Abstract

In recent years, there has been much debate on the best means by which to educate students. Specific to science education, many instructional approaches and reforms have been implemented, and yet American students’ interest, and performance in the sciences continues to wane, especially at the middle and secondary levels. This study explored the impact of Applied Learning on teaching and learning in science at the middle school level.

To address the aim of this study, one central question was explored: What is the experience of middle school science classes teaching and learning within an Applied Learning context? The ways in which participants experienced science education during Applied Learning units of study were documented through detailed personal accounts, namely individual and focus group interviews, as well as classroom observations. A qualitative approach was appropriate to this study as it allowed the researcher to explore and conceptualize the ways in which teaching and learning were affected by this methodological approach.

Through case study analysis, the researcher identified four superordinate, and nine subordinate themes. These themes aided the researcher in developing the following conclusions: 1) Connections to the community engaged students with real-world issues, and agents; 2) Scientific practices allowed students to ask and answer their questions, and to function as contributing scientists; 3) The nature of the work associated with Applied Learning units of study was authentic, and allowed students to apply their knowledge and skills; 4) Students were actively engaged, learned more deeply, and empowered to pursue future scientific endeavors as a result of their experience with Applied Learning.

The findings of this study may be of interest to a number of individuals, the obvious
being teacher educators, school administrators, curriculum developers, and of course, middle level science teachers. The knowledge garnered from this study could prove useful in curriculum planning, and has the potential to positively impact students’ attitudes toward and learning in the sciences at the middle level and beyond.

Key words: Applied learning, science instruction, science education, science teaching methods
Acknowledgements

I dedicate this thesis to my good friends and mentors, Robert and Elizabeth Preti. The Pretis have not only provided me with inspiration, they have also provided limitless encouragement and support. This is an endeavor I would not have begun, nor completed without them.

I thank my family, including my parents, for always believing in me. Special thanks go to my wife Meghan, and our three children, for enduring my physical, and often mental absence during the lengthy and difficult process of developing a thesis, and the years of coursework that predated it. I truly appreciate your unwavering patience and tolerance. I love you all.

I would like to thank the participants for their role in this study. I could not have completed the study without them. I appreciate their thoughtful and honest responses, as well as the time they generously gave to my research.

Of course, I must thank Dr. Karen Reiss Medwed, for her expert advice and encouragement throughout thesis development. I could always count on Dr. Reiss Medwed to answer my questions and assuage my fears with haste. I simply cannot thank her enough for her expertise and backing. Also, thank you to my second and third readers, and members of my defense team, Doctors Valerie Taylor, and John Wironen, for their time and thoughtful feedback.

Finally, I’d like to acknowledge a special teacher, Dr. Kenneth Nye, who passed not long after our time together at the University of Southern Maine. Dr. Nye inspired me with his personal stories, his poetry, his raw honesty, and most of all, his extreme humility despite his obvious greatness. He proved to me that the thoughtful, quiet type could become an exceptional school leader. Undoubtedly, his example put me on my path.
# Table of Contents

## Chapter One: Introduction
- Research Problem 7
- Justification for the Research Problem 8
- Deficiencies in the Evidence 8
- Relating the Discussion to Audiences 9
- Significance of the Research Problem 10
- Positionality Statement 12
- Central Question 15
- Theoretical Framework: Activity Theory 15

## Chapter Two: Literature Review
- Process-oriented inquiry 18
- Hands-on learning 19
- High-stakes testing 20
- STEM-based education 21
- The Next Generation Science Standards 24
- Problem-based Learning and Project-based Science 25
- The Deweyan Perspective on Science Education 26
- Applied Learning 30

## Chapter Three: Research Design
- Research Question 35
- Methodology/Research Design 35
- Research Tradition: Case Study 36
- Researcher Bias 38
- Ensuring Protection 40
- Honesty and legitimacy 40
- Participant stake in the purpose of the study 40
- Participants 41
- Recruitment and access 42
- Data collection and management 43
- Data Analysis 44
- Trustworthiness 45

## Chapter Four: Findings and Analysis
- Participant profiles 47
- Relevant Themes 48
- Community Connection 49
Chapter One: Introduction

Interest in science at the middle school level is often limited. There are several contributing factors to this lack of student interest, however, the most significant limiting factor is the manner in which science is taught in most American schools (Swarat, 2012). Students are motivated to learn scientific concepts when learning units and their corresponding activities are tied to meaningful and authentic situations. Application of science knowledge and skills to real-world questions and problems results in increased engagement and deeper learning.

Exploration of this research problem is significant because, along with interest, academic achievement in the sciences is on the decline, and has been for some time. This is evidenced by American students’ performance on key measures of science literacy, including the Program for International Student Assessment (PISA). Numerous corrective actions have been taken to improve science teaching and learning in our schools, but few have proven effective.

The purpose of this study was to understand the experiences of seventh grade students and their teacher at Frank H. Harrison Middle School, as they participate in Applied Learning units of study. Specifically, this study focused on the participants’ perceptions of engagement and depth of learning during these units. Identifying learning activities that increase student engagement and deepen learning will inform middle level science teachers of best practices in their content area, and possibly improve teaching and learning in integrated and/or related subjects.
Research Problem

In response to concerns over the apparent lack of science interest and proficiency in American students, this study explored the use of an Applied Learning model for instruction, and how this model relates to the degree of student engagement and perceived depth of learning in science. To address the aim of this study, a single central question was explored: What is the experience of middle school science classes teaching and learning within an Applied Learning context?

Justification for the Research Problem

Performance on standardized tests designed to measure academic performance in science has shown that American students, most of which receive a traditional science education, lag behind their European and Asian peers. The PISA test, which is administered to thousands of 15-year-old students around the world on a three-year cycle, is designed to assess students’ scientific literacy, that is, their ability to apply science knowledge and skills. On the 2003 PISA examination, American students were ranked twenty-third internationally in science. The nature of this test, with its bent toward application of science knowledge and skills, puts most American students at an extreme disadvantage. In response to poor results in science achievement, a number of academic reforms have risen to the surface. Some efforts, such as those related to accountability measures, have been applied across disciplines.

A number of educational reforms have been recommended and implemented to improve teaching and learning in science. Some reform efforts have brought about positive change, while others have stymied progress toward excellence in science teaching and learning. Martin, et al. (2005) suggest teachers of science focus instruction on process skills and inquiry, specifically at
the elementary and middle levels. In addition to their push for emphases on process and inquiry, Martin et al. recommend student voice and choice, and meaning making through discovery; both are closely associated with Constructivism. Another Constructivist approach to teaching and learning is hands-on learning. Satterthwaite (2010) purports that learning in science is best when students manipulate objects, work collaboratively with peers, and are provided with opportunities to share and compare their findings with others. In an attempt to boost the science literacy of students, along with our nation’s economy, U.S. government officials and special interest groups alike have proposed STEM education as a solution with great promise (Drew 2011). According to Langdon (2011), job growth in STEM-related areas is three times greater than that of non-STEM areas, thus the push for STEM-based education is warranted. In their 2014 offering, Kennedy and Odell describe the critical elements of an effective STEM program, which they propose can increase academic achievement and engagement in students of science.

Deficiencies in the Evidence

Multiple searches of Applied Learning in science education turned up few relevant articles or studies. Many related articles can be found when searching Project-based Learning, and Problem-based Learning, but neither of these approaches to science education fully encompasses that of Applied Learning. Of the articles located on Applied Learning and science education, the vast majority were concerned with post-secondary education, where its use as an instructional strategy is likely to be more prevalent.

Moreover, no articles or studies were discovered that tied Applied Learning to middle level science students’ engagement and depth of learning. The paucity of research on the subject indicates an area of need. In recent years, students’ knowledge of and performance in science has
become a concern for government agencies, and private interest groups alike. From research and economic/educational policy standpoints, research into the efficacy of Applied Learning in middle level science education is necessary.

**Relating the Discussion to Audiences**

The findings of this study may be of interest to a number of individuals, the obvious being teacher educators, school administrators, curriculum developers, and of course, middle level science teachers. The knowledge garnered from this study could prove useful in curriculum planning, and has the potential to positively impact students’ attitudes toward and learning in the sciences at the middle level, and beyond. Furthermore, research findings may support the success of Applied Learning in seventh grade science classrooms at Frank H. Harrison Middle School.

**Significance of the Research Problem**

Middle school students often arrive in their science classes having developed a dislike of the subject. I know this because I have taught science to literally hundreds of elementary and middle school students in southern Maine over the course of my career. Each fall, I inherited students who professed their aversion to the subject. When I pressed further, many students shared that previous teachers had incorporated few opportunities for Applied Learning into their programs. Few students had engaged in laboratory experiences on a regular basis, and some reported only having completed one to two labs in the previous school year.

According to my students, the majority of their prior learning was either text- or teacher-driven. My personal experience was widely supported by the research. Two juggernauts in the field of education reform, Richard DuFour and Michael Fullan (2013), outline the criteria for the dynamic new learning environments that today’s students require and deserve. Among the
criteria are “irresistibly engaging...students and teachers”, and learning that is “steeped in real-life problems”. They, like other researchers, have noted that schooling has become increasingly uninteresting to students as they proceed through the grades (p. 18).

Of even greater concern is the apparent lack of science knowledge and skills demonstrated by many American students. This is compounded by the fact that time spent on the sciences is decreasing, especially at the elementary and middle school levels. A recent and sweeping change in education, the accountability movement, has had a significant impact on science education. Kozol (2005) and Anderson (2011), among others, have expounded upon the negative impact of high-stakes testing on science education. Both authors agree that our preoccupation with tests, which focus primarily on mathematics and literacy, has limited the time and attention given to other subjects, including science. Emphasis has been placed on improving teaching and learning in the subjects addressed by the Common Core State Standards, that is English language arts and mathematics. Although there has been a push for STEM education in recent years, there is evidence to suggest that the major motivation behind this curricular reform is more about economic stability and maintaining a position of global dominance, than engaging students and deepening their learning in the sciences.

Another problem has contributed to the lack of science interest and proficiency. American elementary and middle school teachers are typically trained as generalists; many lack science proficiency and thus confidence in teaching scientific content. These factors often influence teachers’ curricular decisions. Those who are uncomfortable with scientific concepts often depend upon instructional methods that are either text-based and teacher-driven, or research and report-based. Neither approach is wrong, if used on occasion, and balanced by more
active forms of learning. There is, however, research that suggests that when students participate in meaningful exploration of science concepts, and apply these concepts to real-world situations, that both engagement and learning deepen (Swarat, et al, 2012).

**Positionality Statement**

In sixteen years of teaching intermediate and middle level science, many of my students have expressed limited interest in the subject. Likewise, recent research has shown that while students generally think positively about the role of science in society, they often think negatively in regard to science education in their schools (Swarat, et al., 2012). I share the concern that a lack of student interest in science often translates to decreased science literacy, pursuit of future scientific studies and employment, and engagement in important societal issues. Swarat, et al. (2012) trace these negative student perceptions directly to instructional methods in schools.

I have long held the belief that teaching and learning are most effective when they are centered on real-world situations and problems. I motivated students to learn content that could otherwise be thought of as uninteresting by providing students with curricular units and activities that were engaging. For example, while teaching about major diseases in my biology course, I collaborated with a local pathologist and lecturer who shared his expertise with my seventh grade students. Likewise, while teaching topics related to the cardiovascular system, my students sponsored and volunteered at an American Red Cross blood drive, and dissected pig hearts and lungs, with the help of volunteer, medical professionals.

Over the years I have encountered many former students who have chosen to study and/or work in scientific fields. I am both pleased and honored that some have cited the
experiences I provided in my science class as defining moments in their lives. There is nothing magical about what I did as a teacher; I simply provided students with learning opportunities that captured and held their interest because they were authentic and meaningful. My motivation for conducting research into Applied Learning and science education is merely to validate what I can only support anecdotally at this time.

My teaching philosophy has definitely been shaped by my own experiences as a student of science. Having grown up in the 1970s and 1980s, the majority of my early learning in the content area was passive. Through middle school, teachers and texts were the primary sources of information; there were few opportunities for experimentation, exploration, and shared inquiry. Although I enjoyed my teachers and was naturally drawn to science, I was provided with few opportunities experience it. It was not until high school that laboratory experiments, hands-on, and problem-based activities became a regular part of my educational programming. These experiences in biology, chemistry, earth science, and physics, along with my personal interest in the subject matter, has everything to do with why I chose to continue my studies in science, and eventually become a science teacher. By the time I was a graduate student in education and a student-teacher of science, teaching methods had evolved, becoming increasingly hands-on, and inquiry-based. I am certain too, that my exposure to these approaches to teaching and learning helped shaped my beliefs as an educator and instructional leader.

I am certain that my personal and professional beliefs about teaching and learning in science have much to do with the decision to send my son to a science and technology-based charter school. Finn is a highly intelligent and curious young man, who has not always loved traditional learning. There have been times in his relatively short academic career, where he has
faltering, not because of his ability, but instead, his interest in the academic tasks he was asked to complete.

During his middle school years, my wife and I became concerned about his academic future; his level of interest in school had dropped significantly from fifth to eighth grade. We knew we needed to take action, and seek an alternative setting for his high school years. We also knew him as someone with an amazing ability to focus on tasks, but only if they engaged him, and had practical value.

Baxter Academy in Portland, Maine offers its students a learning environment that is both student-centered, and outward-looking. Subjects are integrated, and have application to the world outside of the school’s campus. Since beginning at Baxter in September of last year, I cannot recall a time when we have had to pester Finn to complete his homework. It is typically done before I ask. On the return trip from a day of skiing in New Hampshire, Finn shared that he liked school at Baxter. This is the first time I can recall him saying this since preschool, when he spent his days, not unlike at Baxter, creating.

Because of my personal and professional experiences with science education, I am sure I am positively biased toward Applied Learning and its effectiveness as an instructional approach. Machi and McEvoy (2009) warn of researcher bias, stating, “personal attachment also carries bias and opinion that can cause a researcher to jump to conclusions rather than arrive at a conclusion after methodical scholarly work” (p. 19). Though personal attachment does sustain a researcher’s passion, it can cloud his vision and mar his results. As Machi and McEvoy (2009) so aptly declared, “A biased researcher can only produced biased findings” (p. 19). Thus, if the research process has been compromised by bias, then the researcher’s work is all for naught. For
this reason, it will be important for me, as an educational researcher, to look beyond my own propensity toward Applied Learning in order to diminish any bias that may exist within me.

**Central Question**

What are the experiences of middle school science classes during an Applied Learning unit of study?

**Theoretical Framework: Activity Theory**

The main assertion of Activity Theory is that people make meaning and develop understanding through activity. By focusing on and completing an assigned or chosen objective, and through interaction with others and objects, people gain an understanding of their environments, and in schools, content. In simpler terms, people (subjects) interact with others and utilize tools, to achieve goals (objects), and are changed (learning) as a result of this experience.

Though Lev Vygotsky is often associated with Activity Theory, S. L. Rubinshtein originally developed it in the early twentieth century as a philosophical and psychological theory. A. N. Leontiev and his associates, known as the Kharkovites for the Ukraine town to which they fled from government persecution, refined Rubinshtein's theory by placing greater emphasis on people’s motives for participating in specific activities. The Kharkovites broadened the scope of Vygotsky’s mediated action theory by introducing human activity as the unit of analysis for individuals, groups, and objects within an environment (Yamagata-Lynch, 2010).

