

THE EFFECT OF ONLINE COLLABORATIVE LEARNING ON MIDDLE
SCHOOL STUDENT SCIENCE LITERACY AND SENSE OF COMMUNITY

by
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A Dissertation Presented in Partial Fulfillment
of the Requirements for the Degree
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ABSTRACT

This study examines the effects of online collaborative learning on middle school students' science literacy and sense of community. A quantitative, quasi-experimental pretest/posttest control group design was used. Following IRB approval and district superintendent approval, students at a public middle school in central Virginia completed a pretest consisting of the Misconceptions-Oriented Standards-Based Assessment Resources for Teachers (MOSART) Physical Science assessment and the Classroom Community Scale. Students in the control group received in-class assignments that were completed collaboratively in a face-to-face manner. Students in the experimental group received in-class assignments that were completed online collaboratively through the Edmodo educational platform. Both groups were members of intact, traditional face-to-face classrooms. The students were then post tested. Results pertaining to the MOSART assessment were statistically analyzed through ANCOVA analysis while results pertaining to the Classroom Community Scale were analyzed through MANOVA analysis. Results are reported and suggestions for future research are provided.

Keywords: middle school, misconceptions, science, collaborative learning, technology, science literacy, sense of community

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List of Abbreviations

Classroom Community Scale (CCS)

Communities of Inquiry (CoI)

Communities of Practice (CoP)

Misconceptions-Oriented Standards-Based Resources for Teachers (MOSART)

CHAPTER ONE: INTRODUCTION

Introduction

Science literacy is a set of skills that enables an individual to understand, critique, and apply scientific knowledge and processes (Impey, Buxner, Antonellis, Johnson, & King, 2011) for the purposes of personal enjoyment, productivity, and participation in current affairs (American Association for the Advancement of Science, 1993). As such, science literacy has been identified as imperative to future civic and scientific success, especially in the face of growing technological and scientific advances and global ecological crises (AAAS, 1993; Impey et al., 2011; Miller, 2007). The topic of science literacy is important as science continuously shapes human culture (AAAS, 1993; Impey et al, 2011). Unfortunately, national and international studies have shown that students are lacking in science literacy (AAAS, 1991; National Science Foundation & National Center for Science and Engineering Statistics, 2010; OECD, 2007). Of increasing concern in the United States is the lack of science literacy among adolescents despite multiple revisions to state and national science standards and related teaching initiatives (AAAS, 1993; Organisation for Economic Co-operation and Development, 2007).

A key component to science literacy is the understanding of science concepts and the level of mastery of conceptual science knowledge (Laugksch, 2000; Roberts, 2007). This is reflected in the evaluative sense of the term *literacy*, which implies the level of mastery of a particular topic (Laugksch, 2000). The acquisition of knowledge and mastery of scientific concepts may only be attained when scientific misconceptions are identified and dispelled (AAAS, 2013; Burgoon, Heddle, & Duran, 2011; Harvard, 2011). Misconceptions may be defined as science conceptions that are held by students that are different from scientific knowledge that is currently accepted within the science

community at large (Burgoon et al., 2011), which may be preconceived or a result of misinformed teaching (AAAS, 1993; Harvard, 2011). Misconceptions, thus, have been identified as an important aspect of overall science literacy (AAAS, 1993).

Revisions of standards and related teaching methods have been directed at increasing science literacy and, more specifically, decreasing overall science misconceptions (AAAS, 1990; AAAS, 1993; National Academy of Sciences, 1996). In the past, science was taught in a didactic lecture-based format (Lunetta, Hofstein, & Clough, 2007). This traditional approach was based upon behavioral theories of learning (Skinner, 1957) with the underlying assumption that objective knowledge should be transmitted to individual students for absorption and recall. This method of teaching has been found ineffective and ill suited to promote science achievement and advance science literacy (Lunetta et al., 2007; Scott, Asoko, & Leach, 2007). Science instruction that utilizes the constructivist approach and authentic hands-on learning strategies are better suited for promoting science achievement and advance literacy (Fang & Wei, 2010; Guo, 2007). Numerous research studies have shown that collaborative activities in the traditional science classroom result in more effective science learning (Bell, Urhahne, Schanze, & Ploetzner, 2010; Mäkitalo-Siegl, Kohnle, & Fischer, 2011; Raes, Schellens, Wever, & Vanderhoven, 2012). Now, as technology advances and online education exponentially grows, there is a need to examine online teaching methods and tools that effectively support aspects of learning and, more specifically, aspects of science literacy (Bell et al., 2010). Researchers need to examine if collaborative teaching methods that support learning and science literacy in the traditional face-to-face classroom can be

mimicked, or even enhanced, by the use of web-based tools and online instruction (Bergtrom, 2011; Lunetta et al., 2007; Underwood, Smith, Luckin, & Fitzpatrick, 2008).

As misconceptions regarding scientific concepts have been identified as a component of science literacy, misconceptions were examined in this study.

Sense of community has also been recognized as important and foundational in collaborative learning both inside and outside of the classroom as well as in traditional and online classrooms (Abfalter, Zaglia, & Mueller, 2012; Dawson, 2008; Rovai, 2002); therefore, sense of community was examined as well. Sense of community for the purpose of this study was defined as how members feel that they belong in a group and how their needs are met within the group, which involves the creation of a social community (Abfalter et al., 2012; Wenger, 1998, Wenger, White, & Smith, 2009). Sense of community is important as it has been shown to be associated with student motivation and an increase in student science knowledge (Lunetta et al., 2007). Specifically, a learning environment that fosters community through peer communication and collaboration is necessary to mimic how the scientific community functions in the real world (Lunetta et al., 2007). Since recent learning theory, such as connectivism, proposes that learning is based on social connections fostered through collaboration and centered on communities, there exists a need for examination of the relationship between sense of community and its support of science literacy (Siemens, 2006).

It is widely accepted that science knowledge is best attained through constructivist activities, especially those that take on a social constructivist approach and encourage peer dialogue, inquiry, and reflection (Scott et al., 2007). Furthermore, communities of practice theory maintains that involvement in a learning community

increases student learning, connectedness, and sense of community (Wenger, 1998). According to distance learning theory, the outcomes of traditional teaching methods and online teaching methods are equivalent (Clark & Mayer, 2011); thus an examination of the effects of face-to-face collaborative learning and online collaborative learning would yield evidence to either support or refute this claim, which would add to the current body of knowledge to further influence current teaching pedagogy.

This chapter will provide an extensive background of the importance of science literacy as it relates to understanding of scientific concepts, sense of community, and collaborative learning. The current literature is discussed, as will the gap in the literature that will lead to the problem statement, purpose statement, and the significance of the study. The research questions and hypotheses are stated, variables are identified, and terms are defined.

