather and climate do not pertain to them.

Since I began my doctoral work in adult learning and development nearly three years ago, I have invited students to add their thoughts and life experiences to classroom discussions and group work. This has enriched both my teaching and their learning, especially as older students who have experienced a variety of weather shared their stories. I noticed that students who have been invited to share are more invested in the course. As a result, my interest in student-centered approaches, including Jane Vella's dialogue education, has motivated me to explore active learning in the classroom (i.e., student activities in the classroom outside of listening to a lecture). A growing body of research (e.g., Bernot & Metzler, 2014; Leonard, 1997; Leonard, 2000; Wieman, 2007) also finds that science education should focus on active learning techniques to help students become scientifically literate and prepare for careers in the sciences.

Scientific literacy is important for all citizens, not just for students majoring in science-related fields (Hobson, 2000; Wang, 2013). For example, only about half of all Americans believe that climate change is the result of human activity, and only a third are aware that the effects of global warming, such as warmer temperatures and rising sea-levels, are already being evidenced (World Meteorological Organization, 2014). In fact, according to the World Meteorological Organization (2014), 13 of the 14 hottest years on record worldwide have occurred in the 21st century. Nevertheless, many adults in the United States see climate change as a problem in the distant future that will affect far-away places (Zhao, 2014). In California, an increase in extreme weather-related events, such as lightning storms, increased wildfires due to Santa Ana winds, and severe, multi-year drought have occurred in recent years (Ray, 2014). Some scientists suggest that these events are linked to or exacerbated by climate change.

Furthermore, America's ability to remain internationally competitive relies on educating adults in science, technology, engineering, and mathematics (STEM) fields (Wang, 2013; Glenn, 2013). The National Science Foundation (2010) has expressed the need for non-scientists to become more aware of scientific information and processes. Leonard (1997) states that "scientific thinking processes are an essential component to any citizen of the world" (p. 6). According to the National Science Foundation (2010), jobs in STEM fields (which include weather-related occupations) have risen 3.3% between 2004 and 2008; this is higher than the 1.3% average increase in employment in all fields (Wang, 2013). Even for students who are not STEM majors, the ability to utilize skills in technical writing and interpreting charts and graphs is increasingly important in the workforce (Huffman-Kelley et al., 2015). It is critical for all undergraduate students to learn scientific concepts that could be useful in future career opportunities.

Approximately 45% of undergraduate students in the United States are community college students, and the community college system in California is the largest in the nation (California Community Colleges Chancellor's Office, 2015a). This system grew significantly during the 1950s when community colleges across the United States began to flourish. As a result, the Master Plan of 1960 was developed by UC Regents and California State Board of Education, and California community colleges have widened their variety of missions, curricula, and courses more than traditional four-year schools. Community colleges also have smaller class sizes and greater contact with faculty who focus on teaching compared to universities with large lecture halls and faculty devoted primarily to research (Caldwell, 2012). At the same time, community colleges, which have less-restrictive admissions criteria than four-year institutions, provide a low-cost option for students to complete general education requirements and transfer. The combination of this open-access policy with lower-cost tuition affords more opportunities for students to attend college.

As result of their policies, community colleges have unique challenges, such as educating underprepared students who lack college-level math, reading, and time management skills (Huffman-Kelley, Perin, & Liu, 2015). There is also a greater diversity of language, culture, ethnicity, and skill sets. With the heavy focus on transfer in California, course curricula with transferrable credits include STEM options that can serve as stepping-stones for similar programs at California public universities. Therefore, introductory natural science courses such as meteorology have the potential to attract community college students. These courses offer non-science-majors the opportunity to gain scientific knowledge and transfer to nearby four-year schools. While they are designed to serve general education purposes, they are also intended to provide a well-rounded education that can help adults build necessary skills for the workforce and become mindful of global environmental problems.

Research Problem

Despite the fact that there are at least 75 meteorology courses taught at community colleges in California and the need for students–and indeed all citizens–to learn basic principles of meteorology, there are no studies that specifically address best practices for teaching weather and climate concepts in community colleges (California Community Colleges Chancellor's Office, 2015a). This gap suggests that further educational research in meteorology should include learning at two-year colleges. While there is research on meteorology education at the university level (e.g., Barrett & Woods, 2012), these studies focus on meteorology majors, and their results may not transfer to community colleges that deal with underprepared students and heterogeneous student populations.

Research on community college students (e.g., Leonard, 1997; Leonard, 2000) suggests that many students are not motivated to learn scientific disciplines due to the abstract and quantitative nature of the science courses that are offered. As noted earlier, students at community colleges in southern California find meteorological concepts to be abstract due to the lack of diverse weather in this geographical area. Some community college students, especially emerging adults, are concrete thinkers who have a difficult time understanding abstract concepts (Arnett, 2000; Leonard, 1997).

These issues are exacerbated by the continuation of transmission-based teaching (e.g., lecturing) in science classrooms (Vella, 2008). The traditional lecture-style approach to teaching is often not effective for science courses in higher education; in fact, research suggests that only 10% of lecture content is retained by students (Wieman, 2007). Lectures can result in students becoming passive learners who cannot absorb content-rich information as quickly as it is transmitted (Bernot & Metzler, 2014). The traditional lecture approach also encourages one-way communication without verbal feedback from students (Center for Integration of Research, Teaching, and Learning, 2013). This may lead to ineffective learning and comprehension of material.

Although there exists no firm consensus that lecturing is an ineffective method for teaching science (partly due to the large variety of course structures and teaching skills of college science instructors), increasing research does show that taking adult learning theories into account has a great potential to impact how well college students learn (Bernot & Metzler, 2014). Hobson (2000) suggests that instructors should make science courses in higher education more socially relevant. When constructivist learning theories are utilized in science education, student motivation and success increase (Bernot & Metzler, 2014; Leonard, 2000; Lane & Harris, 2015). Using social learning theories, such as social constructivism in the classroom, and sharing knowledge among classmates may help students grasp meteorological and other scientific concepts more easily. Discussing political and local environmental issues surrounding climate change can engage students and help them connect the material to their lives and future career prospects. In addition, students in natural science education research studies at the community college level have expressed the need for science instructors to put science into context and utilize scientific knowledge they already have (Cowan & Piepgrass, 1997). The use of experiential learning has resulted in positive effects on student learning and engagement in physics courses (Goldberg et al., 2010). Nevertheless, the possibility of applying adult learning principles in meteorology has not been formally investigated in community college educational research.

Research Question and Rationale

The gap in meteorology educational research, along with my several years of teaching meteorology in California to students who struggle to learn the content, has led me to form my primary research question: What is the impact of dialogue-based group learning on student learning and engagement in community college meteorology education? Based on research results regarding general science education in community colleges and meteorological education research at universities, I wanted to explore the use of social constructivism and experiential learning through a dialogue education framework to see how these might benefit students learning meteorology. Jane Vella's (2008) dialogue education approach utilizes forms of social constructivism and experiential learning in concrete ways to help adults learn. The underlying assumption of dialogue education is that learning is enhanced when instructors involve students in the learning process (Vella, 2002). What sets Vella's (2008) approach apart from other forms of constructivism is the focus on open questions and making content meaningful and relevant to students.

In addition, Vella's (2008) approach is designed to utilize adult learning theories in the classroom. For example, dialogue-based learning tasks are developed to help learners find meaning in the content by situating that content within their lives. The learning needs and resource assessment (LNRA) is provided to each learner before a learning event to elicit knowledge and experience that students bring. This form of experiential learning can lead to enhanced learning, especially for older adults who have a large reservoir of knowledge and experience (Jarvis, 2006). Thus, it is beneficial to explore Vella's concrete applications of social constructivist learning theories within community college meteorology courses.

This research may not only improve teaching practices within meteorology, it may also shed light on best practices in a wide range of community college STEM courses. Since abstract concepts are difficult to teach in any science course, dialogue education has the potential to help students relate to the material and engage with the concepts more effectively. This increased engagement can lead to enhanced learning. In fact, there are educational research studies that support the application of social constructivist learning theories in geoscience and related natural sciences courses at the community college level (e.g., Bentley, 2009; Phillips, 2006; Wenner, Burn, & Baer, 2011). Therefore, the results of this study may have implications for teaching practices in a variety of scientific disciplines at post-secondary schools.

Assumptions and Challenges

Even though there is a great potential for dialogue education to improve teaching practices in community college meteorology courses, there are also various assumptions and challenges within the research that must be addressed. First, although the epistemological framework of dialogue education is rooted in constructivism–and I believe that students would learn science more efficiently and more meaningfully through this approach–I view knowledge acquisition as a hybrid of the postpositivistic and constructivist paradigms. I identify with postpositivistic research due to my background in meteorological sciences, and I continue to believe that some knowledge is discoverable (e.g., the physical and dynamical processes of the atmosphere). However, because of my experiences and the limitations of my study (i.e. working with a small number of students from a single community college), I must consider the knowledge I am creating from this study as context-dependent. I must also be aware that my epistemological framework is grounded in my own knowledge of meteorological concepts as well as my years of teaching meteorology at a California community college. My results may not generalize to many other contexts, as many large, quantitative research studies claim to do. Nevertheless, because science education posits that constructivism and group work enhance learning and engagement, results from this study may be transferable to other community college science programs and useful to other educators.

Additional assumptions are also embedded in the principles of dialogue education. This framework assumes adults will have both the need and desire to learn, along with a willingness to work hard and together with their peers (Vella & Associates, 2004). Adults in a learning event will bring a large reservoir of knowledge to the classroom and take time to reflect on their learning. By offering accessible learning materials, a clear design, and the praxis of safety, dialogue education will allow learners to make meaning out of new content. Inviting students to work with the presented content and become engaged in dialogue-based group learning tasks can set the stage for enhanced learning that will transfer to the adults' lives after the learning events (Vella & Associates, 2004).

Based on these assumptions, implementing dialogue education principles in a community college with a diverse student body and adults at various stages of maturity and development will inevitably present challenges. The student body in community colleges in southern California is approximately 53% female and 47% male, and nearly a third of the students are over the age of 25 (California Community Colleges Chancellor's Office, 2015b). Hispanic/Latino students make up 34% of the student body, while 31% identify as White, 13% as Asian, 10% as Multi-ethnic, and 6% as African American. Six percent did not specify ethnicity. To further complicate the mix, 21% of students are non-U.S. citizens, and 20% of students are English language learners. Approximately 33% of the student body consists of first-generation college students, and 56.5% of students come from low-income families (California Community Colleges Chancellor's Office, 2015b).

Given the diversity of the student body, not every student will fit the profile of the ideal adult learner for dialogue education proposed by Vella (2008). Not all students will be eager to learn with others who may have more knowledge and experience. This is especially true for students fresh out of high school who may be accustomed to the transmission approach to teaching (Vella & Associates, 2004). Learning with the input of students from different cultural or socioeconomic backgrounds may not always be useful or easy (Gregory & Webster, 1996). However, through dialogue and group tasks, adults are likely to share their experiences and enlighten those who have less knowledge and experience. These adults can then help inspire other students to learn meteorology and engage in course material. Dialogue education provides a concrete way to apply adult learning strategies for this student population. Thus, there is great potential for dialogue education to help bring together diverse students, cater to their unique needs in community college, and help them learn meteorological concepts that can prepare society for the potentially dire impacts of global climate change.

Chapter 2: Literature Review

Introduction

This chapter will review the literature centered on multiple areas of adult learning theory; dialogue education; the connections between motivation, interest, and engagement; and meteorology and other natural science educational studies. An overview of adult learning theory will first be examined, followed by a more in-depth review of social cognitive learning, situated learning, social constructivism, and experiential learning. Dialogue education will be discussed in depth with principles that intersect adult learning theory, motivation, engagement, and science education research at post-secondary schools.

Both intrinsic and extrinsic motivation, interest, and multiple domains of engagement will then be investigated with a discussion as to how each of these concepts is related. This discussion will focus on educational research in higher education. Meteorology education in universities and natural science education at the community college will then be explored in relation to social learning and experiential learning theories. Literature in natural science education will include unique student challenges in community college science courses, such as anxiety about taking science courses and the lack of college-level skills.

Adult Learning Theory

Adult learning theory is based on the fundamental idea that adults learn differently from children. The term andragogy was coined by Knowles (1998) as a way to describe the growing literature that supports the praxis and assumptions of adult learning. Knowles' use of andragogy helped professionalize the field of adult education and develop concepts and tools to help adults learn (Merriam & Bierema, 2014). For my research, adults are considered those who are 18 years of age or older, which aligns with the majority of students at community colleges. Some of the younger students assume social roles characteristic of adults, such as working full-time and raising a family. Other students may fit more accurately into Arnett's (2000) emerging adulthood category that places them between adolescence and adulthood.

Knowles (1998) asserted that adults are motivated to learn due to life-centered problems and experiences. This focus stems from adults having a greater number and wider variety of life experiences compared to children. Since the early 20th century, a growing body of literature has focused on how adults think and make meaning of new knowledge. Before seminal work in adult learning, such as Dewey (1920) and Lindeman (1926), much of the research on learning theory focused on children (Adamson, 2012). Within the last century, great progress has been made toward understanding best practices for teaching adults and developing learning environments for them to grow and develop (Merriam & Bierema, 2014).

The assumptions behind adult learning and adult education include the learner moving from being dependent on the teacher to being self-directing (Merriam & Bierema, 2014). This concept plays a major role in dialogue education, where students form groups to discuss content instead of solely relying on the teacher to transmit information. Adults also have a growing reservoir of knowledge and experience that they can use to learn. They have an immediate need to apply new knowledge and to understand why they need to learn new skills or information (Knowles, 1998). These principles are also a part of dialogue education, where group learning tasks utilize learners' experiences and show how the knowledge presented can be used and why it is important to learn it. Adults also tend to be internally motivated to learn. Thus, a learning needs and resource assessment (LNRA) tool in dialogue education can help situate new knowledge into the lives and interests of the learners.

In conjunction with principles of adult learning theory and dialogue education, science education literature has found social learning theories, such as social cognitive theory (SCT), situated learning, and social constructivism, important in helping students learn scientific concepts (e.g., Danielsson & Linder, 2009). Experiential learning, which is important in both adult learning and dialogue education, also plays a key role in science educational research and in science laboratory courses. However, many introductory, non-laboratory-based science courses continue to rely on lecturing. This is where dialogue education can build upon the teaching and learning methods in introductory courses. The section that follows details each of these areas of adult learning in depth.

Social cognitive theory. Bandura (1999) outlines the basic ideas behind SCT within the realm of psychology and social sciences by exploring social context and motivation as important factors in learning. He posits that adults learn through interactions within specific contexts and through observing other adults. Interactions between cognitive, affective, and environmental factors, known as the triadic reciprocal causation, allow learners to understand abstract concepts of behavior and cultural norms by replicating actions of others (Bandura, 1986). Humans also have the ability to self-organize and self-reflect with a potential to gain self-efficacy. Adults who have a high degree of self-efficacy are most likely to learn by observing other adults. Learning that is self-regulated is effective in helping students keep control over their cognition and motivation (Glynn, Taasoobshirazi, & Brickman, 2009). Bandura (1999) also notes that individuals with high self-efficacy are motivated and more confident to achieve career and educational goals. Behaviors that lead to academic success in college environments, such as attending class, studying, and working in groups, are indicators of self-efficacy and motivation (Glynn et al., 2009). Moreover, the foundation of mentoring and cognitive apprenticeships is based on Bandura's SCT, which can be applied to community college students learning career-related and on-the-job tasks (Mullen, 2005).

Ponton and Rhea (2006) explore autonomous learning in relation to Bandura's (1986) SCT for further implications about adult learning and science education. Autonomous learning includes activities associated with self-directed learning projects driven by purposeful learning goals. Ponton and Rhea (2006) assert that autonomous learning does not occur in isolation, since environmental context and the behavior of others can lead to independent and meaningful learning. SCT provides a social and contextual lens through which autonomous learning is studied. The authors examine SCT concepts of human functioning (including symbolization and vicarious learning), self-efficacy, and cognitive motivation. Self-efficacy linked to obtaining perceived desirable goals plays a major role in an adult learner's preference for independence and self-directedness. If science educators can help students develop learning goals that correlate to future rewards and outcomes, self-efficacy and success in learning scientific concepts can grow and may encourage more students to pursue science-related careers.

Glynn et al. (2009) investigate principles of motivation and self-efficacy in college-level, non-science-major students. Using the Science Motivation Questionnaire developed by Glynn and Koballa (2006), they focus on motivational components linked to Bandura's theoretical framework of SCT and self-efficacy (Glynn et al., 2009). These components include instrinsic and extrinsic motivation, personal relevance, self-determination, and self-efficacy. Survey results indicate that the motivation to learn science is related to high school science preparation, college grade point average, and the relevance of science to future career goals. Self-efficacy is also highly correlated with low anxiety levels in terms of test taking and learning science. These findings have strong implications for understanding what motivates students to learn meteorological concepts. Although observing others in the context of science classrooms may not be enough to learn meteorology, motivated students with a high level of self-efficacy may be able to imagine themselves working on complex problems successfully (Hergenhahn & Olson, 2005). Further, the interaction of the cognitive and social factors that act as the foundation of SCT may be more useful to students who find relevance in learning meteorology. This is especially important for students who see weather and climate as being useful in their lives and future careers.

The basic tenets of SCT, self-efficacy, and motivation are beneficial in understanding how social learning theories can be used to enhance adult learning in the classroom. As a leading theorist in SCT, Bandura (1986; 1999) situates his theory in reference to the former psychological tendency to view learning and change as isolated individual efforts. Bandura's (1986) theories align with science educational research that supports social interactions and constructivism-based activites to enhance learning, motivation, and engagement. The most important information from Bandura's (1999) research is the discussion of the link between motivation and self-efficacy, which shows that students with high self-efficacy in science classes are typically more engaged and successful. At the same time, these students sometimes need help from their peers through group work to increase their confidence with complex scientific concepts. Even highly successful students who tend to learn in isolation can benefit from social contexts at times. Social context is also pivotal to dialogue education, as it plays a major role in increasing student learning and engagement (Vella, 2008).