Leontiev’s greatest contribution to Activity Theory is the distinction between goal- and object-oriented activities. According to Yamagata-Lynch, “Object-oriented activity involves interaction among subject, object, motivation, action, goals, socio-historical context, and the
consequences and activity” (p. 21, 2010). The central idea is that activities change those who experience them, as well as their goals and motives for engaging in the activity. Goal-oriented actions, Leontiev purported, have less permanence because they are individually focused and lack the collective consequence of community-based, object-oriented activity.

Activity Theory framework has been used to examine a wide range of phenomena in equally diverse settings. Numerous studies in education have been conducted, with Activity Theory as the primary tool of analysis (Hashim and Jones, 2007). According to Gifford and Enyedy (1999), Activity Theory is an appropriate framework for investigating models of knowledge building. Scanlon and Issroff (2005) utilized Activity Theory to examine the use of technology and collaborative learning in higher education. Liaw, et al. (2007), used Activity Theory to explore attitudes toward e-learning. In the same year, Zurita and Nussbaum presented a conceptual framework and design method for the analysis of a mobile computer-supported collaborative learning system, also using Activity Theory.

Specific to this study, Activity Theory will be used to evaluate the impact of Applied Learning on student engagement and learning in a middle school science classroom setting. In their 2005 study, Scanlon and Issroff looked at the experiences of students and their instructors, as they utilized and interacted with technology-based teaching tools in a post-secondary setting. Similarly, I will use Activity Theory to examine the experiences of middle school students and their teacher as they take part in Applied Learning science units.

Activity Theory is commonly associated with qualitative research methodology, as it has often been used to study human behavior within specific contexts, including schools. In past studies utilizing Activity Theory, data has been collected through observation, interviews, and
documentary materials (Wilson, 2014). Wilson argues that researching an activity system, such as students in a classroom, is similar to a case study approach (p. 21, 2014). Since I observed students within a particular context, Frank H. Harrison Middle School, I selected case study analysis to examine the impact of Applied Learning on students’ perceptions of engagement and learning in a science classroom.
Chapter Two: Literature Review

Throughout the years, science instruction has undergone many changes. Educational reformers have attempted to improve science instruction by making it more authentic, that is, less like “classroom” science and more like “real” science. Instructional approaches, such as process-oriented inquiry, hands-on learning, STEM, and problem/project-based learning have moved science education closer to that ideal. While the aforementioned reforms have brought about progress, other educational reforms, such as the high-stakes testing movement, have stymied progress toward excellence in science education. In this section, I will elaborate on these reforms, and their influence on science education. Also in this section, I will identify intersections between specific reforms, as well as how some combine to form Applied Learning, which is the focus of this study.

Process-oriented inquiry

In their 2005 offering, Martin, et al. discuss the role of process-oriented inquiry in allowing teachers to integrate a Constructivist approach in their science classes. Unlike traditional approaches to teaching science, process-oriented inquiry, as its name implies, places the focus squarely on science processes, and to a lesser degree science content. Martin, et al. suggest teachers employ two distinct sets of science processes in designing units, lessons, and related activities (p. 15).

They refer to them as Basic and Integrated Processes. Basic Processes include, but are not limited to core scientific skills, such as observing, classifying, and measuring. These are essential skills that all elementary students should acquire in their study of science. Integrated Processes read more like the familiar five or six-step scientific method process that most
students learn in their elementary and middle years. Although process-oriented inquiry, as described by Martin, et al. (2005), covers familiar ground, it places emphasis on the application of science skills and processes, the importance of student voice and choice, and meaning-making through discovery, a hallmark of Constructivist learning.

**Hands-on learning**

Satterthwaite (2010) promotes hands-on learning as a means of improving teaching and learning in science. Her review of the literature uncovered evidence that hands-on teaching increases learning, achievement, attitude, skill proficiency, and language development in science. Following her review, Satterthwaite identified three factors that make significant contributions to the success of hands-on learning in science, they are: (1) peer interaction through cooperative learning, (2) object-mediated learning, and (3) embodiment.

Peer interaction is a major component of hands-on learning. Often when students engage in laboratory experiments, they do so cooperatively, either in pairs or small groups. Lev Vygotsky, as Satterthwaite (2010) points out, is credited with having created social-constructivist theory. This theory supports the notion that learning is a social enterprise, that is, people learn through interactions with others.

Closely associated with social-constructivist theory is object-mediated learning. Vygotsky also described the importance of objects, or “tools” as he called them, to the learning process. He believed that “technical tools” (physical objects) and “psychological tools” (symbols and signs) defined and shaped human activity, and went beyond merely facilitating it (Satterthwaite, 2010, p. 8). According to Satterthwaite, it is the manipulation of objects that
causes students to question and seek possible explanations for the phenomena they observe during experimentation.

Finally, Satterthwaite claims that learning is solidified when students make sense of and internalize experiences of manipulating objects, working cooperatively with peers, and discussing their findings with others. Embodiment could be described as the culminating step to hands-on learning: the moment at which new learning occurs, and observed phenomena is understood.

**High-stakes testing**

One of the most sweeping and significant reforms to affect the teaching of science is the high-stakes testing movement. In an attempt to improve our position in international educational rankings, we have adopted many of the policies associated with the Global Education Reform Movement (GERM). GERM is characterized by a focus on specific educational outcomes, increased emphasis on mathematics and literacy, prescribed curricula, the transference of models from the corporate world, and high-stakes policies designed to either reward or punish schools based on their performance (Sahlberg, 2010).

According to Kozol (2005), standardized test preparation and completion are adding up to a considerable amount of instructional time in many schools, especially those that have experienced failure. Most metrics focus heavily on mathematics, reading, and writing. While it is doubtful that anyone would argue that these are fundamental areas of study, by placing so much emphasis on these subjects, we are limiting and even excluding others. As a result, some American students are deprived of the humanities, sciences, and arts, and lack basic geographical awareness (p. 119). Such narrowing of the curriculum neither helps prepare our students for the
ever-shrinking global community and economy, nor the rapidly evolving technologies that play an increasing role in our everyday lives.

In his 2011 article on science education and test-based accountability, Anderson highlights significant moments in the history of science education reform. He notes that the end result of the high-stakes approach has been to limit the time spent teaching science, a reduction in instructional time devoted to inquiry, increased emphasis on the memorization of facts, and fewer connections with the science community.

Additionally, Anderson (2011) summarizes the findings of 35 empirical studies examining accountability and science education practice. Based on his study of the literature, Anderson makes several recommendations for improving accountability policy in science education. His recommendations specific to science education are as follows: (1) Make policy compatible with research-based efforts related to accountability, (2) Testing should encourage active learning and inquiry through performance-based questioning, (3) Place greater emphasis on science skills and reasoning, (4) Use multiple measures to assess learning in science, (5) Eliminate high-stakes testing in mathematics and English language arts to balance curricular emphasis. Perhaps most importantly, Anderson concludes that an active, inquiry-based approach to teaching and learning, can not only work within the high-stakes testing environment, it can actually increase engagement and academic performance.

**STEM-based education**

The recent focus on science, technology, engineering and mathematics (STEM) education has been influenced by several factors. Schools, systems, and government agencies have sounded the call for improved STEM education as a result of poor results on metrics such as the
Programme for International Student Assessment (PISA). Most recently, American 15-year-olds who completed the PISA ranked 28th in mathematics and 24th in science literacy (Kuenzi, 2008).

Economists and industrialists alike have noted the lack of American-born graduates within STEM-related fields. Foreign nationalists from countries such as China, India, Japan, and Taiwan, among others have fulfilled the demand for highly trained workers in science and tech-related fields (Drew 2011). Officials from institutions of higher education have noted a decrease in the amount of students entering STEM-related majors, as well as a large percentage of students abandoning these majors for less challenging areas of study. Many notable researchers, including Nobel Prize-winning physicist and Harvard professor Sheldon Glashow, believe “our people can’t hack it” (Drew, p. 23, 2011). There are numerous data points, including those gathered from PISA that substantiate Glashow’s hypothesis.

The STEM-loss phenomenon is occurring at a time of great need. With almost daily advancements in technology and the rapid increase of automation in production, medicine, and defense, there is high demand for a STEM-literate workforce. STEM literacy benefits its possessors as well. According to Langdon (2011), job growth in STEM-related areas is three times greater than that of non-STEM areas. In the decade from 2000 until 2010, STEM employment rose 7.9%, while non-STEM rose only 2.9%. STEM workers have higher earning potential, and with advanced degrees, less likelihood of prolonged unemployment (Langdon, 2011).

As stated above, STEM literacy has many economic benefits. Research by Kennedy and Odell (2014) not only supports this claim, it also provides evidence that STEM-based study
promotes the use of applied and collaborative learning, and can increase academic achievement and engagement in students. In their 2014 offering, Kennedy and Odell describe, in detail, the elements of engaging STEM education programs. According to the authors, the ten most engaging elements of STEM study are: (1) a rigorous math and science curricula, (2) the integration of technology and engineering, (3) a design and problem-solving focus, (4) the promotion of inquiry (questioning and investigations), (5) a hands-on/minds-on approach to materials selection, (6) learner outcomes that reflect current information, (7) a connection to the community and workforce, (8) an interdisciplinary/multicultural/ multi-perspective outlook, (9) the inclusion of formal and informal learning experiences, and (10) project-based learning.

Kennedy and Odell (2014) also make several recommendations regarding what they believe to be necessary changes to pedagogical approaches in order for STEM teaching and learning to be successful. They purport that pedagogy must be changed to meet the following conditions: (1) curricula that challenge students to innovate and invent, (2) teaching and learning that is problem and/or project-based with clear and specific outcomes, (3) experiences that are meaningful, exist within real-world contexts, and utilize applied and collaborative learning, (4) learning that is interdisciplinary, multicultural, and multi-view in focus, to show that STEM is universal in nature.

Although the articles summarized above cover seemingly disparate topics in science education, some important and connected themes develop when analyzing them through an Applied Learning lens. Several of the articles, including those by Martin (2005) and Kennedy and Odell (2014) reference the application of science skills and processes directly. Likewise, a number of the articles support the idea of collaboration in science learning. Satterthwaite (2010),
as well as Kennedy and Odell (2014), acknowledge the vital role collaboration plays in science
learning, as many hands-on experiences, such as laboratory experiments and engineering
challenges, which are designed to be completed in pairs or small groups. Both Anderson (2014)
and Kennedy and Odell (2014), in their articles on the influence of high-stakes testing and
engaging STEM education, respectively, discuss the importance of connecting science teaching
and learning to the outside world by situating learning in real-world contexts, and by making
connections with the scientific community.

The Next Generation Science Standards

The Next Generation Science Standards (NGSS) were established to improve college and
career readiness. The NGSS began as “The Framework”. The intent of this document was to
articulate a vision for K-12 science education, and to determine what students should know and
be able to do. However, there are several significant differences between the NGSS and prior
sets of standards. The NGSS emphasize inquiry, and include a set of engineering and design
principles, as well as cross-cutting standards. These characteristics are favorable, in that they
place significant weight on the processes of science, and not merely content standards (Pruitt,
2014).

According to Pruitt (2014), successful implementation of the NGSS will require a major
modification to the thinking of most science teachers. NGSS-based units must be comprehensive,
including multiple connections across disciplines, as well as thoughtfully integrated
opportunities for students to engage in inquiry and engineering/design practices. Teachers cannot
simply plan lessons day-by-day, and hope for continuity within a unit of study. The mindset shift
required to successfully implement the NGSS would necessitate significant professional
development, and time to rethink more traditional units. Despite the inherent challenges of change, Pruitt (2014) asserts that implementation is an achievable goal.

It is possible that, like STEM-based initiatives, the motivation behind the implementation of the NGSS is to grow the economy, and maintain relevance in the global science and technology market. The “Next Gen” standards do, however, place significant emphasis on inquiry, and the processes of science, as well as their connection to discovery. These facets of the NGSS correlate well with a Deweyan approach to teaching and learning in science. Inquiry, a focus on process over content, and discovery were all major underpinnings of Dewey’s philosophy as it related to science education.

**Problem-based Learning and Project-based Science**

Problem-based learning (PBL) has allowed some students to become engaged in real-world issues, outside of schools and classrooms. Uyeda, et al. differentiate between “real” and “school” science in their 2002 offering, *Solving Authentic Science Problems*. According to this research team, the school science approach is employed in most schools because it is efficient, and allows teachers to “cover” the maximum amount of content (Uyeda, et al., 2002, p. 24). PBL, by contrast, is centered on authentic problems. Content knowledge is developed simultaneously as students solve problems with the guidance of their teachers. In more traditional science classrooms, students may be presented with problems to solve, but only after the requisite knowledge and skills have been obtained. This is typically accomplished through teacher-driven lessons as part of a larger unit of study. Similar to current practice, PBL is standards-based, but the problems students solve are gathered from the headlines, past or present. Real-world data is collected and used, as students grapple with issues in collaborative groups.
Assessment methods are also authentic. Uyeda, et al. (2002) noted that, the more authentic the assessment, the higher the results. Other favorable characteristics of PBL are: Student-driven, outcome-based, clear performance objectives, connection between school and society, integration of content areas, and emphasis on self-reflection and assessment.

Project-based Science (PBS) is often referred to synonymously with Problem-based Learning in science, and in truth shares many of its principles. The hallmarks of PBS include the exploration of relevant, real-world questions or problems, the planning and execution of authentic investigations, and collaboration through various means to find solutions. Students are assessed through the creation of genuine artifacts, rather than traditional pencil and paper tests, and frequently utilize technology for creation, communication, and collaboration, not only with other students, but with community members and experts as well (Krajcik, 2015, p. 25).

Krajcik (2015) makes the point that PBS is natural and cohesive fit with the NGSS, which call for students to engage in inquiry, utilize data collected during investigations, create artifacts including models, and use technology to create products, collect information and disseminate it. Given the current educational climate of accountability, with its rigorous standards and measures, some may believe that PBS cannot be integrated into their curricula. Krajcik (2015) would disagree. He states, “In the explorations of real-world questions, the content cannot be separated from the doing of the science” (p. 27). Based on his assertions, a PBS approach to teaching and learning, may actually simplify the complex task of incorporating the NGSS into curricula, while simultaneously improving engagement, and deepening learning for students.
The Deweyan Perspective on Science Education

John Dewey is widely regarded as one of the most influential figures in American education. This philosopher, social reformer, and educator transformed the notion of public education through pragmatism, a concept fundamental to the Progressive Movement of the early-to mid-twentieth century. Dewey’s concept of education, as it relates to pragmatism, placed emphasis on meaningful and practical experiences. This approach to learning was a significant departure from the rote memorization and authoritarianism that characterized education in this age of industrialism. Dewey had many critics; they feared that students would not learn from experience alone, and that classroom order would be lost. It is likely that it is this reasoning, in addition to the increasing pressure of accountability that inhibits a progressive approach to teaching and learning, even to this day.