Background

Science literacy has been a topic of concern for educators in the field of science since the early 1950s (Laugksch, 2000). Science literacy was originally seen as necessary only for those who pursued higher education or a career in the science field (Liu, 2009). During the 1970s, science literacy was deemed important for all students in order to be productive and capable citizens in a rapidly advancing world (Liu, 2009). In the 1980s, science literacy began to encompass not only science and literacy, but rather mathematical and technological knowledge as well (Liu, 2009). In the 1990s, the concept became even more complex when the National Research Council added the requirements of understanding scientific processes (Liu, 2009). Finally, in the 2000s, with the continuing increase in scientific and technological advances coupled with increased

competition with other nations, science literacy again moved to the forefront of core educational planning (Virginia Department of Education, 2011b).

Numerous attempts over the course of the years have sought to determine what science literacy really means with some experts citing the importance of science knowledge while other experts placed the focus on literacy (American Association for the Advancement of Science, 1993; Impey et al., 2011; Liu, 2009). Likewise, throughout the research, some experts have focused on the acquisition of science proficiency (Impey et al., 2011), others on scientific reading literacy (Liu, 2009), and still others on the use of technology as it relates to science (AAAS, 2013; International Technology and Engineering Educators Association, 2011; Virginia Department of Education, 2011b). The AAAS's (1993) Project 2061 defined science literacy as the knowledge and habits of mind related to science, mathematics, and technology that individuals must acquire in order to live interesting, responsible, and productive lives. The National Science Foundation (2004) defined science literacy as the knowing of basic scientific facts and concepts and having a general understanding of how science works. Despite the numerous operational definitions of science literacy, researchers have come to the consensus that society has been and remains lacking in scientific knowledge, scientific skill, and application of scientific processes and methods to current events (Laugksch, 2000; Miller, 2007; Organisation for Economic Co-operation and Development, 2007). Of particular concern is the lack of scientific knowledge, the ability to apply knowledge to current events, and the increased misconceptions of scientific principles held by adolescents (Harvard, 2011; Impey et al., 2011).

Recently, the Programme for International Student Assessment (PISA) 2006 survey found that on a scale of 1-6, with 1 being the lowest level of science literacy and 6 being the highest level of science literacy, the vast majority of students in ten countries did not reach a science literacy equivalent to a level 2 (Organisation for Economic Co-operation and Development, 2007). Over 400,000 students from 57 countries were surveyed as participants in the PISA 2006 (OECD, 2007). Approximately 2% of students in nine of the countries surveyed exhibited knowledge consistent with a Level 6, the highest level of scientific literacy. Three key areas noted within the PISA 2006 survey were identifying scientific issues, explaining phenomena using scientific processes, and utilizing scientific evidence (Organisation for Economic Co-operation and Development, 2007).

The PISA 2006 indicated an alarming percentage of students performed at a low proficiency level (level 2 and below) in the areas of science and technology, thus, potentially limiting full and productive participation in life (Organisation for Economic Co-operation and Development, 2007). While the majority of students (92%) believed that science and technology improves living conditions, only 57% of students perceived science and technology have personal relevance (Organisation for Economic Co-operation and Development, 2007). Only 29.3% of students surveyed exhibited proficiency with working within situations that required integration of science or technology and making connections with real-life situations. With rapid changes in the environment and advances in technology that allow cloning, stem cell research, biological warfare, and the creation of genetically modified foods, it is imperative that

adolescents procure skills allowing informed scientific decision making (Impey et al., 2011).

The acquisition of scientific knowledge that allows connections with daily living is integrally tied to misconceptions of science. Misconceptions may manifest as preconceptions, oftentimes obtained through past experiences, or as naïve explanations to explain scientific phenomena (Burgoon et al., 2011). Significant barriers to attainment of science knowledge may exist if misconceptions are not identified or reduced (American Association for the Advancement of Science, 1993; Burgoon et al., 2011; Harvard, 2011). In order to encourage participation in a rapidly advancing scientific world, there is a growing need to examine methods to reduce misconceptions of science (Burgoon et al., 2011), increase science achievement, and foster achievement of science literacy (Roberts, 2007).

Coupled with advances in science, advances in technology seem to be progressing at ever-increasing speed. Technology is now at the forefront of education with policymakers pushing the integration of instructional technology in the classroom and online course requirements (VDOE, 2012b) as well as demanding the acquisition of technological literacy skills (ITEAA, 2011; VDOE, 2011b) in order to ensure competitiveness in the global economy (Williams, 2009). Within education specifically, the availability of numerous tools, programs, and applications allows educators to incorporate technology in instruction at almost any time and any place. The proliferation of online tools has provided convenient access to learning materials for educators and students alike and has led to a push towards collaborative learning (Lou, Abrami, &

d'Apollonia, 2001). Through the use of technological tools, collaboration has become more convenient by transcending boundaries of time and location.

Collaborative learning allows individuals to work together for a common purpose or towards a common goal. Research has consistently shown that collaboration provides both academic and social benefits (Bye, Smith, & Rallis, 2009; Miller & Benz, 2008; Yu, Tian, Vogel, & Kwok, 2010). Additionally, recent studies have shown that collaborative learning through the use of technology has become an integral part of today's classrooms (Keser, Uzunboylu, & Ozdamli, 2011; Yang & Chang, 2012). Commonly referred to as technology supported or computer-mediated collaborative learning, collaboration through the use of technological tools allows learners many of the same benefits as traditional collaborative activities in more effective and efficient ways (Miller & Benz, 2008). Using the basic tenets of constructivism, learners are able to actively engage in learning (Dewey, 1997) and participate in a cooperative learning community (Dewiyanti, Brand-Gruwel, Jochems, & Broers, 2007; Donne, 2012; Vygotsky, 1986). More specifically, learners may be able to construct scientific concepts through cooperative activities with others in an online environment (Vygotsky, 1986).

While multiple studies have examined the effects of collaboration on student achievement in general and found positive results (Bluic, Ellis, Goodyear, & Piggott, 2010; Winters & Alexander, 2011; Yang & Chang, 2012), researchers need to examine the influence of collaboration on science achievement, science misconceptions, and science literacy (Anderson, 2007a; Lunetta, et al., 2007). A study by Jeong and Chi (2007) investigated students' gains in common knowledge of scientific material after engaging in face-to-face collaborative learning activities and found that knowledge

construction increased as well as misconceptions shared among peers, thus indicating that some benefits to learning may exist as well as disadvantages that warrant closer attention.

More importantly, as the integration of technology increases in the classroom and demands for online education expand, there exists a need to examine the differences between face-to-face and computer-mediated collaborative learning (Tutty & Klein, 2008) in an effort to better understand how to structure online learning tasks in ways that facilitate social interaction (Nuankhieo, Tsai, Goggins, & Laffey, 2007). One study investigated whether the positive effects of student achievement attained through face-to-face collaboration was also present in computer-mediated collaboration (Tutty & Klein, 2008). Results indicated that student performance through face-to-face collaboration exceeded student performance using computer-mediated collaboration; however, student interaction, discussion, and inquiry were more frequent among students participating in computer-mediated collaboration (Tutty & Klein, 2008). Benefits were shown, therefore, to exist for both face-to-face and computer-mediated collaboration. There is still a need for further examine how to determine which collaborative structures are best-suited for each mode of learning (Tutty & Klein, 2008). Therefore, it is timely that research be conducted that seeks to understand how online collaboration may assist in knowledge acquisition, application to real-world events, and identification of commonly held misconceptions specifically in the area of science.