Bandura's link between SCT and self-efficacy has also been criticized as being too weak and vague (Boundless, 2014). SCT in general is very broad, without a single, unifying theory that connects SCT's observational learning and self-efficacy. Certain aspects of social learning cannot be directly observed, which suggests that some learning must take place outside of observing others. If students in a science course are working in groups (e.g., through dialogue education group learning tasks), one cannot attribute their learning solely to SCT and observing their peers. SCT also does not take into account adult development stages, as Bandura does not differentiate between how children and adults learn through observation (Boundless, 2014).

In a community college setting with a diverse student body, learning by observing others from different cultural and socioeconomic backgrounds may not always be effective (Gregory & Webster, 1996). Most of the studies that apply Bandura's SCT and self-efficacy ideas to college classrooms focus on university students. These results may not fully apply to two-year schools, as cultural differences among students at these schools can lead to language barriers and resistance to working with others from different backgrounds (Gregory & Webster, 1996).

Situated learning. While SCT focuses on individual learning within social contexts, situated learning theories place more emphasis on learning contexts of the workplace and everyday experiences (Brown, Collins, & Duguid, 1989). This theory helps bridge the gaps between theoretical knowledge and real-life applications of knowledge (e.g., workforce environments). Situated learning is associated with constructivist learning theories by emphasizing learning in a context that is meaningful to the student. Brown et al. (1989) believe that deep and meaningful learning will not occur if the context of knowledge application is not considered a major part of learning and teaching.

Situated learning emphasizes the social interactions that occur during learning, which is effective if accurate contextual components found in the workforce are replicated in the classroom. For example, Kim and Merriam (2010) examined the context, tools, and group work in a computer classroom for older Korean adults. Since these students worked with classroom tools found in a real-world computer lab, and because the Korean students had shared cultural knowledge and experience, the learning was more authentic and meaningful to them. Even the traditional respect of teachers and older adults found in the Korean culture was observed in this classroom, highlighting the importance of culture and social interactions. Science courses that offer tools for students to use and learn scientific approaches that they also find in work environments would help situate their learning experiences. Classrooms that also strive to accomodate various cultural identities of community college students may help students learn more effectively.

Communities of practice are one aspect of situated learning that relies on differential levels of knowledge among learning communities (Wenger, 2000). These practices consist of groups of individuals who share a goal or a belief and interact on a regular basis in order to learn. Lave (1991) discusses the basic tenets of situated learning and communities of practice in forms of apprenticeship grounded in historical and sociocultural contexts. She explains how participants in a community of practice begin as peripheral participants (i.e., newcomers) and can progress into sustained members of a community. She also asserts that learning is always situational, but sometimes the situation is a social construct and not a naturally occurring setting (e.g., Yacatec Mayan Midwifery or Alcoholics Anonymous). In each learning community, the newcomers and oldtimers are dependent on each other; the former learn to become oldtimers, while the latter continue to carry on the community. School settings can include communities of practice if institutional contexts can be defined as social constructs with newcomers as "legitimate peripheral participants" (Lave, 1991, p. 64).

There is some criticism of situated learning in reference to building the math skills necessary for quantitatively heavy science curricula, such as meteorology courses that require algebraic and trigonometric skills (Anderson, Reder, & Simon, 1996). Much of what Lave (1991) and Wenger (2000) use to show that learning is mostly situated in context involves comparing learning mathematics in the classroom to applying that knowledge in the real world. Anderson et al. (1996) do not agree with the basic tenet of situation learning that nearly all action is rooted in the context in which it was learned, and that knowledge typically does not transfer between tasks. They believe that some concepts, especially mathematical information, can be easily applied outside of the classroom. To Anderson et al. (1996), the degree of knowledge transfer can vary widely. It does not necessarily depend on the similarity of context in which the skill was learned and the context in which the skill can be applied.

Anderson et al. (1996) also argue against the claim that abstract knowledge training is not useful. They do not believe that all types of instruction should be done in complex social environments. For example, they explain that it is beneficial to have the basic math skills not necessarily taught in complex social environments before trying to apply more complex math in real world contexts. This critique implies that learning may not require a social environment, which counters my and other authors' experiences that show that social learning helps students improve their understanding of scientific concepts.

At the same time, there are authors who disagree with Anderson et al.'s (1996) critique. For example, Greeno (1997) argues that Anderson et al.'s (1996) claims are focused on the ability of a learner to apply knowledge outside of the social context and not necessarily on the benefits of the social environment on learning. Greeno (1997) stresses that knowledge does not sit exclusively within a learner's head, but instead depends on social and environmental cues. This idea is even applied to abstract mathematics, where learned skills applied in the classroom with other students can lead to enhanced learning. I have witnessed the benefits of situated learning in meteorology classrooms with a large quantitative component. Basic math skills needed to understand abstract meteorological concepts were learned more effectively through collaboration with other students. For example, understanding the physical processes of atmospheric stability in thunderstorms and tornadoes requires college-level algebraic skills. Some students have had success in learning these skills within group activities.

Social constructivism. Social constructivism has also shown promising results in terms of student learning and engagement within science education. Vygotsky (1978) and Bruner (1985) are the primary proponents of this theory, as they suggest that learning is enhanced through in-class dialogue and group activities. They argued that learning does not occur in isolation but is maximized by the utilization students' personal and social histories, in-class dialogue, and social activities. These ideas also align with the principles of SCT and situated learning. Vygotsky's (1978) research emphasized interaction among students and teachers to enhance the construction and meaning of knowledge. Bruner (1985) expanded on Vygotsky's (1978) view of social constructivism by stating that "there is no way, none, in which a human being could possibly master that world without the aid and assistance of others for, in fact, that world is others" (p. 32). Driver, Asoko, Leach, Mortimer, and Scott (1994) also discussed these theories set forth by Vygotsky (1978) and Bruner (1985) and proposed that science education must be rooted in social constructivism. Borsari (1999) suggested that adult learners are motivated by social context and peer interaction and are relatively less engaged in passive learning environments.

As an example, Crouch and Mazur (2001) discussed 10 years of work using peer instruction and cooperative learning strategies in the classroom to improve student engagement and success in physics courses for non-majors. Activities related to these strategies included in-class discussions and quizzes on the readings, applications of difficult material in groups, and student presentations that required students to prove to their peers that their quantitative results were accurate. A dramatic improvement in student engagement and achievement was found compared to physics courses taught with traditional lectures. In addition, student success increased throughout the 10-year period due, in part, to the instructors modifying and improving the active-learning and engaging activities. In the beginning, some students felt uncomfortable with non-traditional teaching methods (Crouch & Mazur, 2001). However, over a semester, most students were motivated to work on in-class problems and go along with the active-learning strategies.

For a large class (200 students) structured around traditional lectures, Terrion and Aceti (2012) explored the use of in-class clicker technology to increase student engagement through social interactions. Peer instruction and group activities were utilized before students entered responses to clicker questions using hand-held devices in which they could electronically respond to questions. Attitudinal and informational surveys were conducted during the last day of class to gauge students' perceptions of learning, motivation, and engagement during classroom time, and to determine if the technology in the classroom led to greater student success in the course. Results demonstrated strong positive correlations between clickers and engagement and learning.

Theories on social constructivism set forth by Vygotsky (1978) and Bruner (1985) provide the foundation for active learning and other constructivism-based tools used in meteorology and other science classrooms. These ideas have proven useful in the literature (e.g., Crouch & Mazur, 2001; Goldberg, Otero, & Robinson, 2010), as they provide evidence of enhanced learning of science through teaching techniques based in social constructivism.

However, much of Vygotsky and Bruner's work is dated and mostly applies to children. Although their ideas seem to work well with adults, it would be useful to see more research that explicitly connects social constructivism to adults (even young adults) who are learning science in higher education.

Crouch and Mazur's (2001) instructional methods applied to young adults in higher education provide examples of how active learning and social activities are beneficial to student success, motivation, and engagement. Because students in this study had incentives to read the textbook before class and participate in discussions during class, they were able to understand difficult concepts more easily. This increase in student achievement also meant that less time was needed to deliver new content through lecturing. These results support much of the science education literature that focuses on active learning and non-lecture-based teaching methods to increase student learning and success (Leonard, 1997).

Experiential learning. Both social learning theories and dialogue education principles are based on utilizing a learner's experience, whether that experience is in the past or present. As adults develop, their reservoirs of knowledge and experience build, and utilizing these reservoirs is at the heart of experiential learning (Jarvis, 2006). Peter Jarvis (2006) expanded on Kolb's (1984) experiential learning model by adding extra stages, including the biography of a learner and factors that lead to both learning and non-learning. Jarvis (2006) posits that learning starts with experience as students attempt to fit new situations into their life stories. When adults are presented with unfamiliar situations, such as learning to apply a scientific concept, they use their senses to understand a situation more fully. They try to familiarize themselves with a new encounter by conducting research, asking for help, and applying new information and learned skills. This process continues until adults have understood what it takes to deal with the new knowledge and situation. At this point, learning ceases until another unfamiliar scenario is encountered.

Research in college science education recognizes the use of a learner's prior knowledge and experience to build scientific literacy. For example, Leonard (2000) posits that constructivism and experiential learning theories are preferred approaches to methods of instruction that produce meaningful knowledge and scientific understanding for students learning science. Because science aims to explain the natural world and students often have preconceived ideas of how the natural world works, instructors can tap into these ideas to help them construct the scientific processes that undergird the world they see and experience (Driver et al., 1994).

Methods of teaching and learning based on experiential learning theories have led to enhanced student learning in college-level physical science education, indicating important relevance in meteorology curriculum that requires an understanding of the physical elements and processes of the Earth. Goldberg, Otero, and Robinson (2010) explored alternative ways to teach physics to non-physics majors using experiential learning theories. Goldberg et al. (2010) developed an approach called Physics and Everyday Thinking (PET). PET helped students build upon their previous knowledge of physical ideas, as well as work in groups to grapple with basic problem-solving skills in physics. Through engagement using group learning and computer simulations, the authors found enhanced learning for students in courses that use PET. These authors noted that the social interactions and debates about principles discussed in the classroom, student reflections on learning physics, and the use of prior knowledge of everyday physical interactions were crucial in the success of PET (Goldberg et al., 2010).

The drawback to most experiential learning studies in science education is that they have been conducted on science majors and university students (Le Cornu, 2005). Attempting to use this method with non-science majors at a community college with various degrees of motivation to participate in class may present challenges. There is also little mention of sociocultural factors that can either enhance or diminish learning by using experience, which is important for studies conducted at community colleges. If learners require a great deal of guidance, then they may not learn from experience as much as self-directed adults who learn from trial and error. Furthermore, using Jarvis' experiential learning theories may be time-consuming, especially if experience-based reflection assessments are used to gauge learning. Although this critique is lessening with time and additional science education research, evaluating students' mastery of content and lower-level learning based on constructivist epistemologies (e.g., open-ended reflection questions utilized in dialogue education) can also be criticized as being too subjective for the hard sciences (Leonard, 2000).

Le Cornu (2005) outlined additional limitations of Jarvis' learning theories in an attempt to enhance and build upon them. By using Jarvis' (2004) model, she posits that there is a gap between what people are learning and the environment in which learning takes place. Le Cornu (2005) claims that Jarvis' experiential learning model focuses too much on a one-dimensional time orientation with little vertical alignment. That is, to Jarvis, learning is considered to happen through unilineal progression of one's life, and learning is more reactive than proactive. Therefore, the model is limited in acknowledging the importance of human consciousness and the related reflection necessary to process acquired knowledge.

Dialogue Education

Social learning theories and experiential learning also undergird the foundation of dialogue education, as this approach "falls under the umbrella of *social constructivism*," and it can be a means toward transformational learning (Vella & Associates, 2004, p. 2). The development of dialogue education over the last four decades has been inspired by Paulo Freire's critical theory approaches to education and Malcolm Knowles' work on adult learning theories and education (Vella, 2008). Freire (1972) utilized dialogic approaches to confront strong oppression and domination in education, health care, and various aspects of society and culture. Dialogue education is, in part, a critical pedagogy where dialogue replaces domination by including the input of learners into the design of learning events. This style of teaching contrasts with the "banking" (Freire, 1972, p. 71) system of education that remains prevalent in schools today. Banking refers to the "deposit" of content by the instructor with little to no involvement of student experiences or input (Vella & Associates, 2004, p. 1). The underlying foundation of dialogue education is to "prevent the appearance or reality of domination at every level" (Vella, 2008, p. 6). In dialogue education classrooms, the power differential between the student and the teacher is minimized. Thus, the involvement of the students is highly linked to the success of learning.

Dialogue education melds adult learning theories and applies practical strategies to use in adult education (e.g., community college meteorology courses). Although Vella's (2008) purpose of dialogue education originates in Freire's (1972) critical pedagogy, many of the principles are also based on social and experiential learning theories. These principles serve as resources for learning and relating scientific content to students' lives. Vella and Associates (2004) posit that "students learn best when they are actively engaged in the learning process, doing learning tasks, and experiencing events" (p. 12).

Dialogue education is different from other types of education because of its focus on open questions (versus fixed-answer questions) and the deliberate placement of content into the lives of each student (Vella, 2008). These learning tasks allow students to answer open-ended questions about the content, to discuss these questions through group-based discourse, to reflect on the content, and to integrate new knowledge into their own contexts. For example, although not all students in meteorology courses will have personally experienced a variety of weather events that would aid in their learning of meteorology, there are usually some in a class who have been through severe weather events. If their stories could be shared though dialogue, they may inspire other students unfamiliar with severe weather to learn and become engaged.

There are numerous examples of dialogue education applied to formal and non-formal adult education settings, such as in the public sector, not-for-profit organizations, international education, and colleges and universities (Vella & Associates, 2004). Dialogue education has been used in national court systems, welfare programs, health-related professional education, and social programs for women and children. Internationally, dialogue education has been applied to school programs in Haiti, health care instruction in Chile, and racism education in Canada, to name a few. Examples of dialogue education in universities include introductory psychology classes, undergraduate nutrition education, accelerated graduate programs, and distance learning courses. Unfortunately, there are no examples of this approach in meteorology courses, nor are there any published examples of this approach at community colleges.

Design. Dialogue education's learning needs and resource assessment (LNRA) is the first tool of the design that helps place science in the context of the students (Vella, 2008). "Constructivism is one of the philosophical roots of the theories of dialogue education, and the foundation of this process of learning needs and resources assessment" (p. 28). The purpose of the LNRA is to understand what the learners perceive they need to learn and what information and resources they already have and can bring to the learning event.

The seven design steps that follow the LNRA are an integral part of Vella's (2008) structure for dialogue education (Table 1). The first step, *Who*, is for understanding who the learners are. This is done through an LNRA, but it can also be accomplished by observing students during the first day of class. Jane Vella (2008) has even visited students in their settings and asked them to join her at her home. These informal settings are great ways to understand the learners. The second step, *Why*, is another crucial part where the instructor can understand the situation and the specific reasons for the learning event. The situation that calls for learning is especially important to understand when diverse perspectives of the learners are a part of the learning event. The third and fourth steps, the *When* and *Where*, are also key for determining the length of time for the learning event, as well as for knowing what tools and resources will be available. Designing too much content for the alloted time can impede deep learning and reflection. In addition, understanding the location and resources of the setting can help in planning how to best serve the adult learner. For example, the physical design of a traditional classroom may impede learning. Jane Vella went so far as to say, "If we want to emphasize learning, we may have to move the furniture" (Vella & Associates, 2004, p. 39).

The last three steps, the *What*, the *What for*, and the *How*, are centered on the content of the learning event (Vella, 2008). The *What* describes the specific content, such as the ideas and skills that will be taught. While LNRA does not determine the content, it does inform how the content will be addressed. The *What for* step includes the learning objectives that are used for assessment and evaluation. Assessment in dialogue education uses "tough action verbs" that are "specific and productive" (Vella, 2008, p. 41). The *How* are the learning tasks designed to address the *What*. These tasks include open questions that are answered in small groups designed to help students learn the content in a meaningful and relevent manner. These tasks are a critical element of the dialogue-based approach in my study.

Table 1 - Seven Design Steps of Dialogue Education

Design Element	**Description**
1. Who	Identifies the learners and their needs, mainly through an LNRA.
2. Why	Situates the learning based on the above step and underlying reasons for the learning events.
3. When	Identifies the time frame of learning to help design the length of learning tasks.
4. Where	Identifies the setting to maximize learning through dialogue.
5. What	Outlines the goals and specific content of the course or program.
6. What For	Details the achievement-based outcomes (ABO) that the learners will achieve by the end of course or program.
7. How	Describes the learning tasks and materials needed for these tasks to help students achieve each ABO.

Design principles fundamental in dialogue education are embedded within these design steps and are based on adult learning principles. For example, *safety* is also a very important factor in dialogue education, which aligns with learners' needs within student-centered classrooms (Caprio, 1999; Vella, 2008). Dialogue-based group tasks that pose *open questions* provide a non-threatening way to learn content in a group setting. Additional adult learning principles, such as *respect*, *relevance*, and *active engagement*, are key to dialogue education that can help reduce students' anxiety about science and build a foundation for a safe and effective learning environment (Vella, 2008). The primary focus of dialogue education framework is that adult learners will become engaged in a meaningful learning event that will be useful to their lives after the learning event concludes.

Challenges. One potential concern over the use of dialogue education in California community colleges is the wide range of native languages among students. Since approximately 21% of students in these colleges are non-U.S. citizens, there may be some who are not only learning meteorology, but also English (California Community Colleges Chancellor's Office, 2015b). It may be difficult for these English language learners to articulate dialogue education writing tasks in their second language. In a community college setting with a diverse student body, learning with the help of students from different cultural and socioeconomic backgrounds may not always be useful or easy (Gregory & Webster, 1996).