Though many are familiar with his general philosophies of education, few may know that Dewey wrote and spoke specifically on science education, the utility of which was debated in his time. On January 28, 1910, Dewey delivered a speech entitled Science as Subject Matter and as Method to the American Association for the Advancement of Science, on this very topic. The ideas contained within his speech were truly innovative and have much in common with the underpinnings of progressive science education today. In fact, it is likely that these contemporary approaches to science education drew heavily from Dewey’s work.

In this well-known speech, Dewey made a number of compelling arguments for including sound science education in the core curriculum. His primary argument for the inclusion of science was that it is a path to knowing. To Dewey, science was not a collection of facts to be memorized; instead it was a process to allow those who engage in it to better understand the
world, and as a means to contribute meaningfully to it.

Dewey’s thinking extended to the manner in which science should be taught. He had many criticisms of the pedagogy of his era. The greatest of these criticisms, had to do with the delivery of science education. In his 1910 speech, Dewey stated, “Science teaching has suffered because science has been so frequently presented just as so much ready-made knowledge, so much matter of fact and law, rather than as the effective method of inquiry into any subject matter” (Dewey, p. 125). According to Dewey, science was more about the process of learning, which included meaningful and engaging experiences, and was less about the gathering of discrete items of information. Dewey said it best in his concluding remarks. He declared, “When our schools truly become laboratories of knowledge-making, not mills fitted out with information hoppers, there will no longer be need to discuss the place of science in education” (p. 127). Dewey may have been endorsing science education when its inclusion among the core curricula was up for debate, but in doing so, described a novel way to approach teaching and learning in science.

Another major tenet of Dewey’s philosophy is the critical role experience plays in science education. In fact, Dewey once stated, “All learning comes about through experience” (Ansbacher, 2000, p. 224). In recent years, practitioners have interpreted Dewey’s reference of “experience” as hands-on learning, or the mere inclusion of laboratory experiments in the curriculum. For Dewey, experience meant something different, and much deeper. When he spoke of experiences, Dewey was referring to genuine life experiences, not those fabricated by well-meaning teachers.

Wong and Pugh (2001) have analyzed Dewey’s writings on experience in science
education. According to Wong and his colleague, Dewey contended that educational experiences should not be choreographed, that they must arise from interactions with the environment. That is, schools must provide rich, worthwhile experiences in order for their students to learn well and learn deeply. Wong and Pugh describe such experiences as “dramatic events” (2001, p. 319). They believe dramatic events cause students to formulate ideas, and these ideas can lead to action. Activities such as laboratory experiments and teacher demonstrations, Wong and Pugh purport, do not typically provide the drama necessary to spark ideas and action. The process students go through, from anticipation to consummation, is where the learning occurs. As students witness the unexpected, questions arise, curiosity is piqued, and action is often the result. In the words of Wong and Pugh (2001), “effective teaching should be about creating anticipation in students, such as engaging students in ideas” (p. 322). This is the very essence of student-centered learning.

Expanding on Dewey’s ideas, Wong and Pugh make an important distinction between concepts and ideas. They put it simply, stating, “Concepts are something that students learn… ideas are something that seizes and transforms them” (p. 325). Wong and Pugh have some important recommendations for teachers in general, and science teachers specifically. The research team, along with their partners at the Dewey Ideas Group at Michigan State University, recommends that teachers create “drama” around content so students become engaged and form new ideas. Particular to science education, the team describes the real challenge that science teachers face; that is, to take concepts - those items that students must know and be able to do - and convert them into ideas. Wong and Pugh describe this process as the “reanimation” of concepts as ideas (Wong & Pugh, 2001, p. 326). Ideas, according to Wong, Pugh, and originally
Dewey, inspire students, as every important scientific discovery - every key scientific concept, began as an idea.

An idea that resonates with this researcher is a statement made by Wong and Pugh in their concluding paragraph. They state, “The good life, and all it connotes, is a life of worthwhile experiences. Life is about worthwhile experience; education should be too” (Wong & Pugh, 2001, p. 335). This declaration encapsulates Dewey’s theories around experience and ideas, their impact on teaching and learning in science, as well as the influence these components has on activating youth to become involved citizens.

In 2014, Rudolf revived Dewey’s well-known and often cited “Science as Subject Matter and as Method” speech from the previous century. In his journal article, Rudolf (2014) brings Dewey’s work into the current era, highlighting the fact that little in American public education has changed since Dewey’s remarks were delivered in 1910, and in some ways, the educational climate has worsened. Rudolf states, “Schools still fixate almost entirely on conceptual content…aiming to increase standardized test scores” (p. 1057). Rudolf continues his criticism of present day science education, claiming that the purpose of recent STEM efforts is to bolster the flat American economy and to maintain power on a global scale.

According to Rudolf (2014), Dewey’s intent behind promoting sound science education through experience and the formulation of ideas. In contrast to the current STEM movement, Dewey’s motivation for improving science education was not motivated by economics. Instead, Dewey’s aim was to engage students in meaningful experiences that would foster new ideas, and promote their participation in the democratic process. Simply stated, he wished for the recipients of experiential education to lead quality lives, and to participate meaningfully in their
government. Dewey believed they could do so by using sound empirical reasoning, in other words, a scientific approach based on observations that can be used in everyday life. Rudolf (2014) summed up Dewey’s intentions best when he asserted, “The alternative Dewey offered to this misplaced emphasis on ‘subject matter’ was to re-envision science education so that an understanding of the method of science was its proper outcome” (p. 1060).

**Applied Learning**

Applied Learning, as described by The Victorian Curriculum and Assessment Authority (VCAA) of Australia (2014) is defined by: (1) an emphasis on the relevance of what is taught to the real world, (2) the establishment of partnerships and connections with individuals and organizations outside of the school environment, (3) the valuing of students’ prior knowledge and skills, as well as their individual learning styles, and (4) the connection of school to the workplace. Much of the VCAA’s description of Applied Learning encompasses prior science education reform efforts of Process-oriented Inquiry, Hands-on Learning, Problem and Project-based Learning, and STEM Education, to name a few. Likewise, the literature on these topics, as referenced above, shows that each method of science instruction has its merits; combined, these approaches resemble Applied Learning, and make for powerful teaching and learning.

Campbell, et al. (2011) have written extensively on Applied Learning in their native country of Australia, where this approach to teaching and learning has taken hold. Campbell and his associates describe the connection between Applied Learning and Constructivism, and define it as when a learner “appropriates knowledge and applies the knowledge to a real, non-academic, non-theorized problem” (p. 17). Their own literature review explores the earlier work of Calder
Campbell, et al. summarize Calder’s description of the key elements of Applied Learning. These elements include: (1) Students solving real-world, open-ended problems, (2) the integration of subjects, (3) students making changes occur outside of themselves, (4) varied and effective communication, (5) tangible results beyond grades, and (6) engagement in the “adult” community outside of school.

Campbell and his team conducted their own qualitative study of Applied Learning in an Australian middle school. As part of an Applied Learning pilot group, students designed physical education units to teach younger students at a nearby elementary school proper sport-related movement and technique. The middle school students involved in the pilot group chose the topic out of their intense interest in athletics and the outdoors. Campbell, et al. (2011) lead interviews of the pilot group’s participants. The vast majority of the students reported increased engagement in their education during the Applied Learning unit. Many acknowledged that they had worked hard, and learned, but had fun, while still addressing the standards their teachers set before them. Additionally, students claimed that they felt more confident in themselves and their ability to communicate with others as a result of their participation in the pilot group.

Pridham and Deed (2012) site a body of research, including Campbell et al. (2011) that establishes the need for increased student engagement during the middle school years. The Australian research pair argues that Applied Learning, with its community partnerships, has the potential to effectively engage middle school students in their studies. Further, Pridham and Deed (2012) make connections between Applied Learning and Dewey’s philosophies of education, notably his support of interaction, reflection, and experience – combined with an interest in, and connection to community (p. 36).
According to Pridham and Deed (2012), Applied Learning has benefits beyond engagement. Because of the many connections make with one another and outside community partners, Applied Learning emphasizes social learning. Social learning has ties to Constructivism, and the notable theorists Piaget and Bandura. What’s more, as students engage in Applied Learning projects they gain a variety of practical and relevant skills as they solve real-world problems (p. 37).

The pilot group referenced in the article by Campbell, et al. (2011), and Pridham and Deed (2012) consisted of students who were of lower socioeconomic status, and some were labeled as “at-risk”. Similarly, Applied Learning has been employed in other alternative settings, such as vocational schools in countries such as England and Australia (Campbell, et al., 2011, p. 18). While Applied Learning may increase the engagement, and academic performance of at-risk, and vocational students, it also has the potential to positively affect students in the typical American middle school.

Over the course of the last century, science education in American public schools has undergone significant change. Most iterations of American public school science education, have moved pedagogy toward authenticity, and away from the “drill and kill” methods which were characteristic of the factory model of education. More recent approaches to science education, including inquiry, hands-on, problem/project, STEM, and even NGSS-based learning, have placed greater emphasis on the processes of science, and have made learning in science more experiential, and thus true-to-life.

High stakes tests, such as the PISA, have uncovered the fact that American students perform poorly on assessments of science knowledge and skills. In recent years, the assessment
of students’ knowledge and skills in core subjects has also drastically increased. These assessments have primarily focused on literacy and numeracy, and as a result, science education has taken a backseat to these “core” content areas. In many American public elementary schools, including the one my children attend, science is only given a 30-40 minute block, whereas writing, reading, and math are each given a full hour, and sometimes more. Moreover, science is often not taught on a daily basis, and time for science is sometimes shared with social studies. That is, the two subjects are either taught every other day, or alternated by unit. Either way, the result is that students are getting a quarter of the instruction they are getting in the “core” subjects of reading, writing, and mathematics. It is no wonder why our students’ science knowledge and skills lags behind those in parts of Europe and Asia.

Science instruction in other countries such as Finland, is process-oriented. This, along with teachers who are true content experts, has proven a winning combination when it comes to student achievement. According to Australia’s Victorian Curriculum and Assessment Authority (2014), Applied Learning has been successful in increasing engagement in middle school physical education. In the same country, Campbell, et al. (2011) report increased academic performance for at-risk students in vocational programs. Thus far, however, I have been unable to find research linking increased engagement and academic performance for middle school science students participating in Applied Learning units of study.

In my review of the literature concerning recent trends in science education, I found that the most successful initiatives were those that increased the authenticity of learning. In the early part of the twentieth century, Dewey made appeals for learning by doing. In the time since, other initiatives, such as Inquiry-, Problem-, and Project-based learning have supported the notion that
science learning is best when experiences are true to life. Authentic learning involves solving real or realistic problems through design, experimentation, collaboration, and connections to the outside world. These same qualities could be used to describe STEM learning, learning organized using the NGSS, and finally, Applied Learning. The problem is, that most middle school science classrooms do not reflect what we know to be best practice, that is, learning that engages students with real science.
Chapter Three: Research Design

Research Question

The question central to this study is, What are the experiences of middle school science classes during an Applied Learning unit of study?

Methodology/Research Design

In order to understand the experiences of students and teachers engaged in an Applied Learning science unit of study, this study takes a qualitative approach rooted in a Constructivist paradigm. The chosen approach situates the researcher in the natural setting, allows him/her to act as the key instrument, and to utilize multiple methods for data collection while interacting directly with his/her participants (Creswell, 2013). During the data collection phase of this study, I was embedded in the classroom setting, as an observer, and was afforded the opportunity to interact with students and staff.

The primary focus of this study was to capture the “lived experiences” (Ponterotto, 2005) of the participants as they participate in an Applied Learning unit in their science classes. Of particular interest was whether or not Applied Learning improved student engagement and performance in science. Also of interest, was teachers’ perceptions of student engagement and performance while employing the chosen instructional approach. Interpretation of these experiences will provide an improved understanding of effective science education at the middle school level, as well as the potential for improving science teaching and learning at Frank H. Harrison Middle School, and beyond.

The ways in which participants experience science education throughout the Applied Learning unit of study was be documented through detailed personal accounts. The qualitative
approach was appropriate to this study because it allowed the researcher to explore and conceptualize the ways in which teaching and learning was affected by an Applied Learning methodological approach. As participants recounted their experiences during the interview phase of data collection, they constructed new meaning and gained greater awareness of effective teaching and learning in science education. Likewise, the researcher’s awareness of changes in these factors was heightened throughout the investigation. As Ponterotto (2005) points out, “the researcher, as well as the participant is changed in some way as a result of the dialogic interaction.”

**Research Tradition: Case Study**

The methodological approach chosen for this study was Case Study research. The purpose of this study was to give voice to a science teacher and his students, as they engaged in an Applied Learning unit of study. Case Study methodology was adopted because of the bounded nature of the study, as it occurred at a specific location, with specific participants, and within a specific timeframe. These characteristics define this research as an intrinsic, within-site study (Creswell, 2013).

According to Yin (2014), case study research is widely used in a variety of research fields, including psychology, sociology, political science, anthropology, social work, business, and education. It is best suited for research in which investigators seek to understand complex, social phenomena, and desire holistic, real-world perspectives of research foci. Case study research is often preferred when examining contemporary events, especially when relevant behaviors cannot be manipulated, as they are in experimental design. Such is the case while studying educational phenomena as they occur in real, live classroom settings. Case study
research shares characteristics with historical studies, however, case studies employ methods, such as direct observation and interviews, which are atypical of historical research. That is, case studies typically include empirical evidence in their data.

Case study research is preferable over other research methods while studying educational phenomena, such as teaching methods, because boundaries between phenomena and contexts within schools are often unclear. Other forms of research, namely experiments, seek to separate phenomena from their contexts.

In looking into the nature of science teaching and learning during an Applied Learning unit of study, this researcher must consider the context in which the teaching methods are used as an integral part of the study. Middle level learners are a unique population. Most are primarily concerned with social matters, thus instruction at this level must be made engaging, and relevant in order for it to carry any weight. Applied learning has great potential for making learning in science both engaging and relevant for middle school students, particularly those who attend Frank H. Harrison Middle School.

A key feature of experimental design is the limitation of variables. Within a case study, variables are many and not predetermined, as they are with experimental designs. The case study researcher considers many more variables than data points in his/her work. In exploring the impact of Applied Learning on teaching and learning in science classes at Frank H. Harrison Middle School, the critical variables will remain unknown to this researcher until classrooms are observed, and participants are interviewed as part of the case study (Yin, 2014).

In his 2014 offering, Yin makes a strong case for case study as a research method. Here he describes four key applications of case study research. The first is to explain causal links in
“real-world interventions that are too complex for survey or experimental methods”, the second application is to describe interventions in real-world contexts in which they occurred, the third application is to illustrate topics within an evaluation, and the final application is to enlighten situations in which the intervention has “no clear, single set of outcomes” (p. 19).

Each of the four applications described above, has a direct connection to this researcher’s topic of interest, in which the effectiveness of Applied Learning in science education at the middle level will be evaluated. Classrooms are complex entities. No two classrooms are the same, as myriad variables, including the very teachers, and students included within them, make each one a unique learning laboratory. This researcher can make general predictions about the outcomes of employing Applied Learning pedagogy, but in truth, cannot forecast the results of its adoption in science classrooms at Frank H. Harrison Middle School, with a specific unit, teacher, and set of students.