Additionally, sense of community has become an increasingly important concept as collaborative activities lead to the creation of learning communities in the classroom (Rovai, 2002b). This is supported by the literature on effective education rooted in constructivism and social constructivism. Further, a point of consensus among many

researchers studying effective online education is the notion that community is a crucial element for learning and thus, for effective education (Gunawardena & McIsaac, 2004; Moore, 1993; Strijbos, Martens, & Jochems, 2004). Applied to the science classroom, sense of community is foundational and related to gaining science literacy.

Little research has explored the effect of face-to-face collaborative learning versus online collaborative learning on students' sense of community (Koh & Hill, 2009), in particular at the adolescent level and in the area of science. The majority of studies have focused on university students' sense of community in distance learning programs (Cameron, Morgan, Williams, & Kostelecky, 2009; Koh & Hill, 2009; Ouzts, 2006) and teachers' sense of community in face-to-face interactions (Admiraal & Lockhorst; Baker & Murray, 2011), thus leaving an integral gap in understanding the effects of collaboration on adolescent students' sense of community in the traditional and online science classroom (Chiessi et al., 2010). Thus, this study sought to fill the gap in examining the effect of online collaborative learning on adolescent students' science literacy and sense of community.

Problem Statement

A multitude of research exists that demonstrates the positive effect of collaborative learning on student achievement as well as the effect of computer-mediated or online collaborative learning on student achievement (Bluic et al., 2010; Winters & Alexander, 2011; Yang & Chang, 2012). However, benefits of engaging in face-to-face collaborative learning or online collaborative learning appear to differ depending on the activity and the degree of interaction among students, leading to questions of how to best

foster student interaction in both traditional and computer-mediated learning environments (Tutty & Klein, 2008).

The recent pedagogical push towards collaborative learning has shed light on the importance of sense of community in the classroom as well (Wighting, Nisbet, & Spaulding, 2009). However, the majority of studies have focused on the effects of collaboration on university students' sense of community (Cameron et al., 2009; Koh & Hill, 2009; Ouzts, 2006). Little research exists that examines the effects of collaborative learning on adolescent students' sense of community.

The lack of science literacy and the related role of misconceptions of science among adolescents has also been repeatedly documented (Harvard, 2011; Organisation for Economic Co-operation and Development, 2007). Since science is generally perceived as a collaborative subject (Scott et al., 2007), there is a growing need to address the effect of online collaborative learning on science literacy as well as the effect of online collaboration on sense of community. Utilizing the conceptual frameworks of constructivism, social development theory, and communities of practice, this study sought to determine the effects of online collaborative learning on middle school students' science literacy as measured by the Misconceptions-Oriented Standards-Based Resources for Teachers (MOSART) assessment (Harvard, 2011) and sense of community as measured by Rovai's (2002a) Classroom Community Scale.

Purpose Statement

The purpose of this quasi-experimental, pretest/posttest control group design study was to examine the effect of online collaborative learning on middle school students' science literacy and sense of community in a rural public school district in

South-Central Virginia. The theory of constructivism, social development theory, and communities of practice theory formed the framework of this study.

The independent variable was the type of learning (traditional face-to-face collaboration or online collaborative learning). Traditional learning was defined as learning that occurs face-to-face in the classroom. Collaborative learning was generally defined as learning that occurs as part of a group where all learners are mutually involved in the learning process (Bernard, Rubalcava, & St-Pierre, 2000). More specifically, online collaborative learning was operationally defined as computer-mediated learning that occurs as part of a group where all learners are mutually involved in the learning process (Dewiyanti et al., 2007).

The dependent variables were student science literacy and student sense of community. Science literacy was generally defined as “understanding key scientific concepts and frameworks, the methods by which science builds explanations based on evidence, and how to critically assess scientific claims and make decisions based on this knowledge” (Impey et al., 2011, p. 34), with a specific focus on the identification of scientific misconceptions (Harvard, 2011). Sense of community was generally defined as “a feeling that members have of belonging, a feeling that members matter to one another and to the group, and a shared faith that members’ needs will be met through their commitment to be together” (McMillan & Chavis, 1986, p. 9). The control variable, student prior knowledge, was statistically controlled through the use of an ANCOVA. Prior sense of community was measured but was not controlled for statistically as the two groups did not demonstrate significant differences in their sense of community prior to

treatment. The intervening variables, gender and ethnicity, were controlled for by the use of homogenous groups.

Significance of the Study

A need for research in science literacy that translates into practice in the classroom through practical strategies has been documented in the educational research (Anderson, 2007a); thus this study was both significant and timely. More specifically, no current research exists that explores the effect of face-to-face collaborative or online collaborative learning on science literacy, although it is widely accepted that science knowledge is attained through social constructivist activities that may be provided by peer-to-peer collaboration (Scott, Asoko, & Leach, 2007). With the recent widespread reporting and resulting concern over lack of science literacy among adolescents, as well as the growing ecological need for science literacy, this study was timely (Impey et al., 2011; Organisation for Economic Co-operation and Development, 2007). Furthermore, little research exists that examines the effect of online collaborative learning on sense of community despite policymakers and educators alike who continue to push social construction of knowledge inside and outside the classroom (Virginia Department of Education, 2011b). In addition, the formation of social communities that requires feelings of mutual care, respect, and work for the common good is becoming increasingly frequent in pedagogy (Cheung, Chui, & Lee, 2011; Dewiyanti et al., 2007; Donne, 2012; Yang & Chang, 2012). The results of this study have aided in filling the current gap in the literature by testing the theories of constructivism, social development theory, and communities of practice theory.

The results of this study were specifically relevant to central Virginia as policymakers consider the adoption and revision of national standards such as the Common Core State Standards for English Language Arts and Literacy in History/Social Studies, Science, and Technical Subjects (Common, 2012; Virginia Department of Education, 2011b). In addition, recent revisions to the state-mandated Virginia Standards of Learning Science Standards have shown a migration towards learning that emphasizes student inquiry, reflection, and collaborative learning (Luft, Bell, & Gess-Newsome, 2008; Virginia Department of Education, 2011a). Added to the current push to increase technology use in the classroom (Virginia Department of Education, 2011a), research that explores science literacy, collaboration, technology integration, and sense of community are timely and much needed to ensure that new policy is research-based.

Perhaps of greatest importance was the significance of this study to teachers and current pedagogy. As online group work becomes more popular (Koh & Hill, 2009) and a need for practical strategies of increasing technology implementation (Witney & Smallbone, 2011) and science learning grows (Anderson, 2007a), it is important that teachers understand the inherent advantages and disadvantages to student collaborative opportunities and the effects of science literacy and sense of community in both face-to-face and online collaborative learning activities. This study provides increased knowledge to teachers that may lead to more effective strategies to increase student science literacy and sense of community at the adolescent level.

Research Questions

The following research questions guided this study:

Research Question 1: Is there a statistically significant difference in middle school students' misconceptions, an aspect of science literacy, as measured by the MOSART testing instrument when participating in online collaborative learning as compared to students who participate in traditional collaborative learning only?