Students may also dislike in-class discussions and group work and be resistant to dialogue education principles. Students fresh out of high school may also be accustomed to the "educational model of our childhood – that of the teacher as the giver of knowledge and learner as receiver" (Vella & Associates, 2004, p. 43). In fact, Bernot and Metzler (2014) suggest that there needs to be a balance between constructivist approaches and traditional lecturing, as students may feel uncomfortable and frustrated with a purely constructivist classroom. When these approaches have a social element, introverted students may be challenged. Moreover, in some cultures, students are not encouraged to participate, contribute, or question their teacher (Hvitfeldt, 1986). Instructors who design and facilitate dialogue in small groups, however, can help involve each student in these groups (Vella, 2008). Since small group learning with a challenging task holds each student accountable for a part of this task, there is a hope that introverted students will become engaged in the learning task and contribute to the work and learning of the group.

Motivation, Interest, and Engagement

It is also important to investigate both motivational factors and levels of interest among college students in order to assess their impact on science education (e.g., Phillips, 2006; Wenner, Burn, & Baer, 2011). In my experience teaching in the community college, I have noticed that some students are not motivated to enroll in or complete science courses due to their lack of preparation, their perception that science is of minimal importance to their lives, low self-esteem, and lack of confidence or self-efficacy. However, intrinsic and extrinsic motivation issues have been researched extensively for general higher education purposes. A higher level of interest can lead to higher student learning and engagement (Barrett & Woods, 2012). Engagement concepts combine several areas of research that include motivation, self-regulated learning, interest in subject matter, and student attitudes (Fredrick, 2011).

Intrinsic and extrinsic motivation. Bye, Pushkar, and Conway (2007) developed quantitative surveys and utilized mixed factorial analysis of variance (ANOVA) to find statistically significant differences between traditional (18 – 21 years old) and nontraditional (28 years and older) students' perceived affective and motivational components of academic life. Traditional students were also defined as those who follow a linear path through college. Nontraditional students had breaks in their paths and strong levels of intrinsic motivation (such as self-improvement and personal growth), positive affect, and greater interest in learning (Bye et al., 2007). In this study, the nontraditional students, despite their lack of extracurricular activities and the increased role of work and family, performed at higher academic levels than traditional students did.

Bye et al. (2007) also found that reinforcing levels of intrinsic motivation for all ages of students could lead to high levels of psychological well-being and student success. Lepper, Corpus, and Iyengar (2005) noted that intrinsic motivation resulted in higher academic success than extrinsic motivation did. In fact, participation in science, technology, engineering, and mathematics (STEM) fields can largely depend on intrinsic motivation. Furthermore, some research studies suggest that a large focus on extrinsic rewards can undermine the intrinsic motivation to learn (Deci, Koestner, & Ryan, 1999; Reynolds, 2006). Although meteorology courses at community colleges are comprised mostly of non-science-majors who may prefer and rely on extrinsic motivators, a larger emphasis on intrinsic motivational factors can lead to persistence and enhanced success in college.

Glenn (2013) also discussed interest and intrinsic and extrinsic motivational factors, but with a greater focus on STEM-related education in community colleges. She focused on factors that motivate students to enroll in STEM courses, leading to potential future careers within STEM fields. Glenn's (2013) research examined students' lack of preparedness for math and science courses at the community college level and the role of preparedness in motivating students to take STEM courses. Specifically, self-determination and achievement theories were studied to find statistically significant correlations between high school academic performance in science classes and motivation and performance in an online biology class. These correlations were also used in multiple regression analyses to find that high school performance in science classes adequately predicted college performance in the online biology class.

Trawick (1992) and Wang (2013) investigated SCT to understand motivation and volition strategies for underprepared community college students. Wang (2013) employed SCT along with a multiple-group structural equation model to investigate the motivations behind recent high school students' decisions to major in a STEM field at post-secondary institutions. Initial results showed that high school math achievement, exposure to math and science courses, and math self-efficacy influenced these students' choices. The results from the structural equation model analyzed these influences based on gender, race, and socioeconomic status. Their results demonstrated a high variability among gender and racial groups in the choice of STEM majors.

Interest. Findings from Glenn (2013) and Wang (2013) may help college faculty to promote STEM education and motivate students to major in STEM-related fields. Their research studies addressed the lack of interest in science-related careers found in first-year students in higher education and ways to remedy this problem. Cowan and Piepgrass (1997) utilized a mixed-methods approach that focused on examining the influences of anxiety and boredom on non-science majors at an open admission, two-year branch of Miami University. First, anxiety and interest scores were found to be negatively correlated with exam scores of non-science-major students. Reasons for anxiety among these students included self-reported low levels of preparedness. Responses from these students about perceived lack of preparation included "I'm bad in science", "I have test anxiety", and "I've heard this [science] class is hard" (Cowan & Piepgrass, 1997, p. 10). Then, the open-ended survey questions revealed that students desire clear and relevant instruction to help them reduce science anxiety and increase their interest in science. For example, they expressed the need for science instructors to use basic, understandable terms and to put "science in [a] context" (p. 9) that is relevant to students.

Students also believe that instructors could relieve anxiety and increase interest if they utilized scientific knowledge that students already know (Cowan & Piepgrass, 1997). For instance, instructors could use pre-tests and life experiences to engage students in science, which can be done through dialogue education's LNRA. These results also matched other studies in science education that support increased engagement and context for improved student success (e.g., Leonard, 1997). Generally, the studies in this section suggest that placing scientific content into the lives of students can reduce anxiety and increase intrinsic motivation, interest in science, and student engagement in science-related courses.

Engagement. As shown above, engagement is connected to motivation, interest, and learning. Traditionally, student engagement research has focused on time-on-task behaviors both within the classroom and as part of campus-wide activites. Natriello (1984) defined engagement as "participating in the activities offered as part of the school program" (p. 14). Lancaster (2014) describes student engagement as "both qualitative (effort) and quantitative (time)" (p. 21). His definition includes academic, social, extracurricular, and interpersonal experiences. Alternatively, Chapman (2003) defined engagement as being centered on a student's use of "cognitive, meta-cognitive, and self-regulatory strategies" (p. 2). These engagement indicators included motivated behaviors to learn concepts on a deeper level (versus simply memorizing content), and to persist in learning by self-regulating behavior (Pintrick & De Groot, 1990).

Increasing student engagement outside of the classroom is difficult for many students at community colleges, especially for those who are working full-time and have family obligations (Lancaster, 2014). While engagement in the classroom can be controlled mostly by the instructor, the motivation of these students to become involved in campus-wide activities, which has been shown to lead to success and persistence, can be challenging in a community college environment due to time constraints of balancing work, school, and family (Hanson, Drumheller, Mallard, McKee, & Schlegel, 2011). Therefore, faculty consider the classroom as the most important setting to engage community college students (Lancaster, 2014).

Based on the work of Skinner and Belmont (1993), student engagement includes three primary domains: cognitive, affective, and behavioral. Cognitive engagement refers to a student's investment or willingness to learn complex ideas (Fredricks, 2011). Students who are cognitively engaged are challenged academically by learning but not discouraged or disinterested in the face of a difficult task. In fact, students may be willing to work harder to understand complex ideas and acquire multifaceted skills. Time may pass quickly when they are mentally engaged in a learning event. Affective engagement in learning is linked to emotion, such as interest or excitement (Fredricks, 2011). Students who are affectively engaged find learning relatable and meaningful, whereas students not affectively engaged may be bored, disinterested, or even anxious. Students who are both cognitively and affectively engaged may not be easily distracted by factors outside of a learning activity (Chapman, 2003). They may exhibit high interest in the topic and a strong motivation to learn. Highly engaged student may feel a sense of belonging in the classroom and value classroom time (Fredricks, 2011).

Behavioral engagement is the third domain that links to students' participation in learning-based activities in both classroom and out-of-classroom activities (Fredricks, 2011). Lane and Harris' (2015) research on behavioral engagement in science education in large lecture halls reported that "students learn best when they are actively engaged and can therefore deeply encode material" (p. 83). This supports Vella's (2008) claim that dialogue education through learning tasks increases student engagement and, therefore, learning. Being actively engaged is especially necessary during long, lecture-based classes because students may lose concentration over time or become distracted by other things besides learning.

Although some studies focus only on a subset of these domains for assessment purposes (e.g., the focus on assessing behavioral engagement in Chapman, 2003), most educational research shows that engagement is multidimensional with cognitive and affective domains intrinsically linked. At the same time, Fredricks (2011) found student engagement indictors not necessarily consistent among all three domains. For example, some students were highly engaged within the behavioral domain but not in the cognitive or affective domain. Additional research also shows the importance of teacher interaction and interaction among students, both of which are advocated in dialogue education, as important predictors of student engagement. Guthrie and Anderson (1999) explain that “social interaction patterns in the classroom can amplify or constrict students’ intrinsic motivation, their use of self-regulated strategies, and their attainment of deep conceptual knowledge” (p. 20). Thus, the various domains of engagement, cognitive, affective, and behavioral, are closely tied both to each other and to motivation and learning.

Meteorology Educational Studies

Studies on students learning meteorology are rare but have been published by university professors who conduct educational research in the classroom. These studies have implemented a wide range of research designs to find common theories and suppositions about student learning and engagement. The studies discuss active learning, field-based research, peer-collaboration, and online resources within meteorology curricula. Although not explicitly stated, most of these studies point to the use of constructivism and experiential learning as the primary learning theories.

Active learning. Much of the literature in meteorology education is focused on utilizing hands-on, active learning techniques for teaching meteorological concepts (Barrett & Woods, 2012; Grenci et al., 2008; Grundstein et al., 2011; Richardon, Markowski, Verlinda, & Wurman, 2008; Yarger, Thomas, Boysen, & Pease, 2003). For example, in a laboratory course in Grundstein et al.’s (2011) research, the students acted as professional meteorologists who were in charge of developing forecasts for severe weather. Through these forecasts, they also learned how to analyze atmospheric conditions that lead to severe weather conditions. Having students engaged in this type of laboratory exercise made them active participants in learning. As a result, the students were "given a sense of relevance, which in turn can help promote student engagement and learning" (p. 23). Through the measurement of student learning outcomes within an expermimental design, these researchers found a significant increase in student interest and learning in the experimental group due to the active learning exercises compared to the control group.

Quardokus, Lasher-Trapp, and Riggs (2012) described a similar undergraduate research laboratory course developed for sophomore-level meteorology students. The goal was to provide extensive experience in authentic research at an early stage of these students' undergraduate careers. In the past, these courses had only been available to juniors and seniors. However, having experiences early on helped students not only to understand atmospheric science, but also to become more comfortable with research. As with the research conducted by Grundstein et al. (2011), students conducting actual research significantly enhanced the learning of atmospheric concepts, and students felt more confident about conducting additional research in the future.

Field-based learning. As part of the quest for active learning, many studies in meteorology education have utilized field experiences (e.g., Barrett and Woods, 2012; Quardokus et al., 2012; Richardson et al., 2008). These studies not only increased retention but also motivated students to become more involved in the learning process. For example, Barrett and Woods (2012) described the use of field experiences in conjunction with classroom learning for students to understand the processes of severe weather more thoroughly. They noted that "recent studies have shown that undergraduate students understand scientific principles through field experiences" (p. 316). While in the field, students were able to see the damage of the devastating tornado that hit Joplin, Missouri in 2011 firsthand. According to Barrett and Woods

(2012), the visit to this traumatized town helped students recognize the societal impacts of accurately forecasting severe weather, which motivated students to understand why learning about severe weather was important.

Barrett and Woods (2012) used pre- and post-tests to measure enhanced knowledge in meteorology-related subjects and careers as a result of their field-based exercises. The learning outcomes revealed statistically significant results in enhanced learning of atmospheric concepts, which helped solidify the authors' argument that fieldwork that includes active learning and the scientific method improves student learning and success. The qualitative survey results conducted in conjunction with the pre- and post-tests also showed improved understanding and more solid career goals in meteorology.

Richardson et al. (2008), researchers at Pennsylvania State University and the Severe Weather Research Center, took undergraduate and graduate meteorology students on a mobile radar research mission across Pennsylvania and Ohio. These students enrolled in a sequence of field-based research courses and were able to get hands-on experience with mobile radars. Like the research activities conducted in Barrett and Woods' (2012) study, these results showed the need for active learning and other hands-on exercises for studying the atmosphere. Since the Pennsylvania landscape is complex with added effects from Lake Erie, rain and snow systems are highly variable. Therefore, students not only learned how to use radar in the field, but they also better understood the effects of ground features on small-scale weather systems in this area. Not only did they find this experience challenging and rewarding, but they were also encouraged to learn more and to enroll in additional field-based research courses.

Teamwork. Another common theme in the literature that helped motivate students to learn meteorology was teamwork (Grundstein et al., 2011; Yarger et al. 2003; Quardokus et al., 2012). This concept nicely aligns with dialogue education's social contextual framework. The students in Grundstein et al.'s (2011) study were placed into teams to work on projects. This type of cooperative learning put pressure on all students because each student was held accountable for doing a part of the project. Through forecasting and other inquiry-based exercises, the students not only learned about atmospheric phenomena conducive to severe weather, but they were also motivated to collaborate with team members.

Teamwork in the research of Quardokus et al. (2012) was found in peer collaboration along with organically formed learning communities. Because the exercises did not follow a rigid format, as some laboratory courses mentioned in Grundstein et al.'s (2011) study did, there was a need to learn from other students. These authentic, real-world research projects helped students form relationships and learning partnerships during times when learning was difficult. For example, each laboratory module was introduced using the traditional presentation of concepts and the strategy of instructional scaffolding. Scaffolding provided students extra support in the beginning of a module that was gradually removed once students began to master the module's concepts and skills. The students then completed modules in a nonlinear way, much as a real researcher would. To assess student learning, Quardokus et al. (2012) utilized qualitative methodologies, such as interviews and surveys, modeled after science education research within the fields of chemistry and biology. Themes from these results included the success of the scaffolding structure of the course, peer collaboration within learning communities, and motivation to complete research aligned with future career goals. These results were then more fully implemented in future meteorology courses.

Online resources. In addition to active learning and teamwork, online components have also been useful for enhancing the learning of meteorological concepts. Yarger et al. (2003)

discussed how computer-simulated tools enhanced learning in a meteorology course at Iowa State University. These tools, which included problem-based learning simulations for introductory-level material, led to a better grasp of meteorological concepts, as opposed to simply disseminating knowledge in a traditional lecture format. Problem-based learning has also been successful in many science educational studies that focus on constructivism-based learning theories (Czabanowska, Moust, Meijer, Schroder-Back, & Roebersten, 2012).

In 2002, Grenci et al. (2008) began to offer online weather forecasting courses and certificates at Pennsylvania State University to adult learners from a variety of backgrounds and careers. This program caters to adults who cannot attend on-campus classes but need or want forecasting skills for hobbies or career purposes. According to Grenci et al. (2008), these students performed well on a national weather forecasting challenge and on other real-world forecasting activities after completing the program. The authors linked the results to the dedication of the adult students to the program and to the interactive and dynamic online texts, discussions, and resources used in each course. In addition, allowing students to participate in actual forecasting in the capstone course led to enhancing skills effectively with a tactile approach. Although the student population of this program was generally older than the more traditional students from the aforementioned research (e.g., Barrett and Woods, 2012; Quardokus et al., 2012; Richardson et al., 2008), Grenci et al.'s (2008) study offered additional support for hands-on, active learning in meteorology, even within an online environment. These notions of active learning online are also supported by Vella (2008) who advocates the relevance of dialogue education in virtual classrooms.

Natural Science Education in Community Colleges

Since there are no published studies on meteorology education at community colleges, it is useful to explore other natural science educational studies conducted at two-year schools. In this section, I first discuss active learning and constructivism-related techniques, basic skills, and anxiety and motivation factors found in community college classrooms. In addition, some of these studies, especially those focused on basic skills, were conducted on non-science-major students. An important distinction between science educational research at universities and studies in community colleges is the need to build basic skills for student success in science courses at the community college.

Constructivism-based learning. There have been a number of educational research studies that support the application of social constructivist learning theories in geoscience and related natural sciences courses at the community college level (e.g., Bentley, 2009; Phillips, 2006; Wenner, Burn, & Baer, 2011). As an example, Steer, McConnell, Gray, Kortz, and Liang (2009) support active learning in their study, which examined student learning and related pedagogy for an electronic personal response system that required peer interaction in a geoscience course. Steer et al.'s (2009) study utilized a quantitative design with pre-and post-tests along with closed-ended surveys to gauge the amount of learning from the peer-instruction response exercises. The response patterns revealed that across all demographics and genders, students benefited from interactive, peer-instruction-based methods. These results support the argument that instructors should use a variety of active learning techniques in science classrooms.

In addition to implementing active learning in the classroom, Bentley (2009) utilized fieldwork to enhance student learning, similar to what was done in meteorology education studies (e.g., Barrett & Woods, 2012). His work discusses the assessments of student learning and performance during two field trips for his introductory-level physical geology course. To help students build conceptual and problem-solving skills for understanding physical geology, he had them visit areas with multiple rock types to evaluate their performance on linking course content to real-world phenomena within the field of geology. By using qualitative, observational techniques to study student performance in the field and interviewing students after the field trips, Bentley noted increased knowledge of and interest in both geologic principles and problem-solving skills. These studies on active learning within both meteorology and other natural sciences support Leonard's (1997) argument that "it is becoming clearer in educational research that learners who are actively engaged in the learning process are the most successful" (p. 11).