In this same volume, Yin (2014) also acknowledges the many criticisms of case study research. According to the author, the most common criticisms of case study research are: 1) it lacks rigor, 2) it is often confused with teaching cases, 3) it is not easily generalizable, 4) it can take too long to complete and may yield massive documents, and 5) it has “unclear comparative advantage” when likened to other research methods (p. 21). Yin goes on to dispel each of these concerns, but readily admits that case study research is complex and difficult to conduct properly. That being said, case study research remains the most appropriate method for this researcher’s focus. The complex nature of the educative process, with its multitude of variables, calls for a research method that is equally complex, and holistic in nature.
**Researcher Bias**

The researcher had two primary roles in this study. The first was to gather data in the form of thoughts, feelings, impressions, and experiences from the informants, namely the science teacher and his students. The second, and equally important role of the researcher was to interpret data in a way that allowed him to draw conclusions about the efficacy of Applied Learning as an approach to teaching and learning science at the middle school level. As a veteran middle school science teacher, this researcher had strong feelings about what makes for effective teaching and learning. These feelings were based upon a decade and a half of practice. Despite these firmly held beliefs, my role, as researcher was not to share personal experiences. In contrast, it was to make meaning from the experiences of others as they take part in the educative process.

For purposes of data collection, I was embedded within an authentic classroom environment. Again, I was already quite familiar with the faculty, specifically the seventh grade team of which I was a part for over a decade. In addition to teaching science, I also held the position of Team Leader, and was once the Science Department Chair as well. This was undoubtedly an advantage as an educational researcher. On the contrary, these positions are ones of relative power; this fact may have had some influence over the subjects. It is possible that some informants, specifically student-participants, may provide the researcher with responses they believe he wishes to hear in the focus group interview. I have formed relationships with some students, as the parent of a seventh grade student and community-based coach; this is at once a liability and an asset. Regardless, these prior interactions could have unintended consequences. This fact highlights the need for strategic sampling methods so as to ensure the
validity of the results of this study. While protecting participants, the researcher hopes to encourage ownership of the study through the interview and member checking process, allowing for a dialogue of sorts to take place.

**Ensuring Protection**

**Honesty and legitimacy**

Protecting the subjects of the study was of utmost importance to the researcher. This process was considered long before the commencement of the study, and continued throughout its duration. Considerations extended beyond merely safeguarding participants’ rights and confidentiality; it also concerned the establishment and maintenance of relationships with the informants, as well as care in preserving ethical treatment while engaging in dialogue with individuals and groups. Ethics were applied equally to the collection and treatment of data.

The researcher obtained the verbal consent of the participants prior to the start of the study. The researcher spoke openly and honestly with informants and reminded them of their right to dismiss themselves from participation in the study. Additionally, participants were informed of safeguards adopted to provide them with anonymity, and to guarantee their ethical treatment and sound overall research practices.

**Participant stake in the purpose of the study**

In order to legitimize the interview process, and perhaps more importantly, the study itself, it is critical that participants understand its relevance. To students, relevance could come from a sense that Applied Learning makes science more real or engaging, or in their terms, “fun”. To the teacher, relevance could develop from a sense that Applied Learning allows for deeper learning of science concepts, and perhaps a growing passion for the subject matter.
Shared enthusiasm, by researcher and informants alike, can only strengthen the results of the study.

Participants’ experiences with Applied Learning in middle school science were shared through responsive interviewing in dialogic process (Rubin and Rubin, 2012). This process increased their ownership of the research, as well as the results of the study. Another factor that may have provided informants with the motivation to participate was the notion that their voices would be heard, and combined, possessed the power to change the nature of science teaching and learning in their school, their district, and beyond, for years to come. Thus, it was critical that the researcher make known the potential benefits of the study. Such conversations around benefits, as well as risks of the study, provided the researcher with opportunities to support its legitimacy and authenticity.

Participants

Purposeful sampling was designated as the participant selection method for this study. The researcher chose a mid-career science educator who has experience with designing units that integrate hands-on learning activities, including laboratory experiments, independent projects, and group problem solving. Having been a colleague of the teacher-participant, the researcher was confident that he would implement an Applied Learning approach to an upcoming unit of study. The student-participants were willing members of the teacher’s seventh grade science classes who have, and will continue to participate in Applied Learning units of study. To some degree, the sampling method was also one of convenience, as both the teacher and student-participants are housed within the researcher’s former place of employment, and within close proximity to the researcher’s home.
The sample consisted of seven, seventh grade students who are members of the teacher-participant’s classes, and who have experienced Applied Learning units. This number of students did not represent the typical number of students in the teacher’s science classes, however, it did represent a fair cross section of his classes. Additionally, the seventh grade science teacher participated in the study, as his perspective as both deliverer of the curriculum, and assessor of student understanding and engagement was highly valued.

Admittedly, the sample size was limited. However, given that this researcher collected multiple forms of data as part of a case study, the quantity of participants yielded more than adequate qualitative data for a detailed analysis. Classroom observations, an individual, and focus group interviews were conducted as part of the data collection process, and resulted in robust data.

Past researchers have expressed concern over the validity of case studies due to their small sample sizes, and what they believe to be a lack of generalizability. The purpose of case study research in general, and this study in particular, was not to make generalizations to wider populations, but instead to add to existing theoretical propositions (Yin, 2014).

**Recruitment and access**

The teacher-participant was selected because he is known to be an outstanding science educator, who is current in his knowledge of content and pedagogy. In addition to his role as a teacher, he has established himself as a leader within the school, district, and beyond. In 2011, he was awarded the highest honor a teacher can achieve, the Milken Educator Award. Last year, he was also recognized as Maine’s Cumberland County Teacher of the Year. These accolades attests to the fact that he is a highly skilled, and well-respected teacher. As far as access is
concerned, the teacher-participant is employed by the Yarmouth School Department. We were
teaching partners for several years at Frank H. Harrison Middle School in Yarmouth, Maine. Mr.
Wood teaches life sciences to approximately 50 seventh grade students. I planned to interview
approximately 12 students from one of his two science classes, but may have interviewed as
many as 24, as I offered the opportunity to participate to both classes.

The researcher delivered a letter explaining the purpose, methods, and approximate time
required for the focus groups participation. The letter was shared verbally with participants prior
to commencement of the study. Included in this letter was notification that participants possessed
the right to withdraw from the study at any time, that confidentiality will be maintained, and the
potential risks and benefits of the study (Creswell, 2013). As an active community member,
former teacher in the school, and parent of one of their classmates, most participants knew the
researcher; familiarity likely provided a relative level of comfort for the participants.

During the interview processes, participants were asked to share their experiences as
deliverer, and recipients of an Applied Learning unit in science. The researcher’s intent was to
bring to light the participants’ perceptions of teaching and learning while utilizing and
experiencing this instructional approach, and to examine the level to which student learning and
engagement is improved through its use.

Data collection and management

The researcher depended upon three primary sources of data: individual and focus group
interviews, and direct observations of instruction within the classroom setting. Both interview
types were recorded by two distinct electronic means (Rubin and Rubin, 2012). Interviews were
held in person, at a private, on-site location. Each interview session lasted roughly sixty minutes.
The participants will be prompted by a limited number of questions; these questions will be reviewed with the participants prior to the interview sessions. As for direct observations of the classroom setting, an observational data collection instrument will be developed for recording purposes.

In addition to the aforementioned digital recordings, handwritten notes and analytical memos were taken and maintained by the researcher. Interviews were manually transcribed and stored digitally on a computer, as well as an external hard drive, both of which were stored at the researcher’s place of residence. Physical data was stored in a locked file cabinet, again at the researcher’s home. Access to data was limited to the researcher, and made available to participants upon request.

**Data Analysis**

Notes and audio files created during the data collection phase of research were organized, transcribed, and stored in a computer database, as well as an external disk drive for duplication. This external drive was kept in a locked file cabinet at the researcher’s home. Once notes from the interview sessions was transcribed, the researcher read, reread, and used his understanding of the data to formulate a description of the case and its context. Next, the researcher analyzed data from the individual and focus group interviews, and developed initial codes for it. Primary level coding focused on establishing common codes from the interviews of individuals.

After interviewing individual informants and a focus group, and conducting classroom observations, the researcher looked for connections between codes developed in the prior step in a secondary level of coding. Next, the researcher will use categorical aggregation to group these codes, and establish themes. After creating a word table to display the themes form each layer of
data collection, the researcher looked for correspondence between the categories. Finally, the researcher developed generalizations about the case (Creswell, 2013).

**Trustworthiness**

Three strategies were used to ensure the validity of this study: triangulation, substantial description, and member checking. Data was collected from a variety of sources, namely individual interviews, a focus group interview, and classroom observations. Multiple and diverse data sources provided for triangulation, that is, the researcher was able to compare and contrast his findings from one source with the others. Thus, one process enlightened the others.

Through triangulation, a significant amount of data was collected in the form of notes, which were transcribed, and then coded. Categories and themes arose from this multistep process, and finally, the researcher developed ideas and theories around Applied Learning in middle level science education. The multiple iterations of data collection and coding made the researcher intimately familiar with the workings of the science classes engaged in the study, and provided him with critical insights into the effectiveness of Applied Learning as an instructional approach. Extensive contact with student and teacher-participants in this study provided the researcher with detailed impressions of the participants’ perspectives. Direct observation experiences embedded the researcher in the classroom setting, and made him part of the teaching and learning experiences.

Finally, member checking was employed to test established themes and resulting ideas and/or theories with informants. This process ensured that the data collected during interviews and observed in classes was captured and coded accurately by the researcher. Additionally, this
allowed the informants to confirm or deny claims made by the researcher regarding the effectiveness of Applied Learning within the middle school setting.
Chapter Four: Findings and Analysis

Applied Learning methodology has been known to increase student engagement and improve learning among middle school students in physical education and alternative settings (Campbell, 2011, Pridham and Deed, 2012). Through this in-depth analysis, the researcher developed a thorough understanding of the experiences of both teacher and student as they participated in Applied Learning units of study within a middle school science setting. The results of this study shed new light upon Applied Learning, and how this instructional approach can positively impact teaching and learning in middle school science. Moreover, Applied learning methodology raised student interest in science, at a time when students’ interest typically tends to wane (DuFour and Fullan, 2013).

This purpose of this study was to explore the experiences of teacher and student as they participated in Applied Learning units of study in middle school science. Throughout the course of the school year, seventh grade students took part in units, and related projects, where they functioned as scientists in the field, all while tackling real-world issues in their community. To address the aim of this study, a single, central question was explored: What is the experience of middle school science classes teaching and learning within an Applied Learning context?

To investigate this question, the interviewer conducted classroom observations, a teacher interview, and a focus group interview of students. The teacher’s background and experience is discussed in the Recruitment and access section of this paper, and below in the Participant profiles section. The students who participated in the focus group interview represent a cross section of Mr. Wood’s classes; male and female students are as balanced as possible, given that there was an odd number of participants. Both teacher and students were asked several (ten)
similar questions, which provided the researcher with a basis for comparison for the teacher’s and students’ experiences.

Following the teacher interview, the researcher identified four superordinate themes, and nine corresponding, subordinate themes. The themes are as follows: 1) Community connection (1.1 Community involvement, 1.2 Community impact); 2) Scientific practices (2.1 Active questioning, 2.2 Problem-solving); 3) Nature of the work (3.1 Authenticity of the work, 3.2 Application of knowledge and skills); 4) Student engagement (4.1 Deep learning, 4.2 Investment in learning, and 4.3 Empowerment).

The themes listed above applied directly to the student focus group interview as well. There were many correlations between the statements of both teacher- and student-participants. The students were surprisingly articulate in describing their learning experiences in Mr. Wood’s classroom. The researcher was impressed by the high level of metacognition among the focus group.

**Participant profiles**

The researcher observed and interviewed a mid-career science teacher who is in his eighth year at Frank H. Harrison Middle School in Yarmouth, Maine. In addition to his role as science teacher, the teacher-participant instructs two math courses, and functions as both team and science learning area leaders. He has been recognized on a local, regional, and national level for instructional excellence. This recognition is the result of the many innovative units and projects he has designed and collaborated on with colleagues. These are learning experiences that have engaged his students in authentic science.
The seven students who participated in the focus group were all seventh graders, and pupils of the teacher-participant for both math and science. I conducted the 45-minute on-site, focus group interview during an end-of-the-day period, known as Enrichment Block. This is a non-instructional period set aside for students who wish to participate in band and chorus. Students who do one or neither Enrichment activity, have study hall. I scheduled the interview during this time to minimize any disruption their participation may have on learning. The students were a mix of male (four) and female (three); all elected to participate in the study after listening to my detailed description of it, and returning all necessary permissions.

**Relevant Themes**

**Community Connection**

During the teacher interview, a frequent topic of discussion was the connection between Applied Learning and community issues and agents. Community connection was identified as the first superordinate theme to arise from the teacher interview. As the teacher-participant pointed out, “a classroom can be thought of as having four walls,” however, what seems to engage students to a greater degree, is the teaching and learning that happens outside of these walls. It is unlikely that anyone would dispute that hands-on learning is a dramatic improvement over traditional textbook, pencil, and paper learning, however, connecting classroom and community to real, local problems and resources raises learning to a higher plane.

**Community Involvement**

Mr. Wood has turned to the headlines to find connections between the assigned curriculum, and issues and events happening locally, regionally, and beyond. Maine is known throughout the world for its seafood. Yarmouth, in particular, is known for its clams. In fact,
there is an annual, summer festival based on the clam. In recent years, the clam population has been on the decline, which has forced festival organizers to look to Canadian suppliers for stock in leaner years. Local scientists have been studying this issue, and its causes, and so have Mr. Wood’s students.

Mr. Wood took his students to Sandy Point, an estuarial beach located where the Royal River empties into Casco Bay. While conducting a survey of the area, his students found few clams, however, they found plenty of European Green Crab, an invasive species which has proven to be a serious threat to Maine’s shellfish. The Softshell Clams which once thrived in the area, are particularly susceptible to the invasive species. While at Sandy Point, students dug for clams, searched for Green Crab, and collected and recorded this data for analysis back in the classroom. These are experiences that simply cannot be supplanted by book- or classroom-learning.

In their study of the clam crisis, Mr. Wood’s students have not only interacted with the local environment and its issues; they have also had multiple opportunities to interact with local experts. These experts include Yarmouth’s Town Manager and Shellfish Warden, as well as researchers from the Downeast Institute, and the University of Maine at Machias. According to Mr. Wood, his students’ are able to learn more deeply by interacting with these experts. He admits, that his students can learn even more from them than him, given their high level of expertise with this content.

Together, with their teacher and guest-experts, Mr. Wood’s students are posing serious, relevant questions like, “Are these viable mudflats?” and “Why are clam populations on the decline?” Using real-world science skills and practices, they are seeking answers to these
pressing questions, and more. According to Mr. Wood, working alongside the experts allows his students to see that they are capable of making a difference, and of accomplishing the type of work required to save a species in peril, like the local Softshell Clam.