Research Question 2: Is there a statistically significant difference in middle school students' sense of community as measured by the Classroom Community Scale when participating in online collaborative learning as compared to students who participate in traditional collaborative learning only?

Hypotheses

The following were the research hypotheses:

H₁: There is a statistically significant difference in middle school students' misconceptions of science as measured by the MOSART testing instrument when participating in online collaborative learning as compared to students who participate in traditional collaborative learning only, while controlling for student prior knowledge.

H₂: There is a statistically significant difference in middle school students' overall sense of community as measured by the Classroom Community Scale when participating in online collaborative learning as compared to students who participate in traditional collaborative learning only.

H₃: There is a statistically significant difference in middle school students' connectedness as measured by the Classroom Community Scale when participating in

online collaborative learning as compared to students who participate in traditional collaborative learning only.

H₄: There is a statistically significant difference in middle school students' learning as measured by the Classroom Community Scale when participating in online collaborative learning as compared to students who participate in traditional collaborative learning only, while controlling for student community.

Alternatively, the following were the null hypotheses:

H₀₁: There is no statistically significant difference in middle school students' misconceptions of science as measured by the MOSART testing instrument when participating in online collaborative learning as compared to students who participate in traditional collaborative learning only while controlling for student prior knowledge.

H₀₂: There is no statistically significant difference in middle school students' overall sense of community as measured by the Classroom Community Scale when participating in online collaborative learning as compared to students who participate in traditional collaborative learning only.

H₀₃: There is no statistically significant difference in middle school students' connectedness as measured by the Classroom Community Scale when participating in online collaborative learning as compared to students who participate in traditional collaborative learning only.

H₀₄: There is no statistically significant difference in middle school students' learning as measured by the Classroom Community Scale when participating in online collaborative learning as compared to students who participate in traditional collaborative learning only.

Identification of Variables

The independent variable in this study was the type of learning. The two levels of learning included traditional collaborative learning and online collaborative learning. Traditional learning was defined as learning that occurs face-to-face in the classroom. Online collaboration took place through the use of the Edmodo educational platform and was defined as computer-mediated learning that occurs as part of a group in which all learners are mutually involved in the learning process (Dewiyanti et al., 2007).

This study included two dependent variables. The first dependent variable, science literacy, was defined as “understanding key scientific concepts and frameworks, the methods by which science builds explanations based on evidence, and how to critically assess scientific claims and make decisions based on this knowledge” (Impey et al., 2011, p. 34). The MOSART (Harvard, 2011) assessment was used to measure student science literacy. Developed by the Science Education Department of the Harvard-Smithsonian Center for Astrophysics (Smith, n.d.), MOSART uses a variety of multiple choice questions divided by grade level and specific subject area that have been developed over five years by leading science and literacy experts (Harvard-Smithsonian Center for Astrophysics, 2012; Center for School Reform at TERC, 2012). The questions have been pilot tested and field tested for reliability and validity and were aligned with the K-12 National Science Standards (Harvard-Smithsonian Center for Astrophysics, 2012). The MOSART Physical Science assessment, specifically, was used for this study.

The second dependent variable, sense of community, was defined as “a feeling that members have of belonging, a feeling that members matter to one another and to the group, and a shared faith that members’ needs will be met through their commitment to

be together” (McMillan & Chavis, 1986, p. 9). The Classroom Community Scale (Rovai, 2002a) was used to measure students’ sense of community. The Classroom Community Scale consists of 20 items that ask students to describe their feelings on a five point Likert-type scale (strongly agree, agree, neutral, disagree, and strongly agree) with two subscales: connectedness and learning (Rovai, 2002a). Connectedness was defined as “the feelings of the community of students regarding their connectedness, cohesion, spirit, trust, and interdependence” (Rovai, 2002a, p. 206). Learning was defined as the “feelings of community members regarding interaction with each other as they pursue the construction of understanding and the degree to which members share values and beliefs concerning the extent to which their educational goals and expectations are being satisfied” (Rovai, 2002a, p. 206). The Classroom Community Scale has been field tested for reliability and validity.

Finally, the control variable, student prior knowledge, is information acquired by the student through the students’ history (Campbell & Stanley, 1963) and past experiences (Gall, Gall, & Borg, 2007). Specific to this study, student prior knowledge involved scientific misconceptions as measured by the MOSART assessment. Student prior knowledge was statistically controlled through the use of an ANCOVA with a pretest and posttest design (Gall et al., 2007). Prior sense of community was measured using the Classroom Community Scale but was not controlled for statistically as the two groups did not demonstrate significant differences in their sense of community prior to treatment. The use of a pretest-posttest control group design ensured that the “experiences of the experimental and control groups [were] as identical as possible” (Gall et al., 2007, p. 405).

Definitions

Classroom Community Scale is a survey instrument developed by Rovai (2002a) that measures the sense of community an individual perceives in relation to the classroom and his or her classmates.

Collaborative learning is “the mutual engagement of learners in the learning process rather than on the sole division of labour to reach a common group goal” (Bernard et al., 2000, p. 262).

Connectedness is “the feelings of the community of students regarding their connectedness, cohesion, spirit, trust, and interdependence” (Rovai, 2002a, p. 206), measured as a subscale of the Classroom Community Scale.

Edmodo is an educational learning platform that allows social networking for teacher and student connection and collaboration (Edmodo, 2012).

Ethnicity is an individual’s “origin of birth or descent...relating to race or culture” (Jewell, 2002, p. 270).

Gender is “a person’s sex” (Jewell, 2002, p. 334), male or female.

Learning as a subscale of the Classroom Community Scale is the “feelings of community members regarding interaction with each other as they pursue the construction of understanding and the degree to which members share values and beliefs concerning the extent to which their educational goals and expectations are being satisfied” (Rovai, 2002a, p. 206).

Misconceptions are science conceptions that are held by students that are different from scientific knowledge that is currently accepted within the science community at large (Burgoon et al., 2011).

MOSART is Misconceptions-Oriented Standards-Based Resources for Teachers, a group of assessments that enable educators to assess student level of science knowledge through identification of scientific misconceptions (Harvard, 2011).

Online collaborative learning is a method of learning in which “the computer facilitates interactions among learners for [shared] acquisition of knowledge, skills, and attitudes” (Dewiyanti et al., 2007, p. 497).

Science literacy is the “understanding [of] key scientific concepts and frameworks, the methods by which science builds explanations based on evidence, and how to critically assess scientific claims and make decisions based on this knowledge” (Impey et al., 2011, p. 34) as measured by the MOSART assessments (Harvard, 2011).

Sense of community is “a feeling that members have of belonging, a feeling that members matter to one another and to the group, and a shared faith that members’ needs will be met through their commitment to be together” (McMillan & Chavis, 1986, p. 9) as measured by the Classroom Community Scale (Rovai, 2002a).

Student prior knowledge is information acquired by the student through the students’ history (Campbell & Stanley, 1963) and past experiences (Gall et al., 2007).

Traditional learning is defined as learning that occurs face-to-face in the classroom.