Basic skills at community colleges. Specific learning needs also exist at the community college level, including the development of basic skills, study skills, and time management skills (Huffman-Kelley, Perin, & Liu, 2015). Basic skills at community colleges are commonly defined as college-level math, science, reading, and writing skills. Professors of these entry-level science courses often notice that students either do not buy or read textbooks. Phillips (2006) points out that "one of the many skills that is needed for success in college is the ability to quickly locate and identify information from textbooks or other reference materials" (p. 575). To aid community college students in learning scientific concepts and building these skills, Phillips (2006) conducted a study focused on reading skills for an entry-level biology class. The goal was to gauge the increase in reading and study skills using open-book tests. These researchers found statistically significant improvements in textbook reading from open book exams, as well as significant improvements in study skills for exams given at end of the course. Phillips (2006) also noted more significant improvements for students who originally exhibited weaker study and reading skills in the beginning of the course.

Wenner, Burn, and Baer's (2011) paper discussed using online math modules to build quantitative skills used in introductory geoscience courses at both community colleges and universities. They used an explanatory mixed-methods design to analyze the effects of these modules. For example, the math tutorials were assigned just before a quantitative exercise was introduced in a geoscience course. Pre- and post-test scores were used to show an increase in quantitative skills in the students who completed these online math modules. Then, survey and interview responses were collected to compare with the test score data. These results also showed that students had strengthened their quantitative skills as a result of online math modules. The various types of data illustrated a promising way to teach quantitative material in a geoscience context. In addition, this research showed statistically significant results that students are better motivated to learn math when the skills are immediately necessary for a science problem at hand. Thus, for meteorology courses in community colleges, not only may constructivism be key to motivation and student success, but building basic skills may also be crucial to ensure that students fully understand meteorological concepts.

Anxiety at community colleges. Cowan and Piepgrass (1997) discussed additional community college isues, such as the lack of preparation for college-level science, which can induce anxiety. Math anxiety can be a major roadblock to learning science, especially if students do not have the adequate preparation for math. In addition, non-traditional adult students (those over the age of 28, as defined by Bye et al., 2007) may feel overwhelmed in science courses, since some of them have been out of school too long to retain skills they need to succeed in science (Hobson, 2000). To help alleviate these issues in science courses at community colleges, not only should instructors employ learning theories that best suit these students, but they must also understand what prevents some students from finding science interesting and approachable.

In addition to active learning and basic skills, common issues discussed in the literature include overall anxiety and the related lack of motivation to enroll in and complete introductory science courses at the community-college level (Cowan & Piepgrass, 1997). Some of these issues may be related to the instability of young adults' experiences of emerging adulthood (Arnett, 2006). Leonard (1997) posited that many students early in their undergraduate careers are concrete thinkers, making the learning of abstract scientific concepts anxiety-producing. However, Phillips (2006) noticed that implementing open-book exams encouraged students to read and understand biological concepts, which sparked student-led, impromptu discussions about these concepts in the classroom. These discussions involved interactive dialogue that generated enthusiam about the textbook and motivated students to view the textbook as a valuable resource for studying the course material.

In addition, math anxiety can be a major roadblock to learning science, especially if students do not have the adequate preparation for math. To address this issue, Wenner et al. (2011) found that it was helpful to present math skills to students when they were needed to solve problems. With online math modules, student perceptions of the usefulness and relevance of the quantitative material improved motivation (Barkley, 2010; Wigfield & Eccles, 2002). Overall, instructors must understand the anxiety-related roadblocks and skills deficits that prevent some students from succeeding in science courses.

Summary

This chapter highlighted the literature that supports social learning theories in adult education; dialogue education; relationships between motivation, interest, and engagement in science education; and primary learning theories found in research conducted in meteorology education in universities and natural science education in community colleges. Social cognitive theory focuses on individual learning within social contexts, as well as the relationships between self-efficacy, learning by observing others, and motivation (Bandura, 1999). Situated learning is centered on the social interactions among learners and environments (e.g., workplace environments) in which learning takes place. These theories also align with social constructivism, which posits that learning is enhanced when adults make meaning out of new content within social situations (Kim & Merriam, 2010; Vygotsky, 1978). In addition, social learning theories utilize experience as a key feature in motivating students to learn and become engaged with new content (Jarvis, 2006). Discussion of dialogue education illustrated its emphasis on social settings and experiences to help students learn in a deeper, more meaningful way. The foundation of this approach intersects adult learning principles, social learning theories, and engagement concepts (Vella, 2008). As a result, dialogue education may offer new opportunities to improve meteorology education in community college classrooms.

Since learning is intrinsically integrated with engagement, interest, and motivation, a discussion of these concepts followed the adult learning sections. More specifically, motivation and interest were analyzed for the purposes of science education in both universities and community colleges. According to Barrett and Woods (2012) and Lane and Harris (2015), interest levels are strongly correlated to intrinsic motivation and classroom engagement. Congitive, affective, and behavioral domains of engagement are commonly found in college science classrooms.

Studies of meteorology education in universities and natural science education in community colleges also explored social learning theories and engagement, with a focus on the internal motivational strategies that enhance the learning of non-science majors in science classes (Barrett & Woods, 2012; Phillips, 2006). Science educational studies in community college focused on unique challenges, such as building basic skills and helping students overcome anxiety related to learning science.

Chapter 3: Research Design and Methodology

Introduction

This chapter focuses on the research design and methodology that answer the following question: What is the impact of dialogue-based group learning on student learning and engagement in community college meteorology education? A quasi-experimental design with a mixed methods approach was used and is discussed in this chapter. This experimental approach included a control group based on lecturing and a treatment (or experimental) group based on dialogue education. Pre- and post-tests along with follow-up surveys constitute the research tools used to collect data to address the primary research question. These tools included both closed- and open-ended questions.

Much of the research on natural science education utilizes quantitative methodologies for understanding what and how students learn about scientific concepts. This preference may be tied to the perceived rigor of these studies by the scientific community. Perhaps because many of these studies are conducted by scientists who mostly utilize quantitative methods, postpositivistic research also seems to be the dominant paradigm for science education research. However, one drawback to using numerical data exclusively is that one may not see the full picture of learning. At the same time, a growing number of qualitative and mixed methods studies is adding new perspectives on learning theories as they relate to science education. These methods nicely complement the heavy quantitative focus of science education research, as Creswell (2003) states that a "researcher can gain broader perspectives as a result of using the different methods as opposed to using [a] predominant method alone" (p. 218).

For example, Barrett and Woods (2012) employed a quasi-experimental approach to measure enhanced knowledge and interest in meteorology-related subjects and careers as a result of constructivist and field-based exercises. In addition, they used student essays in conjunction with pre- and post-tests to assess improved understanding of and interest in meteorology concepts and career options. Wenner et al. (2011) discussed the use of online math modules to build quantitative skills used in introductory geoscience courses at both community colleges and universities. They used an explanatory mixed-methods design to analyze the effects of these modules. Pre- and post-test scores were used to show an increase in quantitative skills in the students who completed online math modules. Survey and interview responses were then collected to compare with the test score data. One of my goals for this study was to use multiple sources of data within a quasi-experimental design to assess the impact of dialogue education on student learning and engagement.

Quasi-Experimental Design and Plan

The specific quasi-experimental design for my research was the pre-post, nonequivalent control group approach, where the pre-test helped establish similarities between the two groups in lieu of random assignment (Stufflebeam & Shinkfield, 2007). The pre-test accounted for differences in the groups and assisted in analyzing post-test results. Follow-up engagement and perceived learning surveys were also included and contained both open- and closed-ended questions to compare with and complement test results. While this research design was primarily quantitative, with emphasis on the numerically-based interest and learning questions in the pre- and post-test, the survey included both quantitative and qualitative data.

Since random sampling is difficult and impractical in educational settings, quasi-experimental approaches are more commonly used (Cook & Campbell, 1979). The primary difference between the experimental and the quasi-experimental is that the latter does not rely on random sampling (Cook & Campbell, 1979; Stufflebeam & Shinkfield, 2007). Participants do not have an equal chance to be a part of the control or treatment groups. In fact, proponents of the quasi-experimental design claim that it has stronger external validity than the strict experimental design because the former has fewer restrictions on the experiment, and the experiment occurs in natural settings (e.g., Cook & Campbell, 1979).

The design of this study included two groups: one that had been exposed to the dialogue-based approach (experimental) and another that had been exposed to a lecture-based approach (control). Since I was assessing the impact of dialogue education within meteorology, and the common mode of teaching scientific concepts is through lecture (Wieman, 2007), the lecture-based approach was used as the control. Both approaches were centered on severe weather (i.e., thunderstorms, tornadoes, and hurricanes – see Appendix A for student learning outcomes). The severe weather events sparked interest in students during a pilot study and have been topics of student interest throughout my seven years of teaching meteorology. These events are also examples of extreme weather that may increase in frequency as the climate warms (Ray, 2014).

Due to the scheduling of courses, institutional constraints, and the limited time that instructors could provide, the timeframe of the experimental and control approaches was restricted to a fixed period of time (one hour and 25 minutes). This timeframe accounted for the signing of consent forms, the pre-test, one of the two approaches, and the post-test. In order to navigate perceived issues of power over students because I was an instructor who assigned grades, this research was conducted during two courses taught by a different instructor.

Dialogue approach. In this approach, dialogue education principles, namely respect, open questions, engagement, and relevance, were highlighted. Respect was emphasized in the form of the learning needs and resource assessment (LNRA), where I asked students to provide me with prior knowledge and experience to help tailor the learning event around the learners

(Vella, 2008). I also focused on open questions to build deeper learning and to invite dialogue. Questions with closed answers tend to elicit short responses and minimal engagement. Active engagement was also key in my design as I asked students to participate in activities and group learning events. The idea of relevance was implemented by emphasizing the need for students to learn about severe weather due to the impacts of climate change and the possibility of a major El Niño event in the near future.

Dialogue-based group learning tasks typically include four steps (Vella, 2008):

1. Induction: Connects the learning task and content to the learners' life experiences (usually through a group activity)
2. Input: Provides the new content in a dynamic and relevant manner
3. Implementation: Asks the learners to work on group activities in class that are linked to the subject content
4. Integration: Allows the learners to take the content home with them and apply it to their lives in some way

During the induction step, students form small groups and think about how the fundamental concepts of the task may be connected to their lives (Vella, 2008). For my research, students formed groups and discussed what they already knew about severe weather and related atmospheric processes. They then shared some of their answers with the rest of the class. During the input step, students are introduced to the content of the task through a presentation or demonstration. For this step, a lecture was presented on severe weather (e.g., thunderstorms, tornadoes, and hurricanes) using PowerPoint. During the implementation step, students typically apply what they have learned in a group-based activity. After the lecture, students returned to their groups to answer additional questions and discuss how severe weather might relate to them (see Appendix B). The integration step usually occurs outside of the classroom. Therefore, this part was not included in the study.

Lecture approach. For the lecture approach, the same slides as in the dialogue education method were shown, but additional material was added to the lecture that addressed the same content so that the length of the lecture matched that of the dialogue approach (45 minutes). This lecture offered the same explanation of research and completion of the pre-test as the dialogue approach, but it did not give students the opportunity to apply the new knowledge during in-class group activities. The same student learning outcomes (SLOs) were addressed in both approaches, but the format of delivery differed. The goal was to assess eventual differences in students' learning and engagement between the approaches.

Data Collection Tools

Pre- and post-tests. The pre-test included the same questions as the post-test, except the pre-test asked students to develop an alias and indicate self-identified gender, age, major, grade point average (GPA), the number of semesters in community college, and whether English was their first language (see Appendixes C and D). The alias was used to match the pre-tests with the post-tests. Information on self-identified gender, age, major, GPA, and the number of semesters in community college helped establish similarities between the experimental and control groups as well as a better understanding of the exam results.

In both the pre- and post-test, I first assessed students' interest levels in severe weather conditions. This assessment helped determine the level of motivation that a student may have had to complete the tests and whether interest levels increased after a particular learning approach. These questions were designed based partially on student interest inventory questions in Barrett and Woods' (2012) research. According to Barrett and Woods, a higher level of student interest may lead to more engagement and higher learning. Then, I assessed retention and application of knowledge in both approaches by using three open-ended, short-essay questions about severe weather events centered on the SLOs. I chose only three questions because students were limited to 15 minutes to complete the tests. I also chose open-ended questions in order to assess the ability of students not to only retain knowledge (which they may have been exposed to in a lecture) but also to apply the knowledge that they gained. The assessment of these questions helped determine if there was a difference between the dialogue-based and lecture-based approaches in helping students learn and apply new knowledge and skills.

Surveys. The second part of the study included a survey for both groups of students to complete regarding their learning events (see Appendix F). Due to the limited time during the learning event, these surveys were conducted during the beginning of the next class period. This survey assessed engagement and perceived learning and application of knowledge. The engagement questions were placed in the survey to encourage students to spend more time on their answers, as well as to complement the questions regarding interest in the pre- and post-tests. There was space for students to explain their answers to the engagement questions so that I could understand more fully why they chose their answers.

The engagement questions in this survey focused on the cognitive and affective domains of engagement and were partially based on task-level engagement as explained in Lee's (2012) paper (questions one through five of survey in Appendix F). Cognitive engagement refers to a student's investment or willingness to learn complex ideas, while affective engagement is an emotion linked to learning, such as interest or excitement (Fredricks, 2011). Students who are cognitively engaged are challenged academically by what they are learning but not discouraged or disinterested when faced with a difficult task. These traits can also lead to affective engagement, especially when learning is interesting and meaningful. Students who are both cognitively and affectively engaged may not be easily distracted by factors outside of a learning activity (Chapman, 2003). They may exhibit high interest in the topic and a strong motivation to learn. Behavioral engagement is the third domain that impacts students' participation in learning-based activities (Fredricks, 2011). However, since students completed learning tasks only in the dialogue education approach, I did not directly assess this type of engagement.

The learning and application questions asked participants to assess their perceived learning and the impact of the severe weather learning event on their levels of interest (questions six and seven of survey in Appendix F). According to Vella's (2008) evaluation model, indicators of learning come from the learning event itself, while indicators of transfer are knowledge and skills that have been integrated within a learner's own context. Transfer occurs after the learning event. Since the participants were completing this survey two days after the events, I included two questions pertaining to their perceived levels of learning and application. The goal was to assess differences in answers between the dialogue-education and the lecture-based approach.

Piloting the Design

The first pilot was conducted during the Spring 2015 semester and lasted one class period (one hour and 25 minutes). This experience and the data informed my research regarding the implementation of the dialogue education framework. During the pilot, I gave students the content through handouts and a short PowerPoint slide presentation, as Vella (2008) purports that students need access to all materials that are available to complete learning tasks effectively. Indeed, I discovered that handouts were very useful in the dialogue design, since students needed to use the new content in these handouts during the group activities.

While searching for instructors at four different community colleges in southern California who would allow me to conduct my quasi-experimental design, I piloted components of the design in September and October of 2015. I first conducted the dialogue and lecture formats with two small groups of students. I validated the interest, learning, and survey questions and tested the timeframe for implementing the new design. In addition, I wanted to test the use of aliases and whether students would remember them for the pre-test, post-test, and follow-up survey during the next class period. Based on student comments, I decided to give students more freedom to choose an alias while not making the process so simple that there would be the risk of duplicate aliases.

Based on their comments, students also found me to be very animated and engaging during the lectures in both approaches. Therefore, when I conducted the lecture in the control group, I decided not to walk around the room, ask students questions, or explicitly show enthusiasm when discussing severe weather. I wanted to mimic a traditional lecture approach that placed students in a passive learning role and only encouraged one-way communication without verbal feedback (Center for Integration of Research, Teaching, and Learning, 2013). This method of lecturing was also used as a comparison in dialogue education sources, especially when considering the effects of "banking" pedagogy (Vella, 2008, p. xxii; Freire, 1972, p. 71). However, it was difficult for me not to be enthusiastic when I discussed severe weather during the actual execution of this design.

I then asked a geography instructor if I could pilot the dialogue approach in her class. This pilot included the pre- and post-test, the dialogue steps, sharing of answers, and a debriefing at the end. The results revealed that I needed to further modify the wording of the survey questions for enhanced clarity, in addition to providing more explicit instructions about the dialogue-based tasks. I also found the need to include more time for the sharing of answers in the dialogue approach and for students to ask questions during the group tasks.

Execution of Design

The official quasi-experimental design was implemented during the seventh week of the Fall 2015 semester in two sections of a physical anthropology course taught by the same instructor at a community college in southern California. Due to the availability of instructors and after some reflection, I decided that meteorology did not need to be a part of the core curriculum. The primary requirements included choosing a physical/biological science course that consisted mostly of non-science-majors who were taking the course for general education purposes.

The participating instructor taught two sections of one course during the same time period (9:35 am to 11:00 am). This time slot was ideal since I needed to control for differences in time of day. Experienced instructors have noted that the time of day a class is offered can impact the type of students who enroll. This instructor had 45 students in each section and was only available for me to conduct my research during one week in October 2015. This was the ideal week to conduct this research due to the timing of Institutional Review Board (IRB) approval processes and the fact that attendance usually drops after midterm week (the eighth week). Thus, I had a very narrow window to implement the design during this semester.

During the week prior to the event, the participating instructor told her students that a special event was going to take place that involved science educational research, adult learning in a community college setting, and severe weather as part of the geography program at the college (see Table 2). She offered extra credit and noted who was participating by taking attendance during the learning event (Monday/Tuesday) and the follow-up survey

(Wednesday/Thursday). However, she did not see the students' responses since she did not collect or review the tests or surveys. In addition, before the first pre-test was given for each group (Monday/Tuesday), written consent was obtained from the students who decided to participate in the study (see Appendix G for consent form). These students were advised that this research would not be associated with class grades. I also disclosed the usefulness of the study as an incentive, along with the fact that I had asked the instructor to offer extra credit to those students who participated. However, in order to collect better data, I did not tell students the exact purpose of my research until all tests and surveys were completed.

For the dialogue education approach, I used Survey Monkey to conduct the LNRA that was due before the learning event. The instructor emailed the survey, and I received the responses, which were anonymous (see Table 2, row 1).

The LNRA was comprised of the following questions:

1. Which type of event, thunderstorms, hurricanes, or tornadoes, interests you the most? Why?
2. Describe a severe weather event, such as a thunderstorm, hurricane, or a tornado, that has impacted you or someone you know.