**Community Impact**

Real issues like Yarmouth’s decline in clam populations, allow Mr. Wood’s students to become involved in their community, and potentially, to impact it positively. Related to the shellfish population issue, Mr. Wood also introduced “the upweller project”. An upweller is a aquacultural device designed for the sole purpose of raising shellfish, such as clams. Mr. Wood and his students constructed and upweller, and have begun raising the “seed” into clams. By spring, they hope to have reared a batch of mature clams for release into the Royal River.

*Returning sophomores at work on the upweller.*
*(Photo courtesy Maine Educator, Dec. 2016)*

According to Mr. Wood, the upweller project is an engaging learning experience for students. Beyond learning, this project also presents students with the opportunity to solve a significant problem in their community. They have observed the devastating effects of human impacts, such as pollution, overfishing, and the introduction of invasives like the European
Green Crab. Through involvement with their community, and its agents, they also have been provided with the opportunity to stem the tide of species depletion in their “backyard”.

In the focus group interview, the students reported favorably on community involvement and impact. One male student said, “It’s definitely more interesting and relatable than before [past science classes]. It’s actually hands-on, and it’s related to our community.” He went on to say that they as students possessed the ability raise the population of clams in their area. This is vastly different from most middle school science projects, which for most may include making a poster board our slideshow presentation. There is nothing inherently wrong with such projects, as they do serve a purpose. However, projects such as these do not possess the power to impact the local ecosystem, and potentially, the economy.

![Students holding some of the young clams they produced using the upweller. (Photo courtesy Maine Educator, Dec. 2016)](image)

An Applied Learning approach to science instruction profoundly affects the nature of teaching middle school students. In traditional middle school science classrooms, teachers are the experts, and the primary source of information for students. Applied Learning shifts the focus away from the teacher, and places it squarely on the students. The students, as both Mr. Wood
and the focus group participants remarked, become the scientists, the researchers, the producers of new knowledge. This approach challenges the old model of the teacher; the teacher of Applied Learning, functions more as architect and facilitator of learning experiences. He or she must design authentic units, projects, and assessments, all while working with experts in his or her community to identify issues in need of solutions that students are capable of providing.

From my interview with Mr. Wood, I have identified the following salient points in regard to the superordinate theme of Community Connections: 1) Involvement in community problems has increased engagement, integrated scientific skills and processes into units, projects and lessons, and allowed students to learn more deeply; 2) Field experts add to both students’ learning experiences, and the teacher’s knowledge and skills; 3) With Applied Learning projects, students possess the ability to make a positive impact on their community.

The students who participated in the focus group interview supported Mr. Wood’s views on community connections. Students expressed great interest in the upweller project and clam flat study; they claimed that their interest was based on the relevance of the topic to their lives and their community. They admitted being bored by science instruction in the recent past, as it often lacked the relevance of this year’s course of study.

Education researchers have also cited the positive impact of community connections on student performance and engagement in science. Kennedy and Odell (2014) offered the ten most engaging aspects of STEM education; number seven on that list was “a connection to community and the workforce.” In his discussion of Problem-based Science, Krajcik (2015) also made the case for community involvement, touting it a viable alternative to high-stakes testing for improving student performance and engagement in science. Specific to Applied Learning,
researchers Campbell (2011), and Pridham and Deed (2012), discuss the need for increased engagement during the middle school years. All three propose that this can be accomplished by developing students’ interest in, and connection to their community.

Scientific Practices

Applied Learning is characterized, in part, by a connection to the real world, and the workplace (VCAA, 2014). This dovetails nicely with the NGSS, which emphasize scientific skills and practices. Embedded within Applied Learning units and projects, like the Sandy Point quadrat study, are essential scientific practices such as collecting, analyzing, and communicating meaningful data.

Active Questioning

Research of all kinds stems from questions. In science, observed phenomena often lead to questions, which require investigations, and the resultant data to answer. In most middle school science classrooms, this process would become known to students as the scientific method. Its steps would be memorized, perhaps for a quiz, or in some cases, applied to a contrived laboratory experiment, of which the results are already known by the instructor. This is not the case with Applied Learning units of study and their projects. Because Applied Learning units and projects are connected to the real world, the results are often messy, and the trajectory much less linear.

Real-world issues, such the decline of a species’ population inspire students to formulate questions. These questions have palpable gravity and urgency. Because their answers are important to students, they will work hard to answer them, and will inevitably develop some of their own. During the Sandy Point study, Mr. Wood’s students developed their own questions
regarding the loss of clams in that area. While interacting with local experts like the Shellfish Warden and Dr. Brian Beal of the Downeast Institute, students were able to seek answers to their questions, and begin to develop their own hypotheses. They could contrast this information with what they observed firsthand, while in the field.

During the focus group interview, one male student had this to say about his connection with local experts: “They tell you about their careers, but at the same time, they tell you about...different facts you’ve never heard before. And, you can actually ask them questions, rather than just getting told what you should know.” This student identified a key component of Applied Learning: learners within an Applied Learning setting possess the ability to seek answers to their questions, and in a sense, direct their own learning. Choice, and self-directed learning are known motivators for students, especially those at the middle and high school levels (Martin, 2005).

**Problem-solving**

According to John Dewey (1910), science is a “method of inquiry into any subject matter” (p. 125), and a means for promoting students’ participation in society (Rudolf, 2014). By engaging in actual issues affecting the local ecosystem, Mr. Wood’s students have utilized scientific skills and processes to attack these issues. Through Applied Learning projects like the upweller, students have participated in finding solutions to local issues; they have participated in, and positively impacted their community. Examples of their impact include not only the production of new clams, but the collection of hundreds of units of blood annually. Blood and its components that are used to save lives all throughout the region.
Authentic problem solving is not part of traditional teaching and learning in science. In typical middle school science classrooms, students collect facts, not data; they use their newfound knowledge to answer questions on worksheets and assessments, or to construct projects to demonstrate their knowledge and skills. The audience for these artifacts is the teacher, and if shared at home, families. The purpose of such artifacts is to assess learning, and the end result is a grade.

The traditional methods just described, contrast starkly with Applied Learning experiences, where students work to find solutions to actual problems occurring in their community. Mr. Wood said of Applied Learning, “...if you identify a problem in your community, the kids become the problem solvers…” When asked about the value of a problem-solving approach to teaching and learning, he had this to say, “It’s not that they’re going to make something, and then just throw it away,” referring to projects like posters and tri-folds. It is true, that Applied Learning is not about making something; it is about making a difference.

Excellent science teachers, as well as the creators of the Next Generation Science Standards, recognize the importance of integrating science skills and practices into instruction at all levels. Both parties know that students acquire new science knowledge best when they have opportunities to tackle real issues, observe and collect authentic data, and the ability to function as problem-solvers, instead of passive learners. Mr. Wood believes that his students are so engaged in Applied Learning units and projects because their work resembles that of the experts with which they have interacted. Their studies of clam and invasive species populations has actually contributed to the body of knowledge established by the local scientific community.
The students, too, see the value in doing “real” versus “classroom” science. They find themselves more enthusiastic about the subject of science than ever before, and are developing interest in related majors and careers for the future. Focus group participants also saw that their time “in the field” observing, collecting, and analysing, has helped them learn both science material and methods. They no longer struggle to recall abstract examples when it comes to assessments; they can draw upon firsthand experiences to answer challenging questions about ecology, or human body systems.

Researchers like Martin (2005) and Anderson (2011) have suggested that educators place greater focus on scientific skills and practices as a means for improving teaching and learning specific to this content area. Their advice may actually be sound. Students from countries such as Finland, where scientific practices and skills have priority over content, have posted scores far superior to those of their American counterparts on assessments such as the PISA (OECD; Kuenzi, 2008).

The development of questions and potential hypotheses are the cornerstones of scientific discovery. There has been extensive research around inquiry in science, and how it engages students in deep learning. Martin (2005), Anderson (2011), the authors of the NGSS, Krajcik (2015), and an assortment of Constructivist theorists support the idea of inquiry as the basis for learning, in general, and specifically for science. The very definition of science is “the state of knowing” (Merriam-Webster). The path to knowledge begins with a question, thus inquiry is paramount to learning in science.

Another facet of Applied Learning that relates to scientific practices, is the focus placed on solving real-world problems. The research of Kennedy and Odell (2014) names
problem-solving as one of the most effectual strategies for improving students’ academic engagement and performance in STEM-based science. Uyeda, et al. (2002), discuss an entire instructional approach, known as Problem-based Learning, where the focus of units is to solve authentic issues drawn from the headlines. As with Applied Learning, students develop content knowledge, while solving problems with the guidance of their teacher, and perhaps even outside experts. Regardless of the title the instructional approach is given, problem-solving is a powerful strategy for engaging students in high-level learning. Calder (2000), Campbell (2011), and Pridham and Deed (2012), all of Australia, each researched and authored articles on the powerful impact of problem-solving as it relates to Applied Learning, in a variety of educational contexts.

Nature of the Work

The nature of the work associated with Applied Learning is clearly different from that associated with traditional forms of learning. In my interviews with Mr. Wood and his students, I heard a great deal about the nature of Applied Learning, and the many positive effects it has had on teaching and learning at Frank H. Harrison Middle School. The Nature of the Work theme refers to the type of work students are asked to complete in their science class. This superordinate theme has has been subdivided into two subordinate themes: Authenticity, and Application of Knowledge and Skills.

Authenticity

There is a great deal of research that supports the notion that the more authentic the work, the more students are invested in it. Project-based, Problem-based, and Applied Learning all place significant emphasis on authenticity. Each of these instructional approaches has been successful, due in part, to the authentic nature of the work (Uyeda, 2002; Krajcik, 2015). Even as
far back as the early part of the twentieth century, educational theorists and reformers, like John Dewey were calling for authenticity in education. Dewey once stated, “All learning comes about through experience” (Ansbacher, 2000, p. 224). By experience, Dewey was speaking of actual interactions with the environment and those in it, not contrived laboratory experiments conducted in the classroom.

Mr. Wood and his students had a lot to say about authenticity. During a unit on human body systems, Mr. Wood invited local, first responders to instruct his students on the assessment of vital signs. This task is one that first responders, and health professionals perform on a daily basis, thus it is authentic by nature. Likewise, assessing the health of a clam flat has practicality, especially in a community famous for its clams. Learning to repopulate the dwindling clam population is, without a doubt a genuine task, one that offers a potential solution to a significant ecological issue.

During his interview, Mr. Wood commented on authenticity, saying, “That’s what applied science has students do...look into the process of science, not just the content. The textbook will give them the content. It’s the actual process I think we need kids to be doing.” He
continued to say, “That’s the neat thing, they are not just students of science, they are scientists themselves.” In a very similar statement, one student-participant remarked, “I feel like, instead of learning about science, we’re actually doing science.” Yet another student said, “With the upweller project, we learned about science that takes place in Yarmouth, actual issues...and, it’s connected to our lives, not something that happened 20 or 400 years ago, that for some unknown reason, we need to learn.”

The focus group participants also talked a great deal about science instruction in past years. All agreed that, prior to this year, science was largely text-based. One student explained how he used to simply “zone out” because the pattern of instruction was to watch a video or read, discuss and answer questions, and occasionally, complete a lab. He used a powerful metaphor to describe his boredom in science, “It’s like knowing your opponent’s every move.” Nods and verbal confirmation from the group indicated that his sentiment was shared.

A complaint that was echoed by many of the student-participants was that even when laboratory experiments were incorporated into instruction, they seemed disconnected from the content, and had little or no application to the world outside of the classroom. The lack of authenticity had a significant effect on the students’ motivation toward science; some even grew to dislike it. Unfortunately, as DuFour and Fullan (2013) pointed out, this is a trend as students progress from elementary to middle school, and beyond. It is a pattern that Mr. Wood hopes to disrupt with an Applied Learning approach.

During the classroom observation I conducted in Mr. Wood’s class, I learned that he and his students would soon be taking part in an authentic lab to add to their growing knowledge of the human body systems. Mr. Wood shared that he and his students would soon be participating
in a porcine dissection lab. From our interview, I also learned that Mr. Wood has expanded the lab over the years to include more guest-experts. Instead of a simple anatomical exploration, as the lab had originated, the dissection now includes stations where volunteer medical professionals (typically parent volunteers) lead presentations on the comparative anatomy of porcine and human circulatory and respiratory systems. This, coupled with the aforementioned visit by local emergency-medical crew makes for impactful instruction. He reports that from this experience, many students discover a desire to study related topics like anatomy and medicine.

**Application of Knowledge and Skills**

Martin (2005), Kennedy and Odell (2014), among others, discuss the importance of application to effective teaching and learning. Application provides students with contexts for their learning. For example, if students are instructed on invasive species, but never have the opportunity to interact with them in some meaningful and authentic way, there is little motivation, other than grades, for most to learn. However, if the context is invasive species diminishing shellfish stocks in the river that runs through your backyard, the motivation for and value in learning is inherent.

A common question posed to teachers, especially those of older students is, “Why do we have to do this?” However, when students are asked to apply science to real-world problems, questions like these become irrelevant. According to Mr. Wood, when searching for answers to questions like, “Is this a viable clam flat?” students utilize science skills and processes to gather data, analyze, and interpret it to make informed decisions. When attacking authentic issues like this, there is no wondering why it must be done; it is learning with an embedded purpose. A female student, who never liked science before this year, said, “I had never really applied it
[science] to my life outside of school.” Later in the focus group interview, the same student picked up where she had left off, stating, “It’s connected to things that are actually happening. Now, I’ll notice something in my garden or backyard, and say to myself, Hey, that’s photosynthesis, or that’s respiration happening!”

Concerned that maybe what the students were describing was their affinity for life science (over physical science), I asked a follow up question to tease out if it was subject matter or teaching practices that impacted interest. The participants agreed that their newfound interest had something to do with this year’s topics. However, they claimed that it was the authenticity, and application of science skills and processes that influenced their thoughts most. In fact, one student claimed the manner in which science has been taught makes up “95% of her feelings” toward the subject. Though this figure may be somewhat arbitrary, it captures this student’s belief that the strongest determinant is pedagogy, not subject matter.

The nature of work associated with an Applied Learning unit of study is vastly different from that of a traditional science unit. Applied Learning projects are not created for a teacher, nor to demonstrate understanding, nor to earn a grade. Instead, Applied Learning projects engage students in authentic scientific work. Students are not just learning about science; they are doing it. Due to the nature of Applied Learning units of study, teachers must plan differently than those who teach science in a more traditional manner. Science teachers who subscribe to this instructional method must be aware of current issues related to their content area, and be savvy when it comes to resources, both capital and human, as shrinking school budgets often fail to cover the costs associated with such involved projects and studies. This work requires a different skillset; again, it is more teacher-as-facilitator, instead of the “sage on the stage” found in
traditional, teacher-centered classrooms.

Mr. Wood’s students also recognized the difference between their studies this year, and those of past years. Several of the student-participants expressed a noticeable disconnect between their past science courses and their lives. This disconnect caused boredom for many student-participants; some grew to dislike science class altogether. The focus group identified a sense that they are now “doing” science, and no longer passively learning content for the sake of an upcoming assessment. Additionally, students expressed excitement when sharing their experiences digging for and collecting data on clams and Green Crab during the transect walk of Sandy Point. They felt similarly about the prospect of repopulating the Royal River, and surrounding bay with the clams they have been raising in the upweller. They believe that such experiences positively affect their ability to learn, and on a more basic level, to recall facts.