In the next section, a review of educational literature is provided. This will include an explanation of educational learning theories, historical trends in education, current trends in education, and recent educational reform initiatives. Additionally, the aspects of science literacy and sense of community are discussed, including an in-depth overview of assessments for each construct respectively. Finally, the current gap within

the literature that this study sought to fill are examined.

CHAPTER TWO: REVIEW OF THE LITERATURE

Introduction

Recent educational reform initiatives such as the Common Core State Standards Initiative (Common, 2012), the National Science Education Standards (National Science Teachers Association, 2012), and Science, Technology, Engineering, and Math (STEM) (Stage & Kinzie, 2009) education have brought science learning to the forefront of education (Virginia Department of Education, 2011b). In higher education institutions, teachers are being introduced to new curricula and teaching strategies to increase students' science learning (Stage & Kinzie, 2009). The National Science Teachers Association's efforts to implement the National Science Education Standards in K-12 classrooms nationwide has resulted in creating new curricula and identifying more effective teaching strategies to promote science literacy (Harvard, 2011; National Science Teachers Association, 2012; Organisation for Economic Co-operation and Development, 2007; Roberts, 2007).

Moreover, the unique characteristics of the current generation of learners (Black, 2010; Evans & Forbes, 2012) have led to a shift in students' learning preferences (Robinson & Stubberud, 2012), which has in turn influenced educational pedagogy (Chelliah & Clarke, 2011). Students today are more socially connected through technology than in generations past (Robinson & Stubberud, 2012). Evidence suggests that adolescents prefer to learn through the use of technology that enhances communication and collaboration (Elsaadani, 2012) and decreases response time (Lightfoot, 2009). Research has supported that "students working in small groups tend to learn more of what is taught and retain it longer than when the same content is presented

in other instructional formats” (Vaughan, Nickle, Silovs, & Zimmer, 2011, p. 113), leading to a preference towards collaborative activities across subject areas (Bell et al., 2010). More specifically, collaboration in the science classroom coupled with the use of computer-supported collaborative learning has become increasingly popular (Bell et al., 2010). Despite its popularity, researchers and practitioners are just beginning to examine what constitutes quality and effective computer-supported collaborative science learning (Clary & Wandersee, 2012).

There is a long history establishing the importance of considering technologies for effective learning (Cobb, 1997; Kozma, 1994; Ullmer, 1994). Some suggest that collaborative web-based technology can enhance learning, whereas others suggest that the use of web-based technology cannot mimic what is done face-to-face and actually detracts from collaboration among students. After examining effective web-based learning, in higher education where most of the research has been conducted, Thomas (2002) suggested that “the attainment of a discourse that is both interactive and academic in nature is difficult within the online environment” (p. 359). On the other hand, Bonk (2009) noted that web-based, collaborative technologies have the ability to transform the manner in which education is delivered and can enhance learning.

Today’s learners have been labeled as “the most socialized generation in the digital world” (Black, 2010, p. 96). The characteristic of increased socialization has led to an increased need to consider how collaborative activities and technology implementation may affect learning in the science classroom. A call for empirical research that utilizes a theoretical framework to examine, technologies and modes of delivery to improve the quality and effectiveness of web-based education exists

(Arbaugh, et al., 2008; Garrison & Kanuka, 2004; Song et al., 2004; Thompson & MacDonald, 2005). A growing number of states are developing online K-12 programs to provide increased options for the already over-stressed educational system (Ronsisvalle & Watkins, 2005). Thus, as most of the literature on the delivery of web-based and online education has been focused on higher education, a growing need exists to examine the transferability of research findings on the K-12 population (Ronsisvalle & Watkins, 2005).

In distance education literature, two desired outcomes of educational experiences have been identified: (a) meaning construction, also defined as critical thinking and deep learning, and (b) construction of a collaborative community of learners (Garrison & Anderson, 2003). Sense of community in the classroom is how students perceive that they belong and matter to peers within a group (McMillan & Chavis, 1986). Since online collaboration has been found to increase sense of community with undergraduate students, specifically togetherness and the building of team bonds (Koh & Lim, 2012), the effect of collaboration on sense of community at the secondary level warrants further study. In addition, critical thinking has been recognized as a key component to effective web-based learning (Garrison & Anderson, 2003) and can be likened to attaining science literacy which requires that students apply critical thinking skills to scientific habits of mind (AAAS, 1990).

This chapter, therefore, provides an overview of the current literature regarding science literacy, sense of community, and collaborative learning. Collaborative learning is discussed, including the definition, the underlying learning theory of social development, and the relationship of collaborative learning to students' learning.

Computer-mediated learning and web-based learning are discussed, with a specific focus on the advantages of technology implementation inside and outside of the classroom. Then, sense of community is reviewed, including a definition of sense of community and the underlying learning theory, communities of practice, as well as the relationship between sense of community and student learning. Science literacy is discussed, including a specific operational definition of science literacy, the importance of science literacy, and the levels of science literacy among adolescents nationally and worldwide. Finally, an overview of the current literature gap and need for research is provided, leading to the significance and implications of the current study.

Social Development Theory

The shared process of learning that emphasizes the importance of social interactions is the foundation of social learning theory (Wenger, 1998; Wenger et al., 2009). Specifically, social development theory posits that individuals learn by the influence of others and through social relationships with others (Vygotsky, 1978). The central tenet focuses on the idea that students learn not only through authentic activities (a constructivist approach) but through social activities (Vygotsky, 1978; Yang & Chang, 2012) that require the engagement of dialogue to assist in problem solving. Vygotsky (1978) proposed that individuals influence the environment surrounding them and are also influenced by their environment. Likewise, individuals develop through the process of collaborative learning (Vygotsky, 1978). The constructivist approach of social development theory is central to the core of collaborative learning. Thus, any strategy that enables increased collaboration, including computer-mediated technologies, may

encourage the development of social relationships (Baker-Doyle & Yoon, 2011; Minocha, 2009b).

Social learning theory has roots in constructivism, which posits that mental structures are constructed by the individual in response to interactions with the environment (Dewey, 1997; Wenger, 1998). Constructivism suggests that individuals learn by doing (Dewey, 1922, 1997); therefore, authentic activities that encourage learner engagement provide greater learning than passive activities because they enable the learner to construct his or her own knowledge (Vygotsky, 1978). As proposed by Dewey (1922), education is the means of “social continuity of life” (p. 2) in which shared activities produce knowledge (Peterson, Divitini, & Chabert, 2009). As Vygotsky’s (1978) Zone of Proximal Development supports, language is critical to cognitive development. Communication is imperative to effective learning (Vygotsky, 1978), and learning should consist of constant communication, peer-to-peer and peer-instructor (Peterson et al., 2009). Learning, therefore, is fundamentally a social phenomenon enhanced through communication and group activity (Wenger, 1998; Wenger et al., 2009).