I was concerned that the LNRA would bias my results. However, I wanted to honor as much of the dialogue education framework as possible, and the LNRA is an essential part of this approach. The LNRA engages the student before the learning event begins and demonstrates respect for what the students will bring to the classroom (Vella, 2008). This helps make the learning event more relevant to the learners.

Table 2 – Timeline of Design Execution

Day	Description of Activities	Participants
Thursday (prior to Day 1)	Instructor emailed students in the dialogue group an LNRA	10 participants from Tuesday/Thursday class
Day 1 (Monday)	I conducted the lecture approach in the instructor's Monday/Wednesday section of Introduction to Physical Anthropology course. Pre-test and Post-test were completed by students.	41 participants from Monday/Wednesday class
Day 2 (Tuesday)	I conducted the dialogue approach in the instructor's Tuesday/Thursday section of Introduction to Physical Anthropology course. Pre-test and Post-test were completed by students.	41 participants from Tuesday/Thursday class
Day 3 (Wednesday)	Students in the Monday/Wednesday class completed the follow-up survey during the first 15 minutes of class.	39 out of 41 participants from lecture group (Monday/Wednesday class)
Day 4 (Thursday)	Students in the Tuesday/Thursday class completed the follow-up survey during the first 15 minutes of class.	35 out of 41 participants from dialogue group (Tuesday/Thursday class)

On Monday at 9:35 am, I conducted the lesson using the lecture approach (see Table 2, row 2). There were 41 students, and I began the session by letting the instructor introduce me and my work (without giving away too many details). I then passed out the consent forms and let students read and sign them. This was followed by the pre-test, which students had 15 minutes to complete (see Appendix G). Afterwards, I lectured for 45 minutes. I used the same slides I had planned for the dialogue education approach, but I added additional ones to stretch the lecture time to 45 minutes and focused on the three established SLOs for my design (see Appendix A). I used a transmission style lecture approach without asking students questions. I had planned to answer questions that students may have had; however, no students asked any. This period was followed by the 15-minute post-test. At the end, I provided a brief overview of my research purpose without giving away any details that could have biased my results or impacted the implementation of the dialogue education approach.

On Tuesday at 9:35 am, I conducted the dialogue approach (see Table 2, row 3). There were also 41 students in this course. Again, the instructor introduced me and my work without giving away too many details. I passed out the consent forms to have students read and sign. Then, I gave them 15 minutes to complete the pre-test. Afterwards, I began my presentation with a question for students in groups of two or three to answer. This was the first part of the dialogue education framework (see Appendix B). I somewhat modified this induction step based on LNRA results. After 10 minutes, I asked two groups to share their answers about their experiences and prior knowledge of severe weather. I allowed four groups to share; many others wanted to participate but could not due to time constraints.

Next, I provided a 15-minute lecture using 23 of the 59 slides from the lecture approach. Instead of using a purely transmission approach, I asked students questions about the material (as this kind of input is common in dialogue approaches). However, no students asked questions. Then, for the third step (implementation), I asked them to go back to their groups and answer three questions related to the material presented (Appendix B). Many students used the handouts I had given them (the PowerPoint lecture slides) while they worked in the groups. Some did not work in a group and did not participate. But, overall, there was quite a bit of dialogue. Then, I called on three groups to share their answers about severe weather. Several groups wanted to share, but, again, I only had enough time for three. Finally, students completed the 15-minute post-test, and I gave them a little more information about what I was doing, being careful not to bias the upcoming survey results.

On Wednesday, I conducted the 15-minute survey in the lecture group (see Table 2, row 4). Thirty-nine students participated. I mentioned that a full debriefing would be available the following week. On Thursday, I conducted the 15-minute survey in the dialogue group (see Table 2, row 5). Thirty-five students participated. I also mentioned that a full debriefing would be coming soon. This group applauded me before I left; the control group did not applaud.

Summary

This chapter discussed the quasi-experimental design with a mixed-methods approach in assessing the impact of dialogue education on student learning and engagement. This research design involved pre- and post-tests and follow-up surveys in both the lecture and dialogue-based groups. The lecture approach consisted of a 45-minute lecture, while the dialogue approach included group activities that took place before and after a 15-minute lecture. Both groups completed pre- and post-tests within one class period (one hour and 25 minutes), along with a follow-up survey at the beginning of the following class period (two days later). The tests included quantitative interest and learning questions, while the survey examined engagement and perceived learning and application questions that were both open- and closed-ended.

Chapter 4: Analysis and Presentation of Findings

Introduction

Findings from this study are provided and discussed in this chapter. While results are analyzed and presented here, full interpretations are not provided until the next chapter. The quantitative results from the pre- and post-tests, including student information and demographic data, are analyzed and presented first. The closed-ended survey results were analyzed statistically. The statistical tests run to assess differences in the two groups include one-way analysis of variance (ANOVA) and effect size.

The open-ended survey questions were analyzed using qualitative methods. Themes were developed using a template analytical approach, along with editing approaches to allow for more interpretive and flexible coding (Bloomberg & Volpe, 2012). Codes were created and collapsed into themes by using a "winnowing process" (Guest, MacQueen, & Namey, 2012). A sequential explanatory mixed-method approach was used to integrate results from the closed-ended questions with the qualitative results.

Pre- and Post-Test Analysis and Results

Analysis methods. There are four primary tests that can be run to find statistically significant results in quasi-experimental designs (Cook & Campbell, 1979). The ANOVA is the simplest method that determines the mean of post-test scores, the treatment effects, and the residuals which account for other factors that contribute to the differences in post-test scores. This statistical method does not account for pre-test scores, nor does it take into account differences in characteristics among individuals. However, the analysis of covariance (ANCOVA) with a single covariate includes the pre-test scores by way of linear regression. The effect of the treatment is investigated through both the pre-test and post-test results. The estimated treatment effect is the difference between the predicted post-test scores that have been matched with individual pre-test scores. The ANCOVA test can also include multiple pre-tests with multiple covariates, which can further illuminate initial group differences (Trochim, 2006).

Alternatively, ANOVA with gain scores investigates the differences in pre-test and post-test results. This is similar to the first ANOVA test noted above except that the gain score is the dependent variable. For this research, I focused on the gain score analysis because the goal was to assess how interest and learning changed in both the treatment and control groups. Gain scores also provide the most direct evidence of the effect of dialogue education versus lecture-based instruction.

Table 3 - Mean and Standard Deviation for Numerical Demographic Data.

		N	Mean	Std. Deviation (s.d.)
Age	Lecture	40	20.6	4.40
	Dialogue	41	20.6	6.40
Gender (proportion of females)	Lecture	40	0.625	0.49
	Dialogue	41	0.634	0.49
Number of Semesters in Community College	Lecture	41	3.50	2.00
	Dialogue	41	3.20	2.10
GPA	Lecture	39	3.10	0.52
	Dialogue	40	3.20	0.39
Proportion with English as First Language	Lecture	41	0.41	0.50
	Dialogue	41	0.83	0.49

Student information and demographic data. Because my participants were not randomly selected, I needed to understand both the similarities and differences between the groups. The pre-test may not have accounted for variables not tested (Gersten, Baker, & Lloyd, 2000). Thus, understanding the selection process and other characteristics of the groups is crucial for analysis of the treatment effect. Once I matched the pre-tests with post-tests based on the provided identifiers, I entered the numerical data (i.e., gender, age, GPA, the number of semesters in community college, and whether English was a first language) into the Statistical Package for Social Sciences (SPSS) software to calculate the average and standard deviation (see Table 3). I ran one-way ANOVA tests to determine if any statistically significant differences existed between the groups (see Table 4). There were a total of 82 participants – 41 students in each group. However, as indicated by N in Table 3, not every student answered each question.

In the lecture group, the average age was 20.6 (n = 40), the average number of semesters in community college was 3.5 (n = 41), and the average GPA was 3.1 (n = 39). This group included 25 women (62.5%) and 15 men (37.5%), and for 41% of these students, English was their first language. In the dialogue group, the average age was also 20.6 (n = 41), the average number of semesters in community college was 3.2 (n = 41), and the average GPA was 3.2 (n = 40). This group included 26 women (63.4%) and 15 men (36.6%), and for 83% of these students, English was their first language.

Table 4 - One-Way ANOVA Results for Student Demographic Data and Information.

	F	*p* (two-tail)
Age	0.001	0.997
Gender	0.007	0.933
Number of Semesters in Community College	0.349	0.557
GPA	0.189	0.665
English First Language	**17.9**	**0.001**

Note: Bold values indicate statistically significant results with a 95% confidence interval.

The ANOVA F test (denoted as “F” in Table 4) evaluates differences between groups and determines whether the difference in means of two groups is statistically significant. This significance is denoted as *p* in Table 4 with a confidence interval of 95%. For example, if the *p* is 0.05, then the probability that the differences in means between the two groups are due to chance is 5% (Salkind, 2010). For age [$F(1,79) = 0.001$, $p = 0.997$], gender [$F(1,79) = 0.007$, p =

0.933], number of semesters in community college [$F(1,80) = 0.349$, $p = 0.557$], and GPA [$F(1,77) = 0.189$, $p = 0.665$], there were no statistically significant differences between the two groups. However, for English as a first language [$F(1,80) = 17.9$, $p = 0.001$], there was a statistically significant difference between the lecture and dialogue groups. This effect will be explored later in the learning questions that required essay writing to see if the ability to write in English had an effect on the results.

Table 5 – Major for each student in lecture and dialogue groups.

Major	Lecture	Dialogue	Major	Lecture	Dialogue
Accounting	1	4	History	1	3
Anthropology	**0**	**4**	Hospitality	0	1
Architecture	1	0	Journalism	0	1
Art	1	0	Kinesiology	1	0
Automotive	0	1	Liberal Studies	1	0
Biology	**1**	**2**	**Nursing**	**3**	**4**
Business	4	2	Psychology	2	3
Child Development	1	4	Public Relations	1	0
Communications	3	1	Social Work	1	0
Computer Science	0	1	Sociology	7	3
Criminal Justice	2	1	Speech-Pathology	1	0
Dentistry	**0**	**1**	Sports Management	1	0
Economics	1	0	Undecided	5	5
Engineering	**1**	**0**	Women's Studies	1	0
Film	1	0			

Note: Bold indicates natural/physical science majors.

I also looked for any discernible patterns among majors to find significant differences between groups. Table 5 shows the majors indicated by students in each group. There were a variety of majors in both groups without obvious, distinguishable patterns or differences between them. The majors in bold indicate students who were science majors. Approximately 82% of students in the lecture group were non-science majors, while 73% of students in the dialogue group were non-science majors. The increase in science majors in the dialogue group is partly due to the four anthropology students. Anthropology can be considered both a social and a physical/biological science depending on the specific area of study. A specialty was not indicated in the pre-test.

Interest questions. There were 41 responses per group for the interest questions. These questions were rated on a Likert scale from 1 to 10. Table 6 shows the mean and standard deviation values for gain scores between the pre-test and post-test for each interest topic. The information in parentheses is a reminder of the questions. Gain scores calculate the differences between the pre-test scores and the post-test scores. For example, if a student rated a 4 for interest in hurricanes in the pre-test and then rated a 10 for interest in hurricanes in the post-test, the gain score would equal 6. These scores are sometimes called change scores because a positive gain does not always result.

Table 6 - Mean and Standard Deviation of Gain Scores for the Interest Topics.

Interest Questions		N	Mean	Std. Deviation (s.d.)
Topic 1 (*Severe Weather*)	Lecture	41	0.37	1.99
	Dialogue	41	0.20	1.12
Topic 2 (*Atmospheric conditions that form severe weather*)	Lecture	41	0.34	1.76
	Dialogue	41	0.61	1.39
Topic 3 (*Thunderstorms*)	Lecture	41	-0.07	1.75
	Dialogue	41	0.05	1.41
Topic 4 (*Tornadoes*)	Lecture	41	0.10	2.05
	Dialogue	41	0.66	1.82
Topic 5 (*Hurricanes*)	Lecture	41	0.05	2.28
	Dialogue	41	1.10	2.11

Table 7 shows the one-way ANOVA results for differences in the interest gain score data between lecture and dialogue groups. Question 5 [$F(1,80) = 4.65$, $p = 0.017$] was statistically significant with a 95% confidence interval. Since the 95% threshold is used throughout the study, only Question 5 is considered statistically significant (see bold figures in Table 7).

To understand how large or meaningful statistically significant differences are, effect sizes are calculated to measure the magnitude of the treatment effect, also known as practical significance (Salkind, 2010). Effect size evaluates statistical significance by investigating the "separation between the distributions that represents each group" (p. 197). This separation is in terms of standard deviation units for each group. It is calculated by taking the difference in means between two groups and dividing it by the standard deviations of the groups (assuming that the standard deviations of the two groups are relatively equal). When the standard deviations of two groups are not equal, then both standard deviation values are included in the calculations (University of Colorado, Colorado Springs (UCCS), 2000).

Table 7 - One-Way ANOVA results for interest gain score data.

Interest Questions	F	*p* (one-tail)
Topic 1	0.22	0.318
Topic 2	0.58	0.224
Topic 3	0.12	0.365
Topic 4	1.70	0.098
Topic 5	**4.65**	**0.017**

Note: Bold values indicate statistically significant results with a 95% confidence interval.

A value close to 0 means the two groups are similar and there is little difference between the set of scores (Salkind, 2010). A value of 1 means the overlap in the two distributions is 45%. Essentially, larger effect size values mean a smaller overlap between the groups. Jacob Cohen (1988) developed guidelines that categorized effect sizes into small, medium, and large. Using *Cohen's d* values, small effects range from 0 to 0.2, medium effects range from 0.2 to 0.5, and values greater than 0.5 represent large effect sizes. The effect size calculator on the UCCS website was used to take into account the standard deviations that were not equal between groups

(University of Colorado, Colorado Springs, 2000). For Question 5, the *Cohen's d* value was 0.47. This value falls in the medium effect size category.

Learning questions. The rubric in Appendix E was applied to score the learning questions on the pre- and post-tests. Table 8 includes text in parentheses for reminders of these questions. For these scores, I normalized the results by dividing each set of scores by the total range of values. This was necessary because each question had a different numerical value in the rubric. For example, since Question 1 had a gain score maximum value of 4.5 and a minimum value of -4.5, the total change score for this question was 9. I divided the score by 9 to compare it to the other learning scores. For Question 2, the gain score maximum was 4 and minimum was -4 (total range = 8). For Question 3, the gain score maximum was 3 and minimum was -3 (total range = 6). Positive values represent an increase in scores from pre-test to post-test, while negative values represent a decrease in scores. I calculated the mean and standard deviation of the scores and ran one-way ANOVA tests in SPSS (see Tables 8 and 9).

Table 8 - Mean and Standard Deviation of the Normalized Gain Scores for the Learning Questions.

		N	Mean	Std. Deviation (s.d.)
Learning Question 1 *(Choose one type of severe weather and identify three atmospheric processes…)*	Lecture	41	0.11	0.10
	Dialogue	41	0.27	0.15
Learning Question 2 *(Choose one severe weather event and list two atmospheric conditions that can lead to its development…explain why these two conditions are not commonly found in California…)*	Lecture	41	0.15	0.14
	Dialogue	41	0.30	0.14
Learning Question 3 *(Choose one severe weather type that interests you and describe three ways you can assess its hazards…)*	Lecture	41	0.06	0.12
	Dialogue	41	0.23	0.17

Note: See Appendix C or D for full questions.

Table 9 displays the one-way ANOVA results for differences in the learning questions between the lecture and dialogue groups. Questions 1 [$F(1,80) = 33.6$, $p = 0.001$], 2 [$F(1,80) = 23.6$, $p = 0.001$], and 3 [$F(1,80) = 30.1$, $p = 0.001$] are statistically significant at the 95% confidence interval. The following numbers represent the *Cohen's d* effect size: Question 1 = 1.28, Question 2 = 1.07, and Question 3 = 1.21, which are considered large effect sizes.

To account for the potential influence of English language skills on the learning question results, I ran an ANCOVA test with the total normalized gain score as the dependent variable, group as the fixed variable, and English as a first language as the covariate. This resulted in no statistically significant results [$F(1,79) = 0.473$, $p = 0.494$], suggesting that the larger number of students in the lecture group who were English language learners did not significantly affect pre- and post-test scores.

Table 9 - One-Way ANOVA Results for Normalized Gain Scores for Learning Questions.

	F	*p* (one-tail)
Learning Question 1	**33.6**	**0.001**
Learning Question 2	**23.6**	**0.001**
Learning Question 3	**30.1**	**0.001**

Note: Bold values indicate statistically significant results with a 95% confidence

Closed-Ended Survey Questions

For the surveys conducted after the learning events, I entered the 5-point Likert-scale data into SPSS to compare the closed-ended questions between approaches. I performed one-way ANOVA tests to determine statistically significant differences in engagement and perceived learning and application of content (see Table 10). Because the survey questions were only asked once (as opposed to the interest and learning questions in the pre- and post-tests), the raw data – not gain scores – were used in analysis.

Table 10 - Mean and Standard Deviation of the Survey Questions.