Authenticity and the application of knowledge and skills have proven to be motivating factors for students of science. These are key components of both Problem- and Project-based learning. The literature on these instructional approaches speaks favorably of the inclusion of authentic problem-solving, and the application of knowledge and skills, citing increased engagement, and a natural fit between content and process, which results in improved academic performance. In his 2015 offering, Krajcik states, “In the explorations of real-world questions, the content cannot be separated from the doing of the science” (p. 27). Uyeda, et al. (2002) also noted that, the more authentic the assessment system, which could include labs or projects, the stronger the results.
Student Engagement

To me, there is little more important to the success of students than engagement. In my sixteen years as a teacher of science, I observed firsthand the positive impact of student engagement on academic performance, behavior, and motivation for future science learning. The influence of student engagement on learning has also been widely researched. Researchers such as Anderson (2011), Campbell (2011), and Pridham and Deed (2012), have purported that active learning models like inquiry-based, STEM, problem/project-based, and Applied Learning, improve both academic performance and engagement in science. Based on the data collected from both the teacher- and student-participant interviews, I further divided the theme of Student Engagement into the following subordinate themes: Deep Learning, Investment in Learning, and Empowerment.

Deep Learning

As with the previous superordinate theme, there was strong correlation between the teacher and his students when it came to engagement. According to both parties, involvement in the community, its issues and agents, has been a major contributing factor to student
engagement. Mr. Wood reflected on his own experience as a child growing up in Maine. His proximity to the woods and ocean, made him an observer of his environment, and influenced his decision to include field experiences in his teaching. As his teaching evolved, he developed units and projects that would encourage his students to interact with the environment, to ask questions, and to seek answers, all while applying scientific skills and processes. These units and projects presented his students with rich learning experiences that increased the depth of their knowledge. In our interview, Mr. Wood said of community connections and learning, “Getting kids out into the community has made them more interested, more engaged...and, it deepens their thinking.”

Another aspect of Applied Learning that deepens the students’ learning is the connection with field experts. Throughout the year, Mr. Wood’s students have interacted with numerous field experts from doctors to shellfish wardens. Opportunities to learn and work alongside those in the field have provided Mr. Wood’s students with direct access to accurate and specific content, as well as a means for answering their questions. Human resources like those mentioned above have guided and informed the students’ work, helping to make it more authentic and impactful.

For most learners, direct experience is more powerful than mere representations. While text-based and teacher-directed learning has a place in the educative process, most students learn best by doing. This is no more evident than in the subject of science. It is one thing to read or hear about the impact of an invasive species; it is another thing entirely to observe it in your hometown. When it comes to assessing student learning, Mr. Wood has found that first hand experience is a game changer. He said, “They write about things they have actually done, and demonstrate a deeper understanding of content.”
Mr. Wood’s students agreed. In their own interview, one student stated, “...on a test, you can actually picture what’s happening.” Another concurred, saying, “If all you ever do is read or see pictures in a book, it’s a lot harder to learn, and easier to confuse.” She continued to describe the experience of actually holding clams and crabs while surveying Sandy Point Beach. A third said, “I think it’s [the content] learned better when we see it happening before us.” Yet another stated, “We can go deeper. If you’re actually seeing it happen, then you can relate to it, you’re able to learn more, and become more interested.” Based on their remarks, I have got to believe that these students, and likely many others, are learning deeply as they take part in such engaging instruction as members of Mr. Wood’s science classes.

**Investment in Learning**

To some, investment in learning could be considered a synonym for engagement. I, on the other hand, think of engagement, as students having great enthusiasm for, and a strong connection to their learning. To me, investment is related to students’ seeing the purpose for their learning, and the work that is associated with it. Investment can be evidenced by the students’ desire to continue their work beyond a lesson, unit, or project.

One way that Mr. Wood has promoted student investment is by creating projects that serve a real purpose. One such example is the annual blood drive he and his students host. The blood drive unit is part of their study of human body systems. As a part of the unit, the students learn about the many reasons blood is needed, and how it is used daily to save lives. Another component of the unit is the project every student must complete in order to demonstrate their understanding of blood compatibility, typing, components, or circulation. The choice of topic and format is up to the students, but the content must be accurate since they will be viewed by
Red Cross representatives, as well as community members who either volunteer to work the drive, or to donate blood. Students must also work a shift at the drive, so in essence, they too are running the event. Students greet donors, and direct them where to go, they are responsible for donor intake and accountability, they work the “canteen” where they feed and re-hydrate donors who have given blood, and monitor their status while waiting the required fifteen minutes before departing. Mr. Wood claims that the students are invested because they know their work, and interactions with donors will be on display for the community to see.

Projects on display at the annual blood drive sponsored by Mr. Wood’s students. (Personal photograph.)

As with the blood drive unit, Mr. Wood’s students know that their work at Sandy Point and the upweller will make a difference in their community. Their work, which has been featured by the local media, raises awareness of human impact on our fragile environment, and shows other children that their efforts can have positive ecological and economic impacts, among others. With both units, Mr. Wood sees students as sophomores and juniors return to work alongside their younger counterparts. Some of Mr. Wood’s former seventh graders who were extraordinarily invested in the upweller have received local grant funds to continue studying
issues related to area shellfish populations. This same group, who voluntarily do this work under Mr. Wood’s direction, is on a short list to potentially receive a grant from NOAA. Anyone who knows fifteen- to sixteen-year-olds, knows that they do not typically volunteer to do additional academic work unless they are completely invested in the work. This example illustrates that when students are engaged in meaningful learning activities, they will work hard, learn more deeply, and become more invested in what they are asked to do. With such a preponderance of evidence in support of Applied Learning, it is with great wonder that I question why educational reform as it relates to science, has not included discussion of Applied Learning at the middle school level.

During my observations of Mr. Wood’s classroom, he introduced a project called the “Disease of the Week” project. It is an independent study of a disease or disorder; its purpose is to expand students’ knowledge of diseases and disorders during their study of human anatomy. Mr. Wood presented the requirements of the project, as well as resources students could use to gather information to complete the graphic organizer he had also provided to them. The class ended with independent work time on the project, while Mr. Wood confirmed topics with students during one-on-one conferences.

From the “Disease of the Week” project, and subsequent presentations, students learn of the cause, effects, and treatments of various diseases (as well as any personal connections to the disease or disorder), and from the vital signs lab, student learn how to assess the functioning of the circulatory and respiratory systems. Once again, from such interactions with health and safety professionals, students are not only learning about content, they are learning about potential, science-based careers as well.
According to the The Victorian Curriculum and Assessment Authority (VCAA) of Australia (2014), Applied Learning is described as having: (1) an emphasis on the relevance of what is taught to the real world, (2) the establishment of partnerships and connections with individuals and organizations outside of the school environment, (3) the valuing of students’ prior knowledge and skills, as well as their individual learning styles, and (4) the connection of school to the workplace. Both the porcine dissection lab, and DOW project fit one or more of the elements from VCAA’s description of Applied Learning. These projects underscore the importance of relevance and community involvement to providing engaging teaching and learning experiences in middle school science.

**Empowerment**

If we reflect on the early history of public education in America, one of its original aims was to empower this nation’s citizens - to involve them in the democratic process. Over time, we have come to know that education possesses the power to enrich our lives, and provide us with increased opportunities to prosper. Applied Learning expands upon the already impressive list of positive impacts of education, by engaging students in science, and as a result, developing in them the desire to pursue it as a course of study and/or career.

One of the reasons Mr. Wood decided to invest his time and energy into developing Applied Learning units of study is because he disliked the statistics he had heard related to American students’ declining interest in science as they progress from elementary to secondary education. Related to this issue, he stated, “I don’t want to be one of those science teachers who’s made the numbers drop. I actually want to increase them! One of the things I’ve seen from
our work is students really getting hooked [on science]. I still have sophomores working with me three years later, who are looking into how we can repopulate clam flats in our town”.

Mr. Wood sends students and their families an annual survey to help him identify what aspects of his teaching are working, and those that are not. He claims that students often respond that their seventh grade year, with its Applied Learning units of study, is the first they have enjoyed science. Additionally, many report that because of their experience with Applied Learning units and projects, they are considering college majors and careers in scientific fields. Mr. Wood reported this with a great deal of pride, as any teacher realizing his or her impact would.

Some students have become so inspired that they have decided to leave Yarmouth’s middle and high schools for charter schools with a science focus. These are bittersweet moments for Mr. Wood, as he knows he is partially responsible for the departure of these students. Yet, at the same time, their leaving represents the highest compliment a teacher could wish for. He recalled the experience of having to write a recommendation for a former student who left Yarmouth for the Maine School of Science and Mathematics (MSSM). It was with great enthusiasm that he recommended this female student for MSSM; she became interested in computers during her work with Mr. Wood in seventh grade science. According to Mr. Wood, she is thriving at her new school, despite the fact that the campus is located in remote Limestone, Maine, four-and-a-half hours from home. This is a powerful testament to the capacity of Applied Learning, and its ability to empower students, particularly those at the middle school level.
Future Scientists

Focus group interview participants believe that their experiences with Applied Learning have positively influenced their feelings toward science as a course of study, both now, and in the future. Furthermore, they expressed an increased interest in science-based careers beyond their college years. Many discovered potential, future careers from their interactions with guest-experts connected to this year’s Applied Learning units and projects.

“I would actually like to study stuff like this in college, but at a more advanced level,” said one student. Another added, “It would be fun. I’d want it to be engaging, and not just looking at books.” From the participants’ responses, it would appear that Applied Learning units and projects have made them hunger for authentic, scientific learning experiences like those they have engaged in, in their seventh grade year. More than one participant said they would like their future studies to resemble theirs from their seventh grade year, but more complex and in-depth. Assertions like these demonstrate the difference an approach to teaching can have, not only on student learning, but also on attitudes toward a subject, and the potential for future studies, and even careers.

Several members of the focus group shared their thoughts about the potential of a science-based career. One participant attributed his recent interest in science-based careers to the many guests speakers and volunteers who have enriched his class. He claimed that the guests provided information relevant to the topic at hand, but more importantly, they shared interesting facts about their jobs. Exposure to science-related jobs has piqued his interest in the field, and encouraged him to pay closer attention in class. The participant felt as though he could apply his newfound science knowledge to a future career in the field. In other words, the information was
relevant and practical, therefore it had interest. Another student commented on the impact of Mr. Wood’s science class on his career outlook. He said, “Last year, I wouldn’t have even thought about a career or major in biology, and now it’s opened me up to it.” A female classmate followed that up, stating, “I honestly didn’t even know what biology was. Now, one of the careers I’m considering is a doctor.” Another student said, “It’s definitely formed a new [career] pathway from what I had previously thought,” and another still said, “I would agree that it has opened up new options for jobs for me.”

With moments until the end of the school day and the focus group interview, a female student interrupted the conversation, and stated, “I feel like what we’ve been talking about is how biology is interesting, but really I think it’s more about how we’ve been taught this year. If we had learned astronomy in this way, we might have been more interested in it.” I followed up with a clarifying question, “So, some of it is the method, and not just the content?” All replied, “Yeah,” in agreement. Another female student continued, saying, “I think any kind of science, taught in this way, would be interesting.” In unison, the focus group replied affirmatively.

According to the teacher and students involved in this study, Applied Learning has had a significant, positive impact on engagement in science. In terms of engagement, I learned the following from my interview with Mr. Wood: 1) Applied Learning units and projects increase students’ desire to continue their science learning; 2) Interactions with area experts not only provides students with accurate and current information, it piques their curiosity about scientific careers; 3) Students are empowered to become involved in their community, and to see themselves as problem-solvers.

In speaking with the student-participants, I learned that Applied Learning units and
projects are, simply stated, “more fun”. These units are often cross-curricular by nature, and thus strengthen connections to other subjects, and require a wide range of skills. Guest-experts create greater interest in and enthusiasm for science topics, as well as future studies and careers. Most students report being more likely, after having experienced Applied Learning units of study, to pursue college majors and careers in science. Perhaps the greatest byproduct of Applied Learning is the sense of empowerment that students feel when working alongside experts in identifying and solving real issues in their community.

Much has been written about factors affecting student engagement. While this study does not have engagement as its primary focus, it was a major topic of discussion in the literature review, and the analysis of both interviews. The work of Campbell, et al. (2011) and Pridham and Deed (2012), supports both the need for academic engagement, specifically at the middle school level, as well as the notion that Applied Learning increases academic engagement. Campbell and associates’ 2011 study pertained to middle school physical education students who participated in an Applied Learning unit. The results of their study showed a greater affinity for, and increased engagement in the subject, greater confidence in communicating with outside groups, and deep learning tied to academic standards. Based on my research, there is reason to believe that Applied Learning has the same positive impact on teaching and learning in middle school science in rural New England. In their research, Pridham and Deed (2012) noted the connection between Applied Learning and Constructivism. According to the Australian research pair, Applied Learning emphasizes social learning and the value of genuine experience, both underpinnings of Constructivist learning theory, and deeply connected to the work of well known theorists Piaget and Bandura.
Concept map of themes.
Chapter Five: Discussion

The specific research question this study sought to answer was: What is the experience of middle school science classes teaching and learning within an Applied Learning context? The researcher performed case study analysis, which enabled him to better understand the experience of participants as they engaged in Applied Learning units and project, as part of the seventh grade science curriculum at Frank H. Harrison Middle School in Yarmouth, Maine. This study relied on the accounts of both teacher- and student-participants, as well as the researcher’s own observations of instruction, to gain a better understanding of their lived experiences.

Summary of Findings

My exploration of the literature on Applied Learning uncovered examples of its ability to increase student engagement and performance in unique learning environments, including alternative and physical education settings. There was, however, limited evidence that Applied Learning had been studied in relation to middle school science instruction. This inspired my research question, and subsequent study.

Interviews with Mr. Wood and his students at Frank H. Harrison Middle School demonstrated that Applied Learning has the potential to positively impact both teaching and learning in middle school settings. Both the teacher and his students described increased engagement, and improved learning as a result of their participation in Applied Learning units and projects. Students described being able to recall facts more readily after authentic learning experiences; more so than following traditional approaches to learning, such as reading, listening to a lecture, or completing worksheets. Student- and teacher-participants responded similarly to questions regarding the nature of the work associated with Applied Learning; both believe that
students learn best by doing. This notion is supported by Constructivist Theory. Applied Learning units of study are based on real-world problems, and often include exposure to experts from the field. Both characteristics heightened students interest, according to the participants. The authenticity of these issues leaves little doubt as to the relevance of the work.

Exposure to Applied Learning seems to have an effect on students’ long term interest in science as well. Many of the student participants wish to continue their studies throughout, and beyond high school. Some even professed an interest in science-based careers in the more distant future. They claim that this desire is the result of their exposure to field science experiences, like the Sandy Point survey, and the upweller, in addition to projects and labs such as the blood drive and porcine dissection.

A favorable byproduct of student engagement in Applied Learning, is empowerment. Students who were once unsuccessful in, or even loathed science, have discovered they can thrive in it, and envision their involvement with it in the future. For some, their experience with Applied Learning has been potentially life-altering, as they contemplate scientific majors and careers.