Communication and shared activities can promote collaboration and thus community and learning both in a traditional face-to-face classroom as well as in a computer mediated environment. Collaboration and interaction among students and teachers within the classroom creates a face-to-face community of learners (Peterson et al., 2009). Communication is enhanced through many of today’s modern technologies (Siemens, 2006). Social technologies such as blogs have been shown to provide a flexible environment conducive to multi-way communication that allows discussion and

reflection while promoting interactivity that can increase learning relationships (Peterson et al., 2009). Hence, a social constructivist approach to learning is supported by social software tools that engage students in communication and collaboration which foster critical thinking and problem solving (Minocha, 2009b), as well as gather information from the ideas and experiences of others through networks of learning (Siemens, 2006).

When these collaborative relationships are fostered in the computer-mediated setting, social networks are created. Social networks consist of the relationships that individuals make with others that provide support and opportunities for growth and enlightenment (Baker-Doyle & Yoon, 2011). Individuals inherently desire group formation, especially when being a part of a group enhances experience and learning—an aspiration that is enhanced by social networking (Minocha, 2009b). The desire to learn while specifically making use of technology to contribute to society is supported by the theory of connectivism. Connectivism posits that individuals desire to engage in learning activities that assist in making sense of the world, developing personally, and contributing to society as a whole through the use of technology, thus creating a network of knowledge (Siemens, 2006). Creation of networks of knowledge requires externalization of ideas expressed through communication. As a result, social networking potentially increases opportunities for collaborative learning through discussion that transcends time and geographic barriers (Lim, Yang, & Zhong, 2009; Siemens, 2006).

An increased amount of learning is now taking place outside of the classroom walls, facilitated through the use of technology (Siemens, 2006), thus creating learning environments that are conducive to more collaborative and interactive activities that

enable the construction of knowledge cooperatively (Peterson et al., 2009). Most importantly, social development theory supports that learning is a social activity (Nuankhieo et al., 2007; Peterson et al., 2009). Cognitive development, as supported by social development theory, occurs through dynamic and complex interactions with mature members of society (Sivan, 1986). In this case, being more mature has less to do with age but rather with being knowledgeable (Vygotsky, 1978). As a result, students can benefit from a relationship of reciprocity between peers (Ding & Harskamp, 2011) and the engagement in social networks of learning (Siemens, 2006).

In the face-to-face environment, collaborative activities have been shown to foster inquiry, critical thinking, and intellectual development (Ding & Harskamp, 2011). In the science classroom, collaborative laboratory learning has been shown to increase interest, curiosity, and motivation through hands-on and social learning (Ding & Harskamp, 2011). Creation of social learning opportunities in the classroom have also been shown to support effective communication, sharing of knowledge, and learner satisfaction (Tutty & Klein, 2007).

Social development theory, therefore, encompasses the very nature of learning through peer assistance, where individual needs and goals are met through instructional and motivational constructs (Sivan, 1986). Since collaboration has been shown to increase cognitive knowledge, affective knowledge, and motivation (Saleh, Lazonder, & Jong, 2007; Stump, Hilpert, Husman, Chung, & Kim, 2011; Yang & Chang, 2012), it can be considered an assistive technique inherent to social development theory that may also assist in building learning communities.

Collaborative Learning

Collaborative learning, or “the mutual engagement of learners in the learning process rather than on the sole division of labour [*sic*] to reach a common group goal” (Bernard et al., 2000, p. 262), has become an increasingly popular teaching strategy across the globe (Johnson & Johnson, 1996; Moolenaar, Slegers, & Daly, 2012) both in the preK-12 setting (Johnson & Johnson, 2009) and the post-secondary setting (Bell et al., 2010; Vaughan et al., 2011). Unlike many educational practices that tend to come and go as fads, collaborative learning has remained a preferred pedagogical practice since the 1980s (Johnson & Johnson, 2009). This is due in part to the benefits that collaborative learning has to offer for teaching and learning as supported in numerous empirical studies (Ding & Harskamp, 2011; Miller & Benz, 2008; Parveen & Batool, 2012; Zhu, 2012).

Research studies have found collaboration to provide benefits to teaching and learning, including increasing students’ motivation, feelings of success, mutual interdependence (Miller & Benz, 2008), communication, level of satisfaction (Zhu, 2012), cognitive growth, and socio-emotional or affective growth (Parveen & Batool, 2012). Collaboration has been shown to be an effective educational practice in meeting the needs of a diverse array of learners with differing needs, personalities, experiences, goals, and levels (Miller & Benz, 2008) by providing opportunities for differentiation in both instruction and learning.

Collaboration fosters engagement in an active learning process, increasing the likelihood of knowledge acquisition and transfer (Treagust, 2007). Research has shown that constructive learning processes are enhanced through collaborative learning

(Dewiyanti et al., 2007). Collaboration also provides opportunities for inquiry-based learning, which has been shown to increase long-term knowledge retention (Akinbobola & Afolabi, 2009).

Inquiry-based learning requires a shift from teacher-centered learning to student-centered learning (Luft et al., 2008). Collaborative learning provides this shift, allowing students to become the focus of instruction through group responsibility (Dewiyanti et al., 2007). As collaborative partnerships are often necessary in the successful workplace, the acquisition of skills that promote inquiry and critical thinking are imperative. These skills are fostered through active learning that promotes engagement with others (Stump et al., 2011). Since collaborative learning is an active learning process (Chelliah & Clarke 2011), collaborative teaching techniques may lead to increased peer engagement (Moore, 2011). Active learning has been shown to produce increased persistence, more positive student attitudes, and greater student achievement than passive learning (Stump et al., 2011), thus becoming a more desirable learning strategy (Cheung et al., 2011). Despite the advantages provided by active learning, educational pedagogy has been slow to change; therefore, a further understanding of learning strategies, such as collaborative learning, is needed to influence future pedagogy.

Collaborative learning that occurs in small peer groups may assist students in communication, sharing ideas, and obtaining feedback from peers, thus leading to gains in student achievement and meaningful knowledge building (Stump et al., 2011). Collaborative group techniques allow students to engage in discussion and debate, where the learner must not only defend his viewpoint but also consider the ideas and opinions of others (Ding & Harskamp, 2011). Individuals more effectively construct their own

meaning when allowed opportunities to collaborate with others through the process of critique, defense, and justification of concepts and opinions (Stump et al., 2011).

Discussion within groups can assist lower-achieving students in increasing active learning through group participation (Saleh et al., 2007).

In collaborative learning, students work together for the learning of both the individual and community (Parveen, Mahmood, Mahmood, & Arif, 2011). Collaborative learning has been shown to be beneficial in partnerships where an asymmetry of knowledge exists, allowing peers to both provide and gain knowledge in a reciprocal-type relationship (Saleh et al., 2007; Stump et al., 2011). As participation increases, collaborative learning in small groups can lead to increased student learning (Saleh et al., 2007).

Studies have shown that collaborative learning strategies in higher education classrooms increase student motivation (Saleh et al., 2007), positive attitudes towards learning (Yang & Chang, 2012), and academic achievement (Yang & Chang, 2012). Research has also shown that student engagement in collaborative learning with peers increases student interest and confidence in the science classroom (Ding & Harskamp, 2011). With increased student interest, engagement, and motivation, construction of conceptual understanding of scientific concepts may improve (Cavas, 2011).