		N	Mean	Std. Deviation (s.d.)
Survey Question 1 *(Learning about severe weather was interesting to me)*	Lecture	39	3.38	0.71
	Dialogue	35	3.74	0.88
Survey Question 2 *(Learning about severe weather was meaningful to me)*	Lecture	38	3.08	1.02
	Dialogue	35	3.40	1.12
Survey Question 3 *(I was challenged by the severe weather learning event…)*	Lecture	39	3.41	1.09
	Dialogue	33	3.27	1.09
Survey Question 4 *(…I was distracted by things not related to the activity)*	Lecture	39	2.97	1.27
	Dialogue	35	1.69	0.87
Survey Question 5 *(…I was so absorbed that time seemed to pass by quickly)*	Lecture	39	2.64	1.06
	Dialogue	35	3.51	1.01
Survey Question 6 *(I was able to retain/remember concepts of severe weather…)*	Lecture	39	2.92	0.93
	Dialogue	35	3.89	0.79
Survey Question 7 *(I am able to apply concepts of severe weather in my life more easily due to this learning event)*	Lecture	39	2.85	0.93
	Dialogue	35	3.77	1.06

Table 11 shows the one-way ANOVA results for statistically significant differences between the lecture and dialogue groups. Questions 1 [$F(1,72) = 3.71$, $p = 0.029$], 4 [$F(1,72) = 25.50$, $p = 0.001$], 5 [$F(1,72) = 13.03$, $p = 0.001$], 6 [$F(1,72) = 22.66$, $p = 0.001$], and 7 [$F(1,72) = 15.96$, $p = 0.001$] were found to be statistically significant at the 95% confidence interval. The following numbers represent the *Cohen's d* effect size: Question 1 = 0.30 (medium), Question 4 = 1.18 (large), Question 5 = 0.84 (large), Question 6 = 1.11 (large), and Question 7 = 0.93 (large).

Table 11 - One-Way ANOVA Results for Survey Question Data.

	F	*p* (one-tail)
Survey Question 1	**3.71**	**0.029**
Survey Question 2	1.64	0.102
Survey Question 3	0.28	0.298
Survey Question 4	**25.50**	**0.001**
Survey Question 5	**13.03**	**0.001**
Survey Question 6	**22.66**	**0.001**
Survey Question 7	**15.96**	**0.001**

Note: Bold values indicate statistically significant results with a 95% confidence interval.

Open-Ended Survey Questions

I entered the qualitative responses to each survey question in Microsoft Excel. I typed the answers verbatim and organized them by alias and group type (lecture vs. dialogue). Once these were digitized, I began to develop codes (as phrases and sentences) that could summarize each response. Some of these codes matched the original comments since many comments were only one sentence long. Other codes comprised pieces of comments, especially if comments were longer than one sentence. Then, I devised a template approach to further develop codes and themes from the students' responses. Template analysis in qualitative research involves creating predetermined codes to help with the reduction and summarization of the data (Crabtree & Miller, 1992). Templates are developed after an initial read of the data and can be modified as analysis progresses (Bloomberg & Volpe, 2012). An editing approach was also used to allow the initial codes to emerge from the data and remain more flexible in case codes needed modification throughout the data analysis processes (Crabtree & Miller, 1992).

I combined all the participants' comments for the first five survey questions that asked them to explain their answers to the Likert-scale prompts. I chose to do this because each of these questions was linked to the students' level of engagement during the severe weather learning events, and answers to one question were often found in response to another (e.g., comments about interest and meaning were sometimes found in one response). I combined the responses from the last two questions of the survey since they did not ask students to explain their answers about engagement. Instead, these questions assessed perceived learning and application of knowledge.

In an attempt to reduce the students' responses into useable data, I first created codes for information that was important, relevant, or interesting in terms of student learning and engagement. I assigned a new code to a piece of data, unless that data resembled a previous code. I exercised judgment in deciding if a student's comment resembled a previous code (Bloomberg & Volpe, 2012). Then, I grouped the codes into categories based on the survey questions and the primary research question, and kept a count of the total number of comments that were a part of each code (see Table 12).

A count was created to keep track of the codes and to determine each code's frequency. This is typical for quasi-statistical processes and content analyses (Crabtree & Miller, 1992). Although this strategy was not purely content analysis, specific phrases were tallied to help determine the relative importance of concepts and findings. According to Ryan and Bernard (2003), repetition is a common strategy for theme development and is based on the idea that if phases are repeated, then they are likely part of a key theme.

I continued to collapse relevant codes and eliminate insignificant codes in a multi-phase "winnowing process" (Guest et al., 2012). This process helped create the final themes in each category (Bloomberg & Volpe, 2012). I also looked for comments and phrases that diverged from the main findings to determine their relevance to the research question. As Bloomberg and Volpe (2012) suggest, a researcher must remain cognizant not only of material that supports a researcher's opinion, but also of responses that may be surprising or "unexpected" (p. 143).

Table 12 – Primary themes found in Survey Questions 1 – 5.

Categories	Lecture Themes	Dialogue Themes
Interest Level in Severe Weather	Interested (27)	Interested, intrigued, and enthused (37)
	Disinterested (8)	Somewhat interested (4)
Meaning of New Severe Weather Knowledge	Good to know (13)	Important knowledge for taking precautions and staying safe (32)
	Knowledge to use in places outside of California (5)	Not meaningful (9)
	To take precautions (3)	
	Not meaningful (3)	
Perceived Challenge of Learning Event	Hard to understand or grasp (10)	Challenging due to science and new information (10)
	Challenging due to lack of prior knowledge (6)	Easy to learn (9)
Perceived Level of Distraction during Learning Event	Distracted, bored, and tired (16)	Not distracted (11)
	Distracted by others on phones and sleeping (3)	Distracted, bored, and tired (10)
	Not distracted (2)	Somewhat distracted (5)
Perceived Passing of Time during Learning Event	Time went slowly (9)	Time went fast (16)
	Time went fast (4)	Time went fairly slowly (2)

Note: The values within the parentheses represent the number of comments within each theme.

Engagement-related survey questions. Table 12 displays the categories and corresponding themes for Questions 1 - 5 with a count in parentheses for the number of comments within each theme. The following five sections describe each of these themes using supporting quotations. Some themes were found in multiple questions, which is why some numbers in Table 12 are higher than the number of participants in each student group. Some comments were not included due to their illegibility or irrelevancy to the primary research question. In addition, not every student left a comment. For the lecture group, 52 out of 205 (41 students times five questions) potential comments (25.4%) were blank, whereas 47 out of 205 potential comments (22.9%) were blank for the dialogue group. In addition, there were two students in the lecture group who participated in the survey but did not leave any comments. The time constraints may not have allowed all students to leave comments for each question. Nevertheless, every dialogue student who participated in the surveys left at least one comment. Because the dialogue group left more comments than the lecture group, the dialogue group may have been more engaged in the learning event.

Interest level in severe weather. For Questions 1 through 5, students from both the lecture and dialogue group expressed varying levels of interest. Their responses were not limited to the first question, which had prompted them to express their level of interest in the severe weather learning event. Overall, students in both groups expressed a great deal of interest in severe weather. However, the students in the dialogue group conveyed an even higher level of interest in severe weather than those in the lecture group. These findings align with the first Likert-scale survey question, which found a statistically significant difference favoring the dialogue group. In the lecture group, there were 27 comments regarding interest in learning about severe weather. However, a majority of comments in this category (18) included the word "interested" without going into further detail. Students may have simply repeated this word since it was in Question 1. Eight additional comments expressed specific interest in severe weather events, such as hurricanes, tornadoes, and thunderstorms. One student was interested "since weather happens every day." On the other hand, eight students expressed their lack of interest by stating that severe weather is "not needed for [a] career" and that they would not "take a class on it." One student did not "feel engaged mainly because of lack of interest," while another student flat out stated that he or she "did not like the lecture."

In the dialogue group, a majority of comments addressing levels of interest (37) also expressed fascination with severe weather and the learning event, but students used more pointed words such as “intrigued” and “enthused.” Students were also drawn to specific severe weather events, as evidenced by the following comment, “I was always interested in how these storms come about and I wish I could witness a tornado.” Other students “wanted to learn more” and one student said, “I loved learning about severe weather.” Four comments expressed mild interest, and two students said that they were “interested, but not in atmospheric ingredients.” One student noted, “I didn’t hate it but [it] didn’t interest me either.” With comments that favored a keener interest and the use of words such as “intrigued” and “enthused,” it seems that the dialogue group was more interested in the learning event. In addition, since a higher interest is an indicator of higher engagement, this finding suggests that the dialogue group was more engaged than the lecture group.

Meaning of new severe weather knowledge. A majority of both groups of students found meaning in the learning event in multiple ways. Even though the closed-ended question regarding meaning (Question 2) did not find a statistically significant difference between the two groups, more students in the dialogue group indicated that they found the learning event meaningful. The dialogue group also had different reasons for finding meaning than the lecture group. In the lecture group, 13 comments indicated that learning about severe weather was “good to know” for the sake of having “more knowledge.” Five comments highlighted the importance of learning about severe weather in places outside of California, while three comments considered learning about severe weather important in order to take precautions should the students experience a severe weather event. At the same time, three comments noted that students found the learning event “not meaningful.” One student even linked a lack of interest to a lack of meaning by stating, “it wasn’t interesting so it wasn’t meaningful.”

The dialogue group had more students (32 comments) expressing meaning in learning about severe weather in terms of taking precautions and staying safe during severe weather events. This group found severe weather “important to know [about]” in order to “save ourselves.” Students expressed the necessity of learning in order to “prepare for different types of weather” and to “protect family and friends.” One student said that it “helps to learn and use [this information] in life.” These statements indicate that the dialogue group found meaning that was more centered on using their new knowledge to protect themselves where they live, versus the lecture group’s learning information that they did not think they would need. At the same time, nine comments indicated that some students did not find this learning event meaningful. One student described learning about severe weather as “unrelatable to me.” Another student said, “We live in California, so severe weather doesn’t happen often.” Even though more students in the dialogue group stated that severe weather was “not meaningful” than those in the lecture group, the dialogue group included comments that linked the importance of learning about severe weather to their everyday lives. Based on these comments, the dialogue group may have found more meaning in the learning event than the lecture group, possibly because they were more engaged.

Perceived challenge of learning event. Students in both groups mentioned that they found the learning event challenging; however, some students in the dialogue group did not find it so. Six comments from students in the lecture group noted that the learning event was challenging because they “had no prior knowledge” of severe weather and the details of severe weather processes “required a lot of attention to grasp.” At the same time, 10 comments suggested that the lecture was “hard to understand” and “confusing.” Two students indicated that more “examples [were] needed.” The dialogue group also included 10 comments indicating that they found the learning event challenging, but their reasons for feeling challenged included the fact that “it was science,” that led to “a strong academic challenge.” Nine comments indicated that the information was easy to understand by suggesting that “examples made it easy to learn,” “[the] professor made it simple,” and “[it] was supportive of a good learning environment.”

As indicated in Table 10, the average score for the challenge-related question was higher for the lecture group than the dialogue group. At first this might seem to indicate that engagement was higher for the lecture group; however, the difference in means was not statistically significant, and students may have had different ideas of what they considered challenging even though I defined challenge in the survey. My goal for this question was to measure the degree of academic challenge that could be linked to their perceived level of engagement. Instead, I received comments on how well they were able to learn and endure the learning event. Only one student in the dialogue group indicated a “strong academic challenge.” This is the optimal balance for challenge, because if a task is too easy, then students may become bored. However, if a task is too challenging, then students may become frustrated and quit. This complexity must be kept in mind when assessing students’ perceived level of engagement based on their comments about challenge.

Perceived level of distraction during the learning event. While questions about interest, meaning, and challenge were indirect indicators of engagement, distraction during a learning event offers a more direct clue as to how engaged students were. As indicated by the themes in this category (as well as the statistically significant differences between the groups), the dialogue group was less distracted by things not related to the learning event than the lecture group. In addition, the things that distracted students in the dialogue group were different from those that distracted students in the lecture group. For example, the lecture group included 16 comments about being tired, bored, and distracted by things outside of the learning event. Three comments indicated that they "fell asleep" and had "heavy eye lids," while four comments claimed that students were "not that absorbed" since it was "hard to focus." Three students also indicated that they were distracted by other students who were sleeping or looking at their phones. At the same time, two students reported not being distracted, one of whom said, "[the] teacher kept us on track."

In the dialogue group, 10 comments indicated distraction and boredom, identifying "group work" and "AD[H]D" as reasons. Five students mentioned feeling mild distraction, but 11 asserted that they were not distracted. One student claimed not to have been distracted since "weather…and natural phenomena [are] interesting." The number of students in the dialogue group who indicated that they were not distracted was much higher than those in the lecture group. At the same time, because some of these students did not elaborate on being distracted, they may have provided their comments simply due to the wording of the survey question. In any event, given the greater number of comments from the lecture group about being tired, bored, or distracted, the dialogue group seemed to have been more engaged. This finding matches the statistically significant difference in means for Question 4 favoring the dialogue group.

Perceived passing of time during the learning event. Another more direct indicator of engagement is the students' perceived passing of time during the learning event. As indicated in Table 12, more students in the dialogue group felt that time went by quickly than those in the lecture group. This aligns with the closed-ended survey question with a statistically significant difference in means between the two groups favoring the dialogue group. In the lecture group, four comments were made indicating that "time went fast" without providing further explanation. Nine comments, however, indicated that "time went by slowly," with four of these stating that the severe weather learning event "was long."

In the dialogue group, 16 comments indicated that "time went fast." Students making these comments also elaborated by stating that "time flies when having fun" and "time flies when you really want to learn something." One student said, "my attention was kept since it was very interesting," while another indicated that the "timing was perfect." At the same time, two students did not agree and stated that "time went by fairly slowly." While this wording is not exactly the same as "time went slowly," it does indicate that not every student felt that the dialogue-based learning event was engaging.

Learning-related survey questions. Table 13 displays the categories and corresponding themes of Questions 6 and 7 with a count in parentheses for the number of comments within each theme. Question 6 asked students to provide an example of what they had learned, while Question 7 asked students to provide an example of a concept that they could apply to their lives. The following sections describe each of these themes using supporting quotations. Some themes were found in both Questions 6 and 7. As with Questions 1 through 5, some comments were not included due to their illegibility or irrelevancy to the primary research question. In addition, not every student left a comment. In the lecture group, 28 out of 82 (41 students multiplied by two questions) potential comments (34.1%) were blank, whereas 15 out of 82 potential comments (18.3%) were blank for the dialogue group. For these survey questions, the percentages of comments left by the dialogue group were markedly higher compared to the lecture group. For Question 6, 23% more comments were left by the dialogue group, and for Question 7, 35% more comments were left by the dialogue group. Again, because the dialogue group provided more comments, this may suggest that this group was more engaged than the lecture group.

Table 13 – Primary themes found in Survey Questions 6 and 7.

Categories	Lecture Themes	Dialogue Themes
Thunderstorms	Formation of thunderstorms (6)	Formation of thunderstorms (10)
	Lightning and thunder (2)	Thunderstorms in California (3)
Tornadoes	Tornado formation and facts (4)	Tornadoes and temperature (8)
	Tornadoes in California (2)	Tornado winds and vertical wind shear (4)
Hurricanes	Hurricanes and the ocean (7)	Hurricanes and 80-degree F water (7)
	Hurricane structure and ingredients (3)	Hurricane structure and ingredients (4)
General Severe Weather Concepts	Location of severe weather (3)	Location of severe weather (3)
		Information through websites (2)
Perceived Learning	Hard to remember (4)	Now have a better understanding (3)
	Already knew about severe weather (2)	Fair understanding of severe weather (2)
	Wanted to learn more (2)	
Perceived Application	Able to apply in life and for safety (8)	Can use for precautions and safety (18)
	Not able to apply in everyday life (8)	Able to apply knowledge in everyday life (13)
	Clearer about the weather (4)	More knowledge to use should severe weather occur (11)
		Can't apply in everyday life (5)

Note: The values within the parentheses represent the number of comments within each theme.

Severe weather concepts students learned. Six comments from students in the lecture group discussed thunderstorm formation by indicating that thunderstorms need “warm air and moisture,” along with “warm air rising [and] cold air coming down.” Some of these comments also noted that students now knew more about the stages of thunderstorms. Two students noted more specific examples of lightning, while one stated that “lightning strikes occur when thunder in [the] sky gets too hot.” This is actually not true, which shows that at least one student did not understand how thunder and lightning work.

Ten comments from students in the dialogue group also described the formation of thunderstorms. These students mentioned that thunderstorms need “warm air near the ground and cold air aloft.” This description is more accurate than “warm air rising [and] cold air coming down” indicated by the student in the lecture group. The dialogue group noted that “lifting mechanisms” are necessary for the initiation of thunderstorm convection. Two students also mentioned that thunderstorms in California are typically confined to the “mountains.” These responses are specific in describing thunderstorms in California, and the enhanced use of weather-related vocabulary shows that the dialogue group was able to remember more detailed information about thunderstorms compared to the lecture group.

Four comments from students in the lecture group regarded tornado formation and facts. One student noted that “a tornado isn’t defined a tornado unless it touches the ground.” Two students even mentioned tornadoes in California by stating that “there are tornadoes in California but not big ones.” Students in the dialogue group did not discuss tornadoes in California, but they did provide more detailed links between tornado formation, temperature, and wind. For example, eight comments described the need for “warm air and cold air colliding” to help create a tornado. One student used the word “aloft” indicating that cold air is usually found higher in the atmosphere. The use of the word “aloft” points to in-depth knowledge of atmospheric terms and vocabulary. In addition, four students also included a more complicated process of “vertical wind shear” when explaining the necessary atmospheric ingredients needed for tornado development.

The comments regarding hurricanes did not differ dramatically between the lecture and dialogue groups. For example, seven students in the lecture group described the link between hurricanes and the ocean, as one student said that “we [in California] don’t have hurricanes because our water is too cold." Three students also mentioned additional ingredients needed, such as strong winds and high humidity. The dialogue group also mentioned these ingredients. However, the link between hurricanes and the ocean was a bit more specific. Seven comments from the dialogue group indicated that "hurricanes need 80-degree [Fahrenheit] water" in order to form. Two students also indicated the need for minimal vertical wind shear and an existing low pressure. These two phenomena are additional requirements for hurricane formation and longevity.

Both groups of students discussed where severe weather is usually located. The lecture group included three comments about other states that are affected, with one student stating that "Florida experiences many [types of] severe weather." The dialogue group also noted the frequency of severe weather in Florida. In addition, the dialogue group indicated that they had learned how to "get informed through websites" about severe weather perhaps due to using these sites during the learning event. The lecture group did not mention weather-related websites despite the fact that these were mentioned during the lecture-based learning event.