**Application of the Theoretical Framework: Activity Theory**

Due to the social nature of the learning that took place within the context of this study, the researcher employed the theoretical lens of Activity Theory, developed by Vygotsky and Rubinshtein (Yamagata-Lynch, 2010) in the early part of the twentieth century, to further examine the participants’ experiences. Activity Theory is commonly associated with qualitative research methodology, as it has often been used to study human behavior within specific contexts, including schools. Several studies of classroom instructional practices, such as those by
Scanlon and Issroff (2005), Liaw, et al. (2007), and Zurita and Nussbaum (2007), utilized Activity Theory as the primary tool for analysis.

Again, the main assertion of Activity Theory is that people make meaning and develop understanding through activity. By focusing on and completing an assigned or chosen objective, and through interaction with others and objects, people gain an understanding of their environments, and in schools, content. In simpler terms, people interact with others and utilize tools, to achieve goals, and are changed as a result of this experience. As was stated in Chapter One, the central idea of Activity Theory is that activities change those who experience them, as well as their goals and motives for engaging in the activity.

Seventh grade science students at Frank H. Harrison middle school have worked to better understand a specific ecological problem in their community. Additionally, with the guidance of their teacher, and local experts, they have experimented with a possible solution to shellfish species depletion in the Royal River and adjoining Casco Bay. As a result of their participation in these Applied Learning activities, and others like it, Mr. Wood’s students have been changed for the better. Factors influencing this positive change included connections between their work and community-based issues and agents, cooperative problem solving with their teacher and peers, and the sense that their work had both personal and practical significance.

The positive transformation in the students’ thoughts and feelings toward science from last to this year was repeatedly supported by their own assertions. When asked their experiences this year, one student-participant remarked, “It just makes me want to do more science...I wish I could learn like this forever!” Some have even expressed a newfound desire to work in the sciences following college.
Of course Mr. Wood’s students have gained new knowledge about local environmental issues, the roles of organisms within a specific habitat, and the negative impacts of human activities. Moreover, his students have learned to enjoy and appreciate science, and its role in making their community a better place in which to live. Many of his students have developed a recent passion for science, and plan to pursue it in some form in the future. Perhaps most importantly, Mr. Wood’s students have experienced a sense of empowerment through Applied Learning, a sense that they can contribute to a growing body of scientific knowledge, now and in the future, and possess the knowledge and skills to make a difference in their world.

John Dewey once said, “All learning comes about through experience” (Ansbacher, 2000, p. 224). Dewey’s belief aligns closely with Activity Theory. He understood that thinking is changed, and that new learning occurs through lived experiences, or activities. According to Dewey, science is not a collection of facts to be memorized; instead it is a process to allow those who engage in it to better understand the world, and as a means to contribute meaningfully to it. That is exactly what Mr. Wood’s students are doing when exploring problems and solutions tied to the Softshell Clam and European Green Crab populations in their community.

At one point in America’s educational history, the utility of science education was actually debated. Some wished to abolish science education from the core curriculum, presumably to make way for other, more critical subjects. This is not so dissimilar from today’s educational climate, with math, language arts, and reading taking precedence over subjects like science, social studies, and the arts, those subjects not measured by local, state, and national assessment systems (Rudolf, 2014). Focus on the core subjects of math, language arts, and reading has been proposed and supported as a means for improving America’s public education
system, however, when you consider the importance of science knowledge and skills to solving current global environmental crises, or to our ever-growing dependence on technology, science education has never been more important.

In his 1910 speech in support of science as a part of the core curriculum, John Dewey said, “Science teaching has suffered because science has been so frequently presented just as so much ready-made knowledge, so much matter of fact and law, rather than as the effective method of inquiry into any subject matter.” When viewed as a “method of inquiry” for all content areas, one could argue that there is no more important subject for us to invest in.

However, despite what Dewey proposed over one hundred years ago, despite what we know about the success of science education in countries like Finland, and despite what studies have shown us about the potential for Applied Learning to positively affect teaching and learning, science education in America, by and large, remains unchanged. There are those few, shining examples of true excellence in science education, classrooms where authenticity and application are embedded in everyday activities, but, unfortunately, they are few and far between.

**Implications for Further Research**

In my preparations for this study, I conducted extensive research around Applied Learning and science education at the middle school level. I was surprised to learn that there were very few articles on the matter. This void created a niche for my own research, but it pointed out that more knowledge is required on the effects of Applied Learning on the educative process in general, and specifically to teaching and learning in science. I believe the two to be a perfect combination for impactful instruction.
I learned from my time with Mr. Wood, and his students while at Frank H. Harrison Middle School, that Applied Learning can positively impact student engagement, their love and depth of learning, their disposition toward future scientific endeavors, and their belief in themselves as community problem-solvers. My experience with the teacher- and student-participants makes me wonder how Applied Learning might be used in other content areas, such as the social sciences, and at other instructional levels. Applied Learning has been employed at the secondary level and in alternative settings with success, but I am unaware of its implementation at the elementary level. From my interactions with the seventh graders at Frank H. Harrison Middle School, I have reason to believe that an Applied Learning approach to elementary science would be equally well received by students, and would yield similar results.

During both interview, the participants spoke of the lasting effects of Applied Learning on student interest in science. Mr. Wood discussed how several of his students cited their experience in his class as a motivating factor for their continued interest in science. Many of the student-participants claimed that they, too, planned to engage in science courses and careers in their future as a result of their experiences with Applied Learning units of study. Of great interest to me, is whether or not these experiences translate to actual longevity in the sciences. By tracking high school course selections, and college majors over time, one could potentially test this hypothesis in a future study.

One possible limitation to this study is that it was conducted in a coastal Maine suburb. Some readers may think it difficult to replicate the conditions described with certain Applied Learning units and projects in an urban setting, for example. I would argue that similar issues exist in a variety of settings, and that regardless of school resources, community involvement is
possible. Many urban schools subscribe to Expeditionary Learning, and it too incorporates community issues and involvement into subjects, including science.

In addition to the setting of the study, some may be concerned by the homogeneity of the focus group. Though the group was fairly well balanced, in terms of the participants’ gender, the participants were not ethnically diverse. This sample group reflects the homogeneity of the study’s setting. It is unknown whether or not the results of the study would be vastly different in a more diverse setting. That said, I believe an Applied Learning approach to teaching and learning science would increase student engagement and performance in most, if not all settings, and for diverse groups of learners.

**Implications for Practice**

The results of this study, coupled with the literature on Applied Learning, support it as a viable method of science instruction at the middle school level. Applied Learning units of study focus on real-world issues; they promote community connections, student inquiry and discovery, and authentic problem-solving. The presence of these attributes has resulted in deep learning, active engagement, and prolonged interest in science in current and former students of Frank H. Harrison Middle School.

Embedded within the Next Generation Science Standards are cross-cutting concepts. These concepts get to the heart of science skills and processes, which clearly deserve greater attention in our nation’s science curricula. Some states, including Maine, initially rejected the NGSS, and thus many school districts have not fully implemented the associated standards and practices. Though the NGSS have their critics, they do emphasize science skills and processes, they reduce the amount of content to be “covered” by teachers, and increase the depth with
which topics are investigated. This approach to teaching and learning in science resembles closely that of countries such as Finland. Countries known for their strong performance on the PISA (OECD; Kuenzi, 2008). With their focus on scientific skills and processes, the NGSS also support the type of teaching and learning connected to Applied Learning.

The foundation of Applied Learning is community involvement. Repeatedly, the teacher- and student-participants referred to their connections to community issues and agents as critical factors influencing teaching and learning in science. The literature on Applied Learning, and other, similar approaches to instruction, spoke of the power of community connections over the educative process.

I recommend that teachers of science, at all levels, develop at least one unit per year that has a strong connection to the local community, its people, and its issues. While planning new units of study, teachers should also consider ways in which to make learning relevant, and meaningful to students. They might also consider ways in which to involve local officials or field experts in their planning. I would strongly encourage teachers to take learning outside of the classroom, and into alternative settings, where “real” science is done.

Of course, teachers cannot do this work in isolation, without substantial support from administration. School leaders must facilitate community involvement in order for students to become involved real issues that exist outside of classrooms and schools. Partnerships must be formed with surrounding organizations, business, and institutions. Successful student endeavors need to be publicized in order to garner community support. It takes a great deal of organization, planning, and effort to successfully implement such complex units of study. In order for teachers to embrace this type and level of work, they must be given adequate resources, most importantly
In addition to temporal resources, school and curriculum leaders must carefully consider curricular materials. A good start would be to explore resources, like *Mystery Science*, that are already aligned with the NGSS, include inquiry-based laboratory experiments for students to perform, and would allow for connections to the community, its issues, and resources. A great deal of professional development time and money has been invested in English-language arts, reading, and mathematics instruction in recent years; perhaps more schools and districts could formulate goals around improving science instruction by increase engagement through community connections.

Science methods courses within teacher preparation programs must begin to reflect what is known about best practices in science education. In order to be certified as a K-8 teacher in Maine, I was only required to take a single science methods course. The course was taught by a local third grade teacher. She was a strong science teacher; one who promoted inquiry as an essential component to science education. We did not, however, explore other methods of teaching, such as Problem- or Project-based Learning, much less Applied Learning. Current and future courses should explore alternative teaching methods, in order to expose pre-service science teachers to new ways of designing learning experiences.

In Chapter One of this paper, I eluded to the fact that American teachers of science are often ill-prepared to teach science due to their own lack of science knowledge and experience. Having been an elementary teacher, and now principal, I can attest to the fact that few elementary teachers have a science background, and many are uncomfortable teaching the subject. Although I did not major in science as an undergraduate student, I at least earned a
minor in biology, and returned for post-baccalaureate coursework in the sciences before entering graduate school in education. I have read extensively on teacher preparation of science educators in Finland. Finnish science teachers attend many of the same courses as those who enter engineering and medicine; they are true content experts.

Having a strong background in science allows teachers to go deep into content, and to avoid the proliferation of misconceptions in science. Teachers’ lack of science expertise is not lost on students. In fact, during the focus group interview, one student remarked, “I feel like, sometimes, some teachers don’t really have any knowledge other than what they read [in the textbook]...like they can’t tell a story that relates to the unit.” Although this statement did not fit into the themes presented in the analysis section of this paper, it supports, rather strongly, the notion that many elementary and middle level teachers are ill-equipped to teach science. This is significant because teachers who lack strong content knowledge rely upon teaching methods that are primarily text-based. The student-participants were clear that they disliked and disengaged with science classes taught in this manner because these classes resembled all of their others. One participant described her science experience from the previous year, stating, “Last year, it would be like read the passage on page 35 and answer the questions below. But, this year, it’s literally hearing from people - experts, and talking to them.”

Colleges, universities, and certification offices should consider more rigorous requirements for teachers of science at the elementary and middle levels. This should apply to both content and methods courses. As the literature and this study pointed out, we are losing students to boredom in and disdain for science, science that is taught using outdated and ineffective methods.
Implications for the Researcher

I am currently the Principal of a PK-6 grade community school in rural Maine. Students in kindergarten through sixth grade receive science instruction, most from their homeroom teachers, within self-contained classrooms. Few, if any teachers have a science background, making it difficult for many to plan for science instruction effectively without the support of curricular materials. Because so few are well-versed in science, instruction has been largely text-based. Students have typically done research to learn about topics, such as animals or planets, as they would for any other subject.

I recently learned about a web-based instructional resource called Mystery Science. Mystery Science is a video and inquiry-based science program for students in kindergarten through grade five. The units are fully aligned with the NGSS; each unit includes at least one, related laboratory experiment, as well as fully customizable formative and summative assessments.

The program is wildly popular among those who access it, and from what I can ascertain, it is also highly effective. I was so impressed with the program that I offered to present on it, with the help of two pioneer teachers, at a recent district professional development day. I integrated some of the theory behind why it works into my introduction of the program, then allowed the teachers to demonstrate how a Mystery Science unit works. Those in attendance were also given the opportunity to register for the program and begin planning their first unit of study. My district’s Assistant Superintendent, who is responsible for curriculum development, received a great deal of positive feedback about the program and our presentation in a follow-up survey.

Although the program may not yet incorporate elements of Applied Learning, as outlined
in this paper, they could certainly be introduced. The first step to full implementation is for my staff to embrace this research- and standards-based program, that engages students in science topics. The next step, will be to encourage and facilitate connections between these units and community issues and agents. My goal as a school leader, and scholar-practitioner, is to take what I have learned from my study, and incorporate it into professional development within my current and future settings. I believe that all students, regardless of demographics, and geographics, deserve an outstanding science education.

**Conclusion**

Extensive research into the literature surrounding science education uncovered that student interest and performance in the sciences diminishes during the middle school years in America. This is the time in students’ academic careers when science instruction becomes increasingly content-based, and less about exploration and discovery. In countries where science is more process-oriented, students have thrived, and performed well on standardized assessments, such as the PISA.

With the release of the Next Generation Science Standards, there was hope that science instruction would become process-driven, rather than content-driven. Unfortunately, in most schools, science teaching methods have remained unchanged. Few education reformers have adopted an Applied Learning approach to instruction. In studies of Applied Learning in England and Australia, this teaching method has shown to increase academic engagement, and improve learning. In this researcher’s study, it was discovered that an Applied Learning approach had similar effects on learning in a middle school science environment. The teacher-participant reported increased levels of engagement, and academic performance in his students. His former
students continue to work on projects they began with him in years prior, and an increasing number of his past students are exploring college majors and careers connected to science and technology.

The positive attributes of Applied Learning discussed in the teacher interview were echoed by the focus group. The student-participants very clearly articulated the differences between past experiences with science instruction, which were largely teacher-driven and text-based, and this year’s Applied Learning units of study. With obvious excitement, the students shared their work researching dwindling clam populations in their community, its causes, and a possible solution via the upweller project. Students cited the strong connection between their community, its issues, and resources, as some of the major reasons science has become so exciting to them, and a subject they plan to pursue in the future. Prior to working within an Applied Learning context, most reported feeling bored with, and disconnected from their learning in science.

Students also reported that Applied Learning helped them to learn science content. They claimed that they no longer struggle to answer questions or recall examples when an assessment is given. According to students, it is not difficult for them to recall facts and examples when they have “done” the science. Prior to Applied Learning, the students described recall as being difficult. This was compounded by the disconnect they felt between their studies in science, and their lives outside of the classroom. Given both the topics and methodologies, learning just did not seem relevant. Within an Applied Learning context, with myriad connections to community, science learning matters, and is seen as a means for solving real-world problems in their backyards and beyond.
The literature on Applied Learning, and the findings of this study support the notion that students learn best when they are engaged in meaningful and authentic work. Over one hundred years ago, John Dewey proposed a radical method for teaching that was based on experience; he described it as, “learning by doing.” In the interest of our students - our future policymakers and scientists - the prosperity of our nation, and the well-being of our planet, we must catch up with Dewey’s century-old thinking.
References


Sahlberg, P. (2012, 09; 2013/6). Quality and equity in Finnish schools: A Finnish education ambassador shares how his country's school system ensures all students have access to quality instruction, sans constant testing. 69, 27+.


Wilson, V. (2014). Examining teacher education through cultural-historical activity theory. 
Teacher Advancement Network Journal, 6(1), 20-29.