Collaboration in the Science Classroom

Collaboration has been found to be especially effective in the science classroom, as students have the opportunity to experience science as an active process and a common endeavor that yields information about the true nature of science (Treagust, 2007). This is in part due to the nature of laboratory learning that lends itself to collaborative group

learning (Ding & Harskamp, 2011). Recently, an increased push for inquiry-based learning in the science classroom (Luft et al., 2008) has become a national imperative (National Science Teachers Association, 2012). Laboratory learning, or learning that occurs through hands-on experimentation and modeling, has been shown to encourage inquiry and increase intellectual development, thus assisting in formation of scientific concepts that relate to the real world (Ding & Harskamp, 2011). Active and collaborative engagement is fostered when students are allowed opportunities to participate in inquiry-based activities that employ scientific methods (Fang & Wei, 2010) much like scientists in the real world. Like scientists, students are able to share ideas and build upon one another's work (Luft et al., 2008, Lunetta et al., 2007). Science, therefore, is a social and collaborative practice that promotes sharing and learning among peers (Kelly, 2007; Miller & Benz, 2008). Collaborative learning techniques such as participation in group laboratory activities enhance science learning (Parveen & Batool, 2012; Parveen et al., 2011) by fostering higher order thinking skills allow students to engage in critical problem-solving and enhancing connections to real-life situations.

Despite the popularity of laboratory and authentic hands-on learning in the science classroom, many instructors find it difficult, with limited class time, to incorporate laboratory activities that foster higher order thinking, such as integrating problem-solving skills and making connections with real-life situations (Ding & Harskamp, 2011). Furthermore, traditional laboratory activities in the science classroom tend to provide large amounts of information that some students may find difficult to digest in a short period of time (Ding & Harskamp, 2011). However, the information provided in class, without authentic learning opportunities, often consists of rote

memorization of facts which have been found to be insufficient in supporting science learning (Akinbobola & Afolabi, 2009; Fata-Hartley, 2011).

Given the socially constructed nature of science learning (Anderson, 2007b), the advancement in technology may be beneficial to student science achievement (Songer, 2007). The integration of technology may enhance teaching and learning and be able to address some of the concerns related to authentic and laboratory learning in the science classroom. However, a need exists to study what type of collaborative activities and what type of technology support science learning (Songer, 2007), especially given that different features of “CMC technologies may support different types of tasks and learners in different ways” (Zhao, Alvarez-Torres, Smith, & Tan, 2004, p. 46). Additionally, some educators report limitations of technology use in the classroom, which may result in decreased quality of learning (Zhao et al., 2004). Given the focus of recent research of online learning in higher education, a growing need exists to examine the possible advantages and disadvantages of computer-mediated learning in the K-12 setting (Ronsisvalle & Watkins, 2005).

Computer-Mediated and Web-based Collaborative Learning

The increasing use of technology in the workplace, home, and school has led to a shift in how individuals learn and how information is delivered (Chelliah & Clarke, 2011; Koh & Lim, 2012). Collaboration in a technological world, therefore, has become a necessity (Wang, 2010). The trend in the information technology world is producing a switch from typically offline software to online software, thus increasing opportunities for computer-mediated collaborative learning both in and out of the workplace (Koh & Lim, 2012). The use of computer-mediated technology allows users the ability to

conduct work collaboratively (Koh & Lim, 2012; Wang, 2010). This is especially important as professionals must have the skills and capability to effectively collaborate within the field; in turn, educational institutions must prepare students for such situations (Lim et al., 2009), which presents a need to integrate computer-mediated collaborative activities in the classroom.

Learners of the 21st century, termed “Homo sapiens digital, or digital human” (Prensky, 2009), were born into a technology-rich world (Black, 2010). The current generation of learners “live, work, and study in technology rich cultures” (Chelliah & Clarke, 2011, p. 277) and prefer new ways of accessing information quickly and efficiently (Black, 2010). Today’s learners demand information in new and often challenging ways—requiring information access, insisting on immediate feedback, engaging in multi-tasking, and being connected to others almost constantly (Black, 2010; Evans & Forbes, 2012; Wenger et al., 2009). All of the aforementioned learner characteristics are driven by web-based technologies (Black, 2010).

Web-based technologies are also known as social software tools—computer-mediated tools that enable interaction and sharing with others (Minocha, 2009a). With computer-mediated tools, individuals cooperatively create and share knowledge, fostering active participation in the learning process (Minocha, 2009a). While numerous social computer-mediated tools exist, many are used not only in the social realm, but in the educational realm as well. These technologies include Facebook, Twitter, and YouTube (Minocha, 2009a) and may provide benefits for students and teachers alike (Minocha, 2009a; Wang, 2010). Edmodo, one such educational platform, provides opportunities for students and teachers to engage in social networking activities, thus providing safe

environments for sharing ideas, asking questions, and collaborating on education-related activities (Trust, 2012; Werner-Burke, Spohn, Spencer, Button, & Morral, 2012). The social nature of the online learning environment created by Edmodo provides the essential components of opportunities for student motivation and engagement required for learning (Werner-Burke et al., 2012). Additionally, an environment that fosters discussion and collaboration is provided, which some consider the cornerstone of the online learning environment (Palloff & Pratt, 2005a).

One research study found that Edmodo was preferred by teachers over other educational social networking platforms (Trust, 2012). Advantages reported included a safe place for sharing ideas, asking questions, and collaborating with other educators. Disadvantages reported were information overload, including the overwhelming amount of information, the need to learn new social norms, and the need to learn new tools (Trust, 2012). Another study involving middle school students found that Edmodo was an effective tool for computer-facilitated written discussion (Werner-Burke et al., 2012).

Research suggests that the use of modern technologies may enhance the learning process through construction of knowledge (Findlay, 2012; Zhu, 2012) and shared meaning (Siemens, 2006). Computer-mediated collaborative learning can assist in the development of problem-solving skills by establishing a collaborative learning community (Clary & Wandersee, 2012), which may translate into future success in the world of work (Minocha, 2009b), thus assisting in preparing students for successful citizenship and global competency (Poore, 2011). Furthermore, use of social technologies may foster interaction and assist in the creation of networks that facilitate the sharing of knowledge and experiences (Siemens, 2006).

Computer-mediated collaborative learning has been reported to show many of the same benefits as face-to-face collaboration, such as increased learning outcomes and academic performance (Koh & Lim, 2012). The interactive nature of web-based technologies bode well for collaborative and cooperative activities while fostering the development of learning communities (Minocha, 2009b). The development of a learning community may lead to mutual engagement, joint enterprise, and a shared repertoire that fosters knowledge acquisition (Wenger, 1998; Wenger et al., 2009). Individuals are given increased flexibility and opportunities to engage in learning relationships with peers through the use of social software such as that provided by web-based technologies (Minocha, 2009b; Siemens, 2006), therefore transcending time and geographic barriers (Dawson, 2008), providing increased flexibility, convenience, opportunities for feedback, and long-term knowledge retention (Lim et al., 2009).