Perceived learning. Although Question 6 did not ask students to explain how well they had assimilated information, some students did indicate their perceived level of learning. The results indicated a difference between the lecture and dialogue groups, just as the results of the learning questions in the pre- and post-tests did. For example, four comments from the lecture group indicated that students found it hard to remember the concepts. One student "needed repetition to fully comprehend the subject." Two students already had knowledge about severe weather and, therefore, did not learn anything new. At the same time, two students did remember concepts and wanted to learn more. In the dialogue group, students indicated that they remembered concepts and had a better understanding after the learning event. One student said that weather concepts are “now stuck in [my] head.” Two students indicated that they only had a fair understanding of the weather and that they “forgot the specifics.” One student even said, “I learned but [it] really doesn’t matter to me.” These last two comments may indicate that even though students had learned something–perhaps more than the lecture group had–they may not have comprehended the full details of the severe weather learning event or found deep meaning in learning the content.

Perceived application. Based on comments in Question 7, the level of perceived application of severe weather knowledge in the dialogue group–as indicated by both the closed- and open-ended survey responses–seemed more prominent than in the lecture group. The ability to learn and then apply new knowledge to life indicates deeper learning and impact, which are among the key tenets behind dialogue education. In the lecture group, eight comments indicated that students could use their knowledge for life and safety. For example, students said that they “learned how to identify phenomena” and that they “will stay indoors during thunderstorms.” One student even indicated that Texas is not a good place to live due to its frequency of severe weather. Four students also indicated the usefulness of enhanced knowledge just for the sake of knowing about the weather. This aligns with the results from Survey Question 2, which indicated that students found meaning from the learning event simply because they now have more knowledge. At the same time, eight comments from students in the lecture group clearly indicated that they do not know how to apply their knowledge. Five students said that they “don’t know how to apply to…everyday life,” while one student indicated that the learning event did not help prepare for an earthquake. Because severe weather is not as common–and therefore uppermost in people’s minds–in California as earthquakes are, this result is not surprising.

However, many more students in the dialogue group indicated the ability to apply their new knowledge in some way. Eighteen comments suggested that knowing about severe weather could help these students stay safe. Students mentioned that they now know to "stay indoors during thunderstorms" and "stay in [the] car [and] away from [the] beach" during lightning. One student said that "[when] looking at thunderstorms, I can look at cumulonimbus clouds and be able to take safety procedures." Thirteen comments indicated that students could use severe weather knowledge in everyday life, such as the ability to "predict when these things [will] happen," know "how to dress for the weather," and use this information for the "military…where severe weather will be active." Eleven comments also highlighted the resources students are now familiar with should a severe weather event occur in California. Four students indicated having "good resources" and "websites to prepare."

While these results suggest that students overwhelmingly found the dialogue approach more useful, there were five students in this group who were not able to apply their newly-learned concepts to everyday life. Some of these students thought there was not enough useful information, while one student mentioned that this information could not be used in California, but perhaps "in other places." These latter results imply that even though more students from the dialogue group expressed the ability to use severe weather knowledge in life, these findings are still limited because of the lack of severe weather in southern California.

Summary

This chapter presented analysis of the quantitative data from the pre- and post-tests and the quantitative and qualitative data from the surveys conducted after the learning events. Data from the closed-ended questions were inputted into SPSS for statistical testing. Gain scores were calculated for the learning questions, and one-way ANOVA tests were run to find statistically significant differences within the quantitative data between the lecture and dialogue groups. Effect sizes for the statistically significant differences were also calculated to determine how large and meaningful these differences were.

Template and editing approaches were used for the open-ended questions to find significant patterns and differences between pedagogical approaches. Using a sequential explanatory mixed-method approach, the qualitative survey data were compared with the quantitative survey and pre- and post-test gain score data to find convergent and discrepant patterns. Overall, the qualitative data generally supported the quantitative results from both the surveys and pre- and post-tests.

Chapter 5: Discussion and Conclusion

Introduction

This chapter focuses on interpreting and discussing results presented in Chapter 4 in relation to the primary research question. The results included statistically significant differences favoring the dialogue group in one interest question and all three learning questions from the pre- and post-tests, in addition to five out of the seven survey questions. The statistically significant differences from the learning and survey results also exhibited large effect sizes. The qualitative survey responses were in general agreement with the quantitative responses. Even though no statistically significant differences were found in survey questions two and three, the lecture and dialogue groups provided different reasons for finding meaning in and challenge from the learning events. This chapter closes with limitations, implications, recommendations, and conclusions.

Learning

For this study, quantitative measures of learning come from the learning questions in the pre- and post-tests and the last two questions of the survey. All three learning questions in the pre- and post-tests and the last two closed-ended survey questions (focusing on perceived learning and application of knowledge) exhibited statistically significant differences (with large effect sizes) between the two groups that favor the dialogue group. In fact, the highest mean of all of the survey questions–3.89 out of 5–regarded the dialogue group's perceived learning. These results suggest that the dialogue-based approach had a greater impact on student learning, as measured by the survey questions and the pre-post tests, than the lecture format. Even though the learning events were relatively short (45 minutes), and more content was introduced in the lecture group, the degree of learning for the dialogue group appears to have been higher.

Content learning. For the first question that asked students to choose one type of severe weather and describe three necessary ingredients for formation, students in the dialogue group earned higher gain scores that were statistically significant compared to those in the lecture group. Because this question focused on content, one might expect that the students who were provided with a more detailed and lengthy lecture would score better on the tests. However, this statistically significant difference suggests that students in the dialogue group actually learned the content more effectively. As reported by Vella (2008) and science educational studies (e.g., Bentley, 2009; Phillips, 2006; Steer, McConnell, Gray, Kortz, & Liang, 2009; Wenner, Burn, & Baer, 201), learning events that utilize prior knowledge, peer-interaction, active learning via group work, and material that is pertinent to the students' lives can lead to enhanced learning. These results were also consistent with those in meteorological studies conducted at universities (e.g., Barrett & Woods, 2012; Grenci, Babb, & Seman, 2008; Grundstein, Durkee, Frye, Andersen, & Lieberman, 2011; Richardon, Markowski, Verlinda, & Wurman, 2008; Yarger, Thomas, Boysen, & Pease, 2003).

Other research shows that traditional lectures only help students retain about 10 to 20% of content, resulting in passive learners who cannot retain and comprehend course material (Bernot & Metzler, 2014; Center for Integration of Research, Teaching, and Learning, 2013; Leonard, 2000; Wieman, 2007). As an example, Crouch and Mazur's (2001) study of student success in a physics course used interactive, dialogue-based instructional methods to show that less time was needed and a reduced lecture was sufficient to deliver content to students. My findings in conjunction with those of these other research studies support Leonard's (1997) statement that "it is becoming clearer in educational research that learners who are actively engaged in the learning process are the most successful" (p. 11).

Application of content. The dialogue group also exhibited higher gain scores on the second learning question, which were statistically significant compared to the lecture group. The second learning question was focused on both content and application of knowledge. It measured higher order learning (Bloom, 1956, as cited in Vella, 2008) by asking students to compare and contrast the typical conditions in California that do not lead to severe weather with typical weather patterns in parts of the country that have more severe weather. The third learning question focused on the application of content by asking students what they would do should a severe weather event occur. Both learning events provided information on ways to assess impending hazards and protect students from them. However, the dialogue group scored higher (with statistically significant differences) on this question than the lecture group. In addition, the greatest average gain score was found in the dialogue group for the third learning question.

Even though the lecture provided more information about the usual absence of severe weather ingredients in California, students in the dialogue group were able to work with this information with peers and share their answers. As a result, students were able to learn and apply new knowledge more effectively compared to the lecture students. This result aligns with science education literature that overall supports constructivism (Leonard, 1997; 2000) and demonstrates how the structure of the dialogue-based group learning event helped these students grasp concepts more effectively and apply concepts more easily. For these learning questions, the dialogue group also worked with open questions. Open questions help bring relevance to the topic and are “the essence of dialogue education” (Vella, 2008, p. 64). The use of open questions likely helped students learn how to apply the content.

The results from all three learning questions further support the use of social forms of constructivist learning theories. For example, social cognitive theory (SCT) suggests that adults learn through interactions and within contexts where they can observe other adults and engage in in-class dialogue and group work (Bandura, 1999; Bruner, 1985). Brown, Collins, and Duguid (1989) suggest that learning in contexts and using everyday experiences can help students comprehend more meaningfully and deeply. When students have an immediate need to apply knowledge (either in the group work or later in life), they become more self-directed (Merriam & Bierema, 2014) and understand why they need to learn (Knowles, 1998). Vygotsky (1978) states that "there is no way, none, in which a human being could possibly master [the] world without the aid and assistance of others for, in fact, [the] world is others" (p. 32). Thus, the social element of group work and in-class discussions within the dialogue approach helped students use the behavior of others to help them learn independently and find relevance and meaning in their own work.

Perceived learning and application of content. The last two survey questions focusing on perceived learning and application of content resulted in higher scores that were statistically significant in favoring the dialogue group. The associated open ended responses also demonstrated a greater level of learning and application of severe weather knowledge for the dialogue group, as the responses from this group offered more in-depth explanations. This further supports the enhanced learning of the dialogue students compared to the lecture students.

For example, the enhanced use of weather-related vocabulary for describing thunderstorms and tornadoes shows that students in the dialogue group were able to remember more detailed information than those in the lecture group. The students' use of the words "aloft," "vertical wind shear," and "lifting mechanisms" showcased their in-depth knowledge of atmospheric terms and vocabulary. The dialogue group's link between hurricanes and the ocean was also more specific, as students in this group more often noted that ocean temperatures needed to be 80 degrees Fahrenheit for hurricane development and sustainability. Students in the dialogue group also indicated that they learned how to "get informed through websites" about severe weather. The lecture students did not discuss these websites even though they were included in the lecture-based learning event.

While students in the lecture group did learn how to avoid severe weather by "staying indoors," many did not know how to apply their newly acquired knowledge to their lives in general. The majority of students in the dialogue group, however, learned not only to stay indoors and take precautions, but also to have good resources, the ability to determine inclement weather by looking outside, and the forethought to seek out certain websites during severe weather. This implies that students were able to apply their knowledge to everyday life – something that Vella (2008) cited in her studies. Based on the examples provided and direct comments from students about their perceived learning, it appears that even a small amount of dialogue education, with its focus on students' lives and input, can have a profound impact on student learning. This seems to be the case even with abstract concepts such as severe weather in southern California and in community colleges with diverse populations who have varying degrees of knowledge and skill sets.

In total, the results from the dialogue group indicate deeper learning and impact. Deeper learning is indicated by mastery of in-depth content and higher-order thinking skills, such as the ability to apply newly acquired knowledge (Martinez & McGrath, 2014). These findings are supported by key tenets behind both dialogue education and recent science education literature (including meteorology educational studies in universities) that support constructivism (Leonard, 1997; 2000; Vella, 2008). For example, Goldberg, Otero, and Robinson's (2010) research showcases experiential and social constructivist learning theories for learning and applying concepts from physical science. These authors found evidence of enhanced learning through active learning, group work, and the use of prior knowledge and everyday thinking of physical processes to help students grasp material. The students were able to find applications for new knowledge in their lives as they fit this new knowledge into their "existing cognitive framework" (Leonard, 1997, p. 13). Even if students in my study had not experienced severe weather, the LNRA (which is based on experiential learning) could have tapped into their preconceived ideas about severe weather and helped inform their life stories (Driver, Asoko, Leach, Mortimer, & Scott, 1994).

Engagement

While greater learning may imply enhanced engagement, the more direct indicators of engagement in this study include the interest questions in the pre- and post-tests and the first five questions of the survey. While only one interest question (about hurricanes) favoring the dialogue group showed statistical significance, three out of the five engagement-related survey questions were statistically significant. These results suggest higher engagement and show that the dialogue approach may have allowed students to become engaged in a potentially meaningful learning event that could be useful to them in the future. In addition, 72% of potential survey comments were completed by the lecture group, while 91% of potential comments were completed by the dialogue group. These results provide additional evidence of enhanced engagement of the dialogue students. This may also imply that the lecture students were not only less motivated to fully complete the survey, but also less motivated to learn (Lovelace & Brickman, 2013; Steiner & Sullivan, 1984).

Interest. Greater interest can also lead to greater intrinsic motivation and engagement (Leonard, 1997). It appears from the interest questions in the pre- and post-tests that there was very little change in interest between the lecture and dialogue groups for the first four interest questions (e.g, severe weather, atmospheric conditions behind severe weather, thunderstorms, and tornadoes). However, there was a statistically significant difference in interest gain scores for hurricanes in the dialogue group. The survey results also showed that students in the dialogue group demonstrated a higher interest in the severe weather learning event that was statistically significant. Perhaps during the time of the learning event, students did not exhibit increased interest in specific aspects of severe weather, but two days later, their reflections showed greater interest than those of the lecture group. Vella (2008) proposes that it takes time to reflect on learning, and this may explain the increased interest that blossomed during this two-day period.

The comments from the survey question about interest support higher interest in the dialogue group than the lecture group. While students in both groups expressed interest in severe weather, the students in the dialogue group conveyed an even higher interest in severe weather than those in the lecture group. With comments that favored a keener interest and the use of words such as “intrigued” and “enthused,” it seems that students in the dialogue group were more interested in the learning event. Overall, there was less interest inspired by the longer lecture approach than the dialogue approach.

Cowan and Piepgrass (1997) found that students need clear instructions and relevant materials in order to reduce anxiety and increase interest in science. Science needs to be put into context, and the LNRA helped situate knowledge in the lives of the students, even if they had limited experience with the content (Leonard, 1997; Vella, 2008). Students were then able to share their answers within groups and through whole-class discussions, which may have helped spark interest and engagement (Wells & Arauz, 2006). These findings also align with social learning theories (e.g., social cognitive theory, situated learning) that may help explain why the dialogue students may have been more motivated to work on and learn about complex problems, such as understanding severe weather (Bandura, 1999; Hergenhahn & Olson, 2005). Guthrie and Anderson (1999) claim that social interactions can amplify intrinsic motivation, which are linked to multidimensional engagement factors (e.g., cognitive, affective, and behavioral). This would be especially true if students see that knowledge about severe weather is useful in their lives.

Perceived distraction and passing of time. The scores from the survey questions that focused on distraction and perceived time were higher for the dialogue group, and these differences were statistically significant. In addition, based on the number of comments from the lecture group that noted being tired, bored, and distracted by others sleeping or using phones, those in the dialogue group seemed to be more engaged. Students in the lecture group even noted having fallen asleep, but students in the dialogue group mentioned no distractions from sleepiness or difficulty keeping focused. Students in the dialogue group also indicated that time went by more quickly than those in the lecture group, and dialogue students used phrases such as, “time flies when [you are] having fun,” which may have indicated that they enjoyed the group work. One student even said that “my attention was kept since it was very interesting.”

Distractions and the perception that time passed slowly may have been more prevalent in the lecture group due to the loss of concentration that is common for students during lectures (Barnes et al., 2007; Lancaster, 2014; Blatchford, Edmonds, & Marin, 2003; Fenollar, Roman & Cuesta, 2007; Young, Robinson, & Alberts, 2009). These findings also align with Csikszentmihalyi’s (1990) work, which considers students engaged when they become absorbed in learning and lose track of time (Egbert, 2003; Lee, 2012). According to Vella (2008) and Lane and Harris (2015), these engagement factors are the strongest when students are actively participating in applying knowledge within a group setting. Dialogue education focuses on interactions among students, as well as safety, relevance, and active engagement (Vella, 2008).

These engagement-related results also support Cowan and Piepgrass' (1997) findings that show a negative correlation between anxiety and boredom for students in an open-admission, two-year branch of Miami University. They found that more anxiety (especially during a lecture with a large amount of information) can result in less interest and more boredom. Caprio (1999) also noted that safety is important in science education in two-year schools, where a safe learning environment includes support from instructors and trust among students that allow them to make mistakes and learn from them. Relevance, which is also a dialogue education principle, can help reduce students' anxiety about science (Cowan & Piepgrass, 1997) and build a foundation for an effective learning environment. Therefore, the reduced distraction and increase in the perception of timing moving quickly found in the dialogue group are supported by recent studies on adult learning, dialogue education, and science education.

Meaning. The question about meaning in the survey did not yield statistically significant results with a 95% confidence interval. At the same time, the average score for the dialogue group was statistically significantly higher with a 90% confidence interval. In the open-ended portion, more students in the dialogue group indicated that they found the learning event meaningful in various ways. For example, students in the lecture group believed the newly acquired knowledge was good to have for the sake of having "more knowledge." The dialogue students realized that they could use this knowledge to "prepare for different types of weather" in order to protect family and friends. The dialogue group found meaning that was more centered on using their new knowledge to protect themselves where they live, versus the lecture group's learning information that they did not think they would need. Overall, the students in the dialogue group included more comments that linked the importance of learning about severe weather to their everyday lives.

As Vella (2008) states, one of the purposes of the dialogue education framework is meaning and relevance. Even though the qualitative responses may suggest that the dialogue education students found more meaning in the learning event, the combination of these results with the closed-ended results still did not show as much enhanced meaning among students in the dialogue group as expected. These findings do not align with Vella's (2008) principles of dialogue education or Knowles' (1998) assertion that adults are motivated when material is life-centered so they can make meaning of new knowledge. However, this finding does support Le Cornu's (2005) research that indicated extensive reflection necessary for experiential learning (e.g., experience through groups) to have deeper meaning and impact on learning. Without a longer period of reflection, students may not find enhanced meaning in learning new content. In addition, college students are often transitional thinkers who are, at times, able to think using abstractions without any concrete sensory experiences, but at other times need to touch, see, or even hear something in order to learn (Leonard, 1997). This transitional phase can make it challenging for them to think about the meaning of abstract concepts, such as extreme weather that could impact California due to climate change and future El Niño events.