317-336.

systems analysis methods (pp. 13). New York: Springer US.

doi:10.1007/978-1-4419-6321-5

Sage.
Appendix A - IRB Approval

NOTIFICATION OF IRB ACTION

Date: January 12, 2017  IRB #: CPS16-11-14
Principal Investigator(s): Karen Reiss Medwed
                          Mark McDonough
Department: Doctor of Education Program
           College of Professional Studies
Address: 20 Belvidere
         Northeastern University
Title of Project: Applied Learning in Middle School Science: A Study of
                Teacher and Student Experiences
Participating Sites: School Permission letters forthcoming
DHHS Review Category: Expedited #6, #7
Informed Consents: One (1) signed parent/guardian consent and child assent form

Monitoring Interval: 12 months

APPROVAL EXPIRATION DATE: JANUARY 11, 2018

Investigator’s Responsibilities:
1. The informed consent form bearing the IRB approval stamp must be used when
   recruiting participants into the study.
2. The investigator must notify IRB immediately of unexpected adverse reactions, or new
   information that may alter our perception of the benefit-risk ratio.
3. Study procedures and files are subject to audit any time.
4. Any modifications of the protocol or the informed consent as the study progresses
   must be reviewed and approved by this committee prior to being instituted.
5. Continuing Review Approval for the proposal should be requested at least one month
   prior to the expiration date above.
6. This approval applies to the protection of human subjects only. It does not apply to any
   other university approvals that may be necessary.

C. Randall Colvin, Ph.D., Chair
Northeastern University Institutional Review Board

Nan C. Regina, Director
Human Subject Research Protection

Northeastern University FWA #4630
Appendix B - Teacher Recruitment Letter

February 2, 2017

Dear Mr. XXXXXXX:

I am conducting a research study entitled *Applied Learning in middle school science: A study of teacher and student experiences*, and as the this title suggests, I am examining the impact of Applied Learning on teaching and learning at the middle school level. As you know, Applied Learning is an approach to teaching that emphasizes the relevance of what is being learned to the world outside of the classroom. You have designed units and projects, such as the upweller and blood drive, that fit this description.

Participation in the study will require a group interview of student-participants, which will last approximately 45 minutes. This interview will take place on campus during a non-instructional period. I also wish to conduct two brief interviews with you, lasting about 25 minutes, and complete two classroom observations.

The results of this study may be published in scientific research journals or presented at professional conferences. However, your name and identity will not be revealed and your record will remain confidential. To protect the identity of participants, I will use pseudonyms when referring to specific students.

Participation in this study will not benefit you directly. However, your participation may benefit school leaders, teachers, and other students by providing insight into the benefits of Applied Learning. You can choose not to participate. If you decide not to participate, there will not be a penalty to you or loss of any benefits to which you are otherwise entitled. You may withdraw from this study at any time.

If you have questions about this research study, you can contact me at XXXX or the Principal Investigator, Dr. Karen ReissMedwed at XXXX. If you have questions about your rights as a research participant, you can contact Nan C. Regina, Director, Human Subject Research Protection, 490 Renaissance Park, Northeastern University, Boston, MA, 02115. Tel: ####, Email: XXXX Please reference IRB #: 1197254. You may call anonymously if you wish.

Sincerely,

Mark E. McDonough
Doctoral Candidate, Student Researcher
Northeastern University, College of Professional Studies
Appendix C - Student Recruitment Letter

December 10, 2016

Dear Seventh Grade Student:

My name is Mark McDonough. I am the parent of a seventh grader, a former HMS teacher, and Doctoral student at Northeastern University in Boston, Massachusetts. I am conducting a research study with your class, and am asking for your participation. My study is entitled Applied Learning in middle school science: A study of teacher and student experiences, and as the title suggests, I am examining the impact of Applied Learning on teaching and learning at the middle school level. Applied Learning is an approach to teaching that focuses on the connection between what is being learned to the real world. Your teacher, Mr. XXXXXXXX, has designed units and projects, such as the upweller, that fit this description.

Participation in the study will require a group interview, which will last approximately 45 minutes. This interview will take place here at HMS during a non-instructional period. I will be accompanied by Mr. XXXXXXXX during the interview session. In addition to the group interview, I will be interviewing Mr. XXXXXXXX, and conducting two classroom observations, but neither of these activities should impact your learning. The risks to you as a participant are minimal. These include missing study hall time, or perhaps a band or chorus session, with your teacher’s permission.

The results of this study may be published in scientific research journals or presented at professional conferences. However, your name and identity will not be revealed and your record will remain confidential. To protect your identity, I will use pseudonyms (false names) when referring to specific students.

Participation in this study will not benefit you directly. However, your participation may benefit school leaders, teachers, and other students by providing insight into the benefits of Applied Learning. You can choose not to participate. If you decide not to participate, there will not be a penalty to you or loss of any benefits to which you are otherwise entitled. You may withdraw from this study at any time.

If you have questions about this research study, you can contact me at mcdonough.mar@husky.neu.edu or the Principal Investigator, Dr. Karen Reiss Medwed at XXXX. If you have questions about your rights as a research participant, you can contact Nan C. Regina, Director, Human Subject Research Protection, 490 Renaissance Park, Northeastern University, Boston, MA, 02115. Tel: ####, Email: XXXX. Please reference IRB #: 1197254. You may call anonymously if you wish.

Sincerely,

Mark E. McDonough
Appendix D - Student Assent

December 10, 2016

Dear Seventh Grade Student:

We are doing a study to learn about Applied Learning in middle school science. Applied Learning is an approach to teaching that focuses on the connection between what is being learned to the real world. We are asking for your help because we don’t know very much about how kids learn in science classrooms where this approach is used.

If you agree to be in our study, we will ask you some questions about your learning in science class. We want to know how you would describe your learning and interest in science. For example, we may ask you to describe your experiences with science this year.

You can ask questions about this study at any time. If you decide at any time not to finish, you can ask us to stop.

The questions we will ask are only about what you think. There are no right or wrong answers because this is not a test.

If you sign this paper, it means that you have read this and that you want to be in the study. If you don’t want to be in the study, don’t sign this paper. Being in the study is up to you, and no one will be upset if you don’t sign this paper or if you change your mind later.

Sincerely,

Mark E. McDonough
Doctoral Candidate, Student Researcher
Northeastern University, College of Professional Studies

______________________________________________
Signature of person agreeing to take part

______________________________________________
Date

______________________________________________
Printed name of person above

______________________________________________
Signature of person who explained the study to the participant above and obtained consent

______________________________________________
Date

______________________________________________
Printed name of person above
Appendix E - Parent Consent

Signed Informed Consent Document - Parents  
Northeastern University, Department: College of Professional Studies  
Name of Investigator(s): Dr. Karen Reiss Medwed (Principal Investigator), Mark E. McDonough (Student Researcher)


Informed Consent to Participate in a Research Study
We are inviting your child to take part in a doctoral research study. This form will provide you with information about the study. Additionally, the Student Researcher will explain it to your son or daughter. Your child may ask the Student Researcher any questions s/he has. Your son or daughter does not have to participate in this study. If you decide to allow your child to participate, please sign this document. The researcher will make a copy for you to keep.

Why am I being asked to take part in this research study?
Your child is a middle school student whose teacher has planned Applied Learning units of study in science.

Why is this research study being done?
The purpose of this study is to learn about the impact an Applied Learning approach has on learning for middle school science students.

What will I be asked to do?
If your child participates in the study, s/he will be asked to take part in a single focus group interview session. During the focus group interview, students will be asked 5-6 open ended questions about their learning in science class.

Where will this take place and how much of my time will it take?
The focus group session will last approximately 45 minutes, and take place during a non-instructional period (Enrichment Block). Additionally, the Student Researcher will be observing two class lessons, each approximately 50 minutes. The focus group session will take place in a nearby, empty classroom at Frank H. Harrison Middle School, and will be supervised by an adult observer. Classroom observations will take place in Mr. XXXXXXXX’s classroom.

Will there be any risk or discomfort to me?
N/A

Will I benefit by being in this research?
There is no direct benefit to participants. However, the information learned as a result of this study could help teachers and school leaders to determine the kind, and quality of science education that will most benefit their students.

Who will see the information about me?
Participants’ role in this study will remain confidential. Only the researchers of this study will see the information gathered during data collection. No reports or publications will use information that can identify participants in any way, or any individual as being part of this project. To protect the student-participants’ identity, the researchers will use pseudonyms when referring to specific students.

The focus group interview will be recorded using an electronic recorder for later transcription. This recording will be maintained for a period of two months, while the researcher is compiling and analyzing data, and writing up his findings. During this process, the recorder will remain at the student-researcher’s place of residence, under lock and key. Once this process has been completed, the data will be erased from the device as further protection to the participants.

**If I do not want to take part in the study, what choices do I have?**
Participation in the study is completely voluntary. There is no penalty to not participating.

**What will happen if I suffer any harm from this research?**
N/A

**Can I stop my participation in this study?**
Even if you consent, your child can stop participating at any time. If students decline to participate, or decide to quit, no rights, benefits, or services will be lost.

**Who can I contact if I have questions or problems?**
If you have questions or concerns regarding this study, please contact:

Mark E. McDonough, Student Researcher  
Karen Reiss Medwed, Principal Investigator  
XXXXX  
XXXX

**Who can I contact about my rights as a participant?**
If you have any questions about your child’s rights in this research, you may contact:

Nan C. Regina, Director, Human Subject Research Protection, 490 Renaissance Park, Northeastern University, Boston, MA 02115. Tel: ####, Email: XXXX. You may call anonymously if you wish.

**Will I be paid for my participation?**
No. There will be no remuneration for participation in this study.

**Will it cost me anything to participate?**
No. There are no costs associated with this study.

**Is there anything else I need to know?**
N/A
I agree to have my child take part in this research.

<table>
<thead>
<tr>
<th>Signature of person [parent] agreeing to take part</th>
<th>Date</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Printed name of person above</th>
<th></th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Signature of person who explained the study to the participant above and obtained consent</th>
<th>Date</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Printed name of person above</th>
<th></th>
</tr>
</thead>
</table>
Appendix F - Parent e-mail

Dear Seventh Grade Parent/Guardian:

Today, I met with your child’s class to describe a research study I am conducting to investigate Applied Learning in middle school science. Applied Learning is an approach to teaching that emphasizes the relevance of what is being learned to the world outside of the classroom. Your child’s teacher, Mr. XXXXXXXX, has designed units and projects, such as the upweller and blood drive, that fit this description.

Your child will be sharing a recruitment letter with you. It will provide you with all of the relevant details related to the study. Enclosed with this letter, you will find a consent form to sign, should you decide to allow your child to participate. Participation will include a 45-minute focus group interview, which will be conducted at Harrison Middle School, during a non-instructional period. In addition to the focus group, I will be interviewing Mr. XXXXXXXX, and observing at least two of his lessons.

While I hope for a robust response to this email, and the forthcoming consent form, participation in the study is completely voluntary. There is no direct benefit to participation, but it is my hope that the information gained from this study will help to raise the level of teaching and learning in schools, locally, regionally, and even nationally.

If you wish for your child to participate, please use my email below to confirm your interest. Also, please return the signed consent form as soon as possible. Once I have received all of the consent forms, I will schedule an informational meeting for the families of those who wish to participate. If you should have any questions about the study, feel free to contact me at mcdonough.mar@husky.neu.edu, or my faculty advisor and Principal Investigator Dr. Karen Reiss Medwed at k.reissmedwed@northeastern.edu.

Thank you for your time and consideration.

Sincerely,

Mark E. McDonough
Doctoral Candidate, Student Researcher
Northeastern University, College of Professional Studies
Appendix G - Teacher Consent

Signed Informed Consent Document - Teacher

Northeastern University, Department: College of Professional Studies

Name of Investigator(s): Dr. Karen Reiss Medwed (Principal Investigator), Mark E. McDonough (Student Researcher)


Informed Consent to Participate in a Research Study
We are inviting you to take part in a doctoral research study. This form will provide you with information about the study. Additionally, the Student Researcher will explain it to you. You may ask the Student Researcher any questions you have. You do not have to participate in this study. If you decide to participate, please sign this document. The researcher will make a copy for you to keep.

Why am I being asked to take part in this research study?
You are a middle school science teacher who has planned Applied Learning units of study.

Why is this research study being done?
The purpose of this study is to learn about the impact an Applied Learning approach has on learning for middle school science students.

What will I be asked to do?
If you participate in the study, you will be asked to take part in an interview, and will be observed during science lessons. You will be asked 5-6 open ended questions about your experience teaching an Applied Learning unit of study.

Where will this take place and how much of my time will it take?
The interview will last approximately 20 minutes, and take place during a non-instructional period (Enrichment Block). Additionally, the Student Researcher will be observing two class lessons, each approximately 50 minutes. Observations will take place in your classroom at Frank H. Harrison Middle School.

Will there be any risk or discomfort to me?
N/A

Will I benefit by being in this research?
There is no direct benefit to participants. However, the information learned as a result of this study could help teachers and school leaders to determine the kind, and quality of science education that will most benefit their students.
Who will see the information about me?
Participants’ role in this study will remain confidential. Only the researchers of this study will see the information gathered during data collection. No reports or publications will use information that can identify participants in any way, or any individual as being part of this project.

The interview will be recorded using an electronic recorder for later transcription. This recording will be maintained for a period of two months, while the researcher is compiling and analyzing data, and writing up his findings. During this process, the recorder will remain at the student-researcher’s place of residence, under lock and key. Once this process has been completed, the data will be erased from the device as further protection to the participants.

If I do not want to take part in the study, what choices do I have?
Participation in the study is completely voluntary. There is no penalty to not participating.

What will happen if I suffer any harm from this research?
N/A

Can I stop my participation in this study?
Even if you consent, you can stop participating at any time. If you decline to participate, or decide to quit, no rights, benefits, or services will be lost.

Who can I contact if I have questions or problems?
If you have questions or concerns regarding this study, please contact:

Mark E. McDonough, Student Researcher
XXXXXXXX
Karen Reiss Medwed, Principal Investigator
XXXX

Who can I contact about my rights as a participant?
If you have any questions about your child’s rights in this research, you may contact:

Nan C. Regina, Director, Human Subject Research Protection, 490 Renaissance Park, Northeastern University, Boston, MA 02115. Tel: ####, Email: XXXX. You may call anonymously if you wish.

Will I be paid for my participation?
No. There will be no remuneration for participation in this study.

Will it cost me anything to participate?
No. There are no costs associated with this study.

Is there anything else I need to know?
N/A
I agree to take part in this research.
<table>
<thead>
<tr>
<th>Signature of person agreeing to take part</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>______________________________________________________________________</td>
<td></td>
</tr>
<tr>
<td>Printed name of person above</td>
<td></td>
</tr>
<tr>
<td>______________________________________________________________________</td>
<td></td>
</tr>
<tr>
<td>Signature of person who explained the study to the participant above and obtained consent</td>
<td>Date</td>
</tr>
<tr>
<td>______________________________________________________________________</td>
<td></td>
</tr>
<tr>
<td>Printed name of person above</td>
<td></td>
</tr>
<tr>
<td>______________________________________________________________________</td>
<td></td>
</tr>
</tbody>
</table>