Challenge. The question about challenge in the survey also did not have statistically significant results. The average score for the challenge-related question was actually higher for the lecture group than the dialogue group, which at first may indicate that engagement was higher for the former (Lee, 2012). However, the difference in means was not statistically significant. A majority of comments noted the students' ability to learn and simply endure the learning event. Similar results were found in Cowan and Piepgrass' (1997) study, where students expressed their beliefs that science was hard and that they were inherently bad at science. These convictions were evident in some of the comments made by students in the dialogue group. Those in the lecture group, however, expressed difficulty in grasping the concepts because it required a great deal of attention and was, at times, confusing to them.

Task engagement in the classroom can be classified as the degree of flow and involvement of the student (Csikszentmihalyi, 1990; Lutz, Guthrie, & Davis, 2006). Based on Csikszentmihalyi's (1990) theories of engagement, a learner is optimally engaged when the tasks at hand require a balanced level of skill. If a task (such as listening to a lecture or participating in group work) is not challenging, then students can become bored. However, if the activities are too challenging, then students are likely to give up out of frustration. Therefore, although students in the lecture group found the lecture difficult to endure, based on their comments, this difficulty most likely led to boredom or frustration and not engagement.

Limitations

There are at least four limitations in this study. First, the time span of this study was one week. There may not have been enough time to fully investigate the impact of dialogue education, especially since the time to reflect on learning would have been limited to this period of time. Future research might benefit from using a full semester's worth of the dialogue approach to better understand the impact of dialogue-based group activities on meteorology education. At the same time, the learning events were designed with the brief time limit in mind and tailored to fit the reduced time frame as optimally as possible. In fact, Jane Vella (personal communication, August 10, 2015) commented on the value of this design despite its limited timeframe, saying, “I could learn a great deal from you in one hour.”

Despite Vella’s acknowledgment of this study’s dialogue education design, a second limitation is the researcher’s ability to design the dialogue-based group activities well enough to know whether the favorable results were, in fact, due to the design of the group activities. It usually takes educators additional time and training to become experts in designing and implementing dialogue education (Global Learning Partners, 2014). I was still a novice at this approach. At the same time, I did take a course on program development using dialogue education, and I learned a great deal on how to design and execute dialogue-based activities through multiple pilot studies. Future research would benefit from continued refinement of my abilities to teach adults through the framework of dialogue education.

A third limitation would be the use of a non-random design. To more faithfully know the impact of the treatment effects, employing a random sampling strategy would have been optimal. Although statistical tests can be and are used frequently to determine treatment effects, quasi-experiment methods may contain biases that must be taken into consideration when analyzing the effects of the experimental treatment and determining statistically significant differences (Gersten, Baker, & Lloyd, 2000). At the same time, quasi-experimental designs are very common in education since random sampling is usually not feasible. Quasi-experimental approaches also have stronger external validity since they are usually conducted in natural settings. Thus, research conducted in the classroom has stronger external validity when applied to other classroom settings.

Quasi-experimental biases are not detrimental to analysis if they are kept in mind when designing research and preparing data for analysis (Cook & Campbell, 1979). For example, my research did not include my own students, the lecture and dialogue approaches were designed with the limited timeframe in mind, student information was gathered for both groups to determine similarities between the two student bodies, and experimental and research biases were kept in mind when the contrasting pedagogical approaches were conducted. Selection bias and maturation were also controlled by using only one instructor for both approaches, scheduling the events at the same time of day, and having only a one-day difference between the implementation of the treatment and control approaches. In addition, the two groups were likely not aware of each other, so compensatory rivalry and resentful demoralization were not threats to validity either (Cook & Campbell, 1979).

Finally, only 82 students (41 in each group) participated in the research design at a single community college in southern California. Even though these numbers are normal for experimental designs in education, they may be too low for generalizing results to a much wider community college student body. These numbers would have likely been higher if there had been fewer institutional constraints on conducting quasi-experimental research in a college setting. Additional research with a larger number of students would strengthen the results of this study. Random sampling could also be used with more students and across different schools.

Due to these limitations, alternative explanations for this study's results include the increased engagement of students because I was a guest lecturer (although this effect would have been evident in both approaches), the fact that the lecture approach was conducted on a Monday morning, and my two groups of students being different in some way that was not measured within the quasi-experimental design. The use of handouts and structured lecture (and the shorter length of the lecture) may have contributed to the enhanced learning within the dialogue education group, especially because younger students as part of the "millennial" generation generally enjoy group work and expect learner-centered classrooms (Barnes, Marateo, & Ferris, 2007; McGlynn, 2008). Since the average age of both groups of students was nearly 20, these results may reflect the needs of millennials and emerging adults who value social activities and student-centered classrooms (Arnett, 2000; McGlynn, 2008). Community college students sometimes lack basic skills, including the ability to locate information from references and resources (Phillips, 2006). Structured learning events with materials readily available may have fit the learning needs of these students.

Implications and Recommendations

So, what do these results imply for teaching meteorology to non-science-majors in community colleges? It appears that the dialogue education approach works well for community college students learning meteorology. While Vella's (2008) dialogue education approach is typically geared for older adults with a large reservoir of knowledge and experience, based on results from this study, that approach appears to fit the learning needs of younger students as well. Therefore, placing meteorological content into students' lives by asking them about their experiences in weather and what they think about the weather should be emphasized in meteorology education at community colleges. Using El Niño and the effects of climate change could be further explored in practice to help situate knowledge more effectively for these students. As suspected before this research study, my continued effort to include students' thoughts and life experiences further aids in student learning and engagement in meteorology courses.

In addition to dialogue education, expanded use of group work and in-class activities in lecture courses could be implemented in the curriculum of community college meteorology. With abstract meteorological concepts, group work can be an effective method of utilizing social learning theories and enhancing the knowledge of and experience with weather for all students. At the same time, I have found throughout my teaching experience that students at community colleges tend to resist group work. Group work in my classes is often tied to a grade, where group work in this study was not. Perhaps group activities that lead to grades may not always work due to the possible lack of accountability of each student (Vella, 2008). At the same time, one student from the dialogue group did comment on how group work was distracting. Future research is warranted to further explore the use of group work in community college meteorology courses.

Educators could also ask open-ended questions that tie the material to the students' lives. These types of questions have a better chance of increasing student engagement because there are no fixed answers that can easily be solved. As Vella (2008) says, open questions invite dialogue whereas closed questions do not do so as much. Open questions are more complex and require more attention from students. These questions can be worded to include ideas from students' prior knowledge and experiences (through an LNRA), which can help students find more interest and meaning in the material. In addition, having students reflect on the content for an extended period of time may increase their chances of finding more meaning and interest. This method can also be used to help alleviate anxiety in learning science and other STEM fields and motivate non-science majors to learn and become engaged.

One of the challenges with teaching meteorology in southern California is the difficulty students have in relating to the material. However, dialogue education puts the effort of placing content into the students' lives at the forefront. Although it still may be difficult with the lack of tangible examples of severe weather in this region of the country, it would still be a useful practice to implement because dialogue education principles put the students first. In the end, the strong results discussed in this chapter demonstrate that dialogue education can have a promising impact on students' learning and engagement in meteorology at California community colleges. Because there is very little research on meteorology education in general and meteorology at community colleges specifically, dialogue education and related pedagogical practices should be further explored within this scientific field.

An additional implication goes beyond teaching meteorology in community colleges. The Achieving the Dream (AtD) Initiative is a program at American community colleges that supports colleges in collecting and analyzing student data to help increase persistence (i.e., the number of college students who return to college for a second year) and student success (Achieving the Dream, 2012). One of the emphases of this initiative is student engagement in the classroom, which by extension helps improve learning and student success. Because of the notable increase in student engagement in the dialogue group, dialogue education in community college has the potential to increase persistence and student success in a variety of community college courses.

Conclusion

This study examined the impact of dialogue-based group learning tasks on student learning and engagement in community college meteorology education. A quasi-experimental design was used to compare lecture-based instruction with dialogue-based group learning. Pre- and post-tests were used to measure learning and interest, while surveys were conducted to assess engagement and perceived learning and application of content. The results from the pre-post tests and surveys showed that the dialogue approach helped students learn more successfully compared to the lecture-based instruction. The qualitative responses overall supported these results and showed that the dialogue students were able to remember more concepts and apply these concepts to their lives.

Based on the closed-ended survey results, dialogue students were also more engaged. The associated qualitative data also supported increased engagement for the dialogue students. Interest in specific meteorological topics did not change significantly for either group of students; however, interest in learning about severe weather was higher for the dialogue group. Neither group had found the learning events markedly meaningful, although the dialogue group's comments exhibited a stronger sense of meaning compared to those of the lecture group. The active engagement found in the dialogue group helped students be less distracted and more absorbed in the learning event. This increased engagement most likely led to the resulting enhanced learning.

With this study's limited number of students and colleges in southern California, it is too soon to know for sure if dialogue education is always superior to traditional lectures. Some of the lingering questions and resulting speculations cannot be answered definitively through this study. In any event, I suspect that Vella's methods, especially compared to listening to a long lecture, would help students of any age learn and become more engaged. This study further supports the use of student-centered approaches in community college science courses. This is true even for meteorological concepts that students might not find interesting or relevant. While students in neither group found deep meaning in the learning events–possibly due to the lack of diverse weather in southern California–the dialogue approach nonetheless helped students learn and engage with difficult scientific concepts that may help them understand some of the most pressing weather-related issues of our time. This increase in knowledge among community college students can help them become more scientifically literate and allow them to gain a well-rounded education for the workforce and for adapting to the effects of global climate change.

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Appendix A

Student Learning Outcomes for Severe Weather Learning Events:

1. Students will identify and explain atmospheric processes that influence severe weather, which include thunderstorms, hurricanes, and tornadoes.
2. Students will identify and explain reasons why severe weather events (e.g., thunderstorms, hurricanes, and tornadoes) do not occur as often in southern California as in other places within the United States.
3. Students will analyze the hazards of severe weather events and apply associated risks of these events to their lives.

Appendix B

Dialogue-based Group Learning Tasks on Thunderstorms, Tornadoes, and Hurricanes:

1. Induction (8-10 minutes): In a group of two or three, develop a list of what you believe are necessary atmospheric conditions for thunderstorms, tornadoes, and hurricanes, based on prior experience and previous knowledge you have learned (social media, online news sources, etc.) We will hear a sample from students.

2. Input (15 minutes): Watch the short PowerPoint presentation on these forms of severe weather. Take notes on the atmospheric conditions necessary for thunderstorms, tornadoes, and hurricanes, especially in terms of where and why these storms occur across the United States (and sometimes in California).

3. Implementation (15-20 minutes):
    a. Choose a type of severe weather that interests you, and describe the atmospheric conditions necessary for these storms.
    b. Explain ways you could analyze these conditions to understand whether this event would occur near your home (and for safety reasons). For example, what sources (e.g., websites, social media, etc.) could you use to see if these weather events were going to affect where you live?
    c. Which areas in southern California do you think would be most susceptible to each kind of severe weather? Focus on the ingredients of each severe weather type and determine when and where these ingredients *might* be found in southern California (especially in light of climate change). Please explain your answers. We will hear a sample from students.

Appendix C

<u>First Activity (to be completed in about 15 minutes)</u>

<u>Student-related Questions:</u>

1. In order to match this first activity with the last activity without using your real name, please indicate an alternative ID by combining a fake name and a two- to four-digit number (for example, Jane4545). *Please remember or write down this alternative ID for future use!!*

   ____

2. Please indicate your self-identified gender:

   ____

3. Please indicate your age:

   ____

4. Please indicate your major:

   ____

5. Please estimate your grade point average:

   ____

6. Please indicate the number of semesters you have completed in community college:

   ____

7. Is English your first language?

   ____

Interest Questions:

On a scale of 1 – 10, where **1 is low** and **10 is high**, how would you rate your ***interest*** in the following topics?

a. Severe weather: ________

b. Atmospheric conditions that form severe weather: ________

c. Thunderstorms: ________

d. Tornadoes: ________

e. Hurricanes: ________

Assessment questions:

1. Choose **one** type of severe weather (thunderstorms, tornadoes, or hurricanes) and identify **three** atmospheric processes (or ingredients) necessary for this type of weather event to occur. Provide a brief explanation of each process.

2. Choose **one** severe weather event (thunderstorms, tornadoes, or hurricanes) and list **two** atmospheric conditions that can lead to its development. Explain why these **two** conditions are **not** commonly found in southern California compared to other regions in the United States.

3. Choose **<u>one</u>** severe weather type (thunderstorms, tornadoes, hurricanes) that interests you or would most likely affect you in southern California, and describe **<u>three</u>** ways you can assess its hazards to **<u>protect</u>** yourself from it.

Appendix D

<u>Last Activity (to be completed in about 15 minutes)</u>

Please indicate your alternative ID you used on the pre-test:

____

<u>Interest Questions:</u>

On a scale of 1 – 10, where **1 is low** and **10 is high**, how would you rate your **<u>interest</u>** in the following topics?

a. Severe weather: ________

b. Atmospheric conditions that form severe weather: ________

c. Thunderstorms: ________

d. Tornadoes: ________

e. Hurricanes: ________

Assessment questions:

1. Choose **one** type of severe weather (thunderstorms, tornadoes, or hurricanes) and identify **three** atmospheric processes (or ingredients) necessary for this type of weather event to occur. Provide a brief explanation of each process.

2. Choose **<u>one</u>** severe weather event (thunderstorms, tornadoes, or hurricanes) and list **<u>two</u>** atmospheric conditions that can lead to its development. Explain why these **<u>two</u>** conditions are **<u>not</u>** commonly found in southern California compared to other regions in the United States.

3. Choose **one** severe weather type (thunderstorms, tornadoes, hurricanes) that interests you or would most likely affect you in southern California, and describe **three** ways you can assess its hazards to **protect** yourself from it.

Appendix E

Rubric for Pre- and Post-Tests

Rubric	Prompt	Breakdown of Points
1	Choose one type of severe weather (thunderstorms, tornadoes, or hurricanes) and identify at least three atmospheric processes (or ingredients) necessary for this type of weather event to occur. Provide a brief explanation of each process.	Correctly identifying three atmospheric processes = 3 points, 1 point per process. Explanation of each process = 0.5 point. **Total score = 4.5 points.**
2	Choose a severe weather event and list two atmospheric conditions that can lead to its development. Explain why these two conditions are not commonly found in southern California compared to other regions in the United States.	Correctly identifying two atmospheric processes = 2 points, 1 point per process. Full explanation of why these processes are not commonly found in southern California compared to other regions in the U.S. = 2 points, 1 points each. 0.5 point will be given to a partial or vague explanation instead of 1 point. **Total score = 4 points.**
3	Choose a severe weather type that interests you or would most likely affect you in southern California, and describe at least three ways you can assess its hazards to protect yourself from it.	Correctly identifying and explaining three ways to assess hazards of a severe weather event, including real-world ways to minimize risk of being impact by these events = 3 points, 1 point for each assessment. 0.5 points will be given to partial or vague responses. **Total score = 3 points.**

Appendix F

Survey (to be completed after severe weather learning event):

Please indicate your alternative ID you used on the pre-test and post-test:

____

Please circle **one** of the numbers that **best** indicates how well you agree with the following statements regarding the severe weather learning event. Please provide a **brief** explanation for your answers.

1. Learning about severe weather was interesting to me.

   Strongly Agree 5 4 3 2 1 Strongly Disagree

   Please explain:

2. Learning about severe weather was meaningful to me.

   Strongly Agree 5 4 3 2 1 Strongly Disagree

   Please explain:

3. I was challenged by the severe weather learning event. *Challenge* refers to academic or intellectual challenge, which is the mental energy required to learn the material and participate in the learning event activities. *Greater challenge is linked to higher engagement during the learning event*.

Strongly Agree 5 4 3 2 1 Strongly Disagree

Please explain:

4. During the severe weather learning event, I was distracted by things not related to the activity.

Strongly Agree 5 4 3 2 1 Strongly Disagree

Please explain:

5. During the learning event, I was so absorbed that time seemed to pass quickly.

Strongly Agree 5 4 3 2 1 Strongly Disagree

Please explain:

6. I am able to retain/remember concepts of severe weather from this learning event.

    Strongly Agree 5 4 3 2 1 Strongly Disagree

    Please provide an example of a concept that you easily remember (if any):

7. I am able to apply concepts of severe weather in my life more easily due to this learning event.

    Strongly Agree 5 4 3 2 1 Strongly Disagree

    Please provide an example of a concept that you can apply to your life (if any):

Appendix G

Dear Student,

My name is Jason Finley, a student pursuing a PhD degree. I am requesting your support in my dissertation research. As part of your support, you are given an opportunity to participate in this research to understand better how students learn about weather in community college courses. Your participation is voluntary but extremely beneficial in helping instructors teach meteorology and related sciences more effectively.

The objective of this study is to investigate how students learn through various teaching techniques. The hope is to improve teaching through learning tasks focused on specific weather events. During this research we will examine your knowledge of severe weather before and after the event in class, followed by a short survey completed during the next class period. Your participation in this research will NOT affect your grade in this course. In addition, you will earn extra credit for your participation.

All names and other personal identifiers will remain confidential. In any event, you have the right to refuse or withdraw at any time during any part of this study without penalty or impact on your grade in this course.

If you are willing to participate in this project, please sign this form and submit to your professor. You will be given a copy of this form to keep. If you have any questions at any time during this study, you may contact me via email (finleyjp@piercecollege.edu) or phone (818-610-6555), my senior advisor (Dr. Terry Keeney) at tkeeney@lesley.edu, or Lesley University's Institutional Review Board at irb@lesley.edu.

I have been given information about this research study and its risks and benefits and have had the opportunity to ask questions and to have my questions answered to my satisfaction. I freely give my consent to participate in this research project. I also certify that I am 18 years of age or older.

______________________________________ _______________

Signature (and print name) Date