As opportunities for feedback and interaction increase, students' motivation to learn, ability to retain information, and academic performance may also increase (Mahle, 2011). Collaborative learning, therefore, is facilitated by the social nature of web-based technologies (Cheung et al., 2011). However, the majority of studies on online learning, specifically collaborative learning, tend to focus on students in higher education (Dewiyanti et al., 2007; Miller & Benz, 2008; Nicholas & Ng, 2009; Zhu, 2012). Research suggests that technology is not suited for all learning tasks (Zhao et al., 2004). While the incidence of technology integration in the classroom has increased, few practices are evidence-based and may be ineffective for learning (Zhao et al., 2004). A key component of computer-mediated learning, however, has been the extent and quality of communication as well as the immediacy of feedback (Zhao et al., 2004). Thus, a

growing need exists to examine the impact of technologies on student learning at the adolescent level (Resta & Laferrière, 2007; Songer, 2007) as well as the generalizability of research findings to the K-12 classroom (Ronsisvalle & Watkins, 2004; Zhao et al., 2004).

Community and Effective Online Learning

Imperative to examining the effects of collaboration on student learning is the understanding of social presence, otherwise known as sense of community, or the feelings of connection and community among peers (Palloff & Pratt, 2005b).

Collaboration has been shown to increase learner sense of community by reducing the potential for learner isolation, therefore increasing opportunities for in-depth learning experiences (Palloff & Pratt, 2005b). The creation of a learning community is cultivated through collaboration that affords social construction of knowledge (Palloff & Pratt, 2000).

The Community of Inquiry (CoI) framework is perhaps one of the most thoroughly researched and reported frameworks when studying online education (Garrison & Arbaugh, 2007; Garrison, Anderson, & Archer, 2010). The CoI framework is based on three elements: cognitive presence, social presence, and teaching presence (Garrison, Anderson, & Archer, 2010). Cognitive presence is defined as “the extent to which learners are able to construct and confirm meaning through sustained reflection and discourse” (Garrison & Arbaugh, 2007, p. 161). Social presence is defined as the “ability of learners to project themselves socially and emotionally, thereby being perceived as ‘real people’ in mediated communication” (Garrison & Arbaugh, 2007, p. 159). Teaching presence is defined as the “design, facilitation, and direction of cognitive

and social processes for the purpose of realizing personally meaningful and educationally worthwhile learning outcomes” (Garrison & Arbaugh, 2007, p. 163). The underlying assumption of the theory is that effective online learning occurs when interactions between the three essential elements overlap, thus becoming an indicator of the effectiveness of online education.

Rovai (2002) suggested that the classroom community is a social community of learners who learn through the sharing of knowledge, values, and goals. However, the extent to which students experience feelings of disconnect may lead to decreased participation in the learning community; thus, connectedness is an important indicator of the effectiveness of the learning community. In order for learning to occur, feelings of connectedness and community must occur to facilitate acceptance of group values and goals (Rovai, 2002). Therefore, the extent to which the learner experiences learning and connectedness will influence the learner’s sense of community—or social presence—and thus influence the quality of the learning experience.

Communities of Practice Theory

Sense of community, the general feeling of belonging (McMillan & Chavis, 1986), is grounded in the theory of communities of practice (Wenger, 1998; Wenger et al., 2009). The theory of communities of practice follows in the footsteps of social development theory in that the central theme posits that learning is a fundamentally social phenomenon that occurs through social participation (Wenger, 1998; Wenger et al., 2009). Four premises exist within the theory of communities of practice: learners are social beings, knowledge entails competence and respect for valued enterprises, knowing occurs through active engagement, and learning should ultimately produce meaning

(Wenger, 1998). The four premises lay wake to four interconnected components (meaning, practice, community, and identity) that support the idea that social participation fosters the learning process (Wenger, 1998). These components are defined as follows:

- **Meaning:** a way of talking about our (changing) ability—individually and collectively—to experience our life and the world as meaningful.
- **Practice:** a way of talking about the shared historical and social resources, frameworks, and perspectives that can sustain mutual engagement in action.
- **Community:** a way of talking about the social configurations in which our enterprises are defined as worth pursuing and our participation is recognizable as competence.
- **Identity:** a way of talking about how learning changes who we are and creates personal histories of becoming in the context of our communities. (Wenger, 1998, p. 5)

A community of practice may be defined as community that develops over a period of time through the pursuit of a common set of wants, needs, and goals. A community of practice can manifest as any informal group in which mutual engagement, joint enterprise, and a shared repertoire exist—a family, a work group, a class, or a social group. Thus, a fundamental part of people’s daily lives involves communities of practice. In order for true learning to occur, individuals must participate within a community of practice where knowledge is socially gained (Wenger, 1998) through an interconnected web of giving and receiving (Gardner, 1996). As learning occurs through the interactions

of daily life, learning is the result of both social structure and situated experience (Wenger, 1998). Learning, therefore, consists of the shared histories and experiences of the community of practice (Wenger, 1998).

Learning is not a static object, but rather an emergent, cycling process (Wenger, 1998). The practice of learning is an “ongoing, social, interactive process” (Wenger, 1998, p. 102). A community of practice engages learners through establishment of personal identity, mutual engagement, and creation of complex interrelations between new and existing members (Wenger, 1998). Participation within the community of practice is essential for situated learning to occur (Smith, 2003). Situated learning posits that learning occurs as a result of social learning as well as the surrounding culture that influences mental functioning (Lave & Wenger, 1991).

Several principles support the idea of social learning within a community of practice:

- An intrinsic part of human nature is learning; therefore it is an inseparable and ongoing life activity (Wenger, 1998).
- Learning involves negotiation of new meanings; thus engagement and participation is essential for learning to occur (Wenger, 1998).
- Structure is created by learning; thus, implying that experience and continuous negotiation of meaning are imperative for learning (Wenger, 1998).
- Learning involves inherent experiential and social constructs; thus, supporting the importance of social engagement, creation of social identity, and building of experience within the community of practice (Wenger, 1998).

Each of those principles sustains the idea that learning is social and requires learner participation. Thus, learning is fostered through educational processes that are situated in social participation (Wenger, 1998). Understanding and enhancing social opportunities for learning, such as that provided in collaborative activities, is essential in cultivating citizens that are globally competent and able to function in today's ever-changing society (Wenger, 1998).

Research has shown that pedagogy rooted in social activities promotes learner satisfaction (Rovai, Wighting, & Liu, 2005). As pedagogy increasingly begins to require technology integration, examining the effects of multiple methods of instruction on the learning community will become necessary (Rovai, 2002b). Perhaps more importantly, research has found a relationship between peer connectedness within the learning community and cognitive learning, thus suggesting that activities that foster social learning within a community of practice may increase sense of community (Rovai, 2002b). An understanding of the social bonds that are created among learners in both face-to-face and computer-mediated learning is necessary in order to develop a more comprehensive picture of sense of community in the adolescent classroom (Rovai et al., 2005).

Technology has been purported to provide links for common experiences among individuals, thus establishing a community of practice (Wenger, White, & Smith, 2009). As a community of practice is established, learning may become more relevant, trust and mutual engagement may increase, and communicative learning may therefore be fostered (Wenger et al., 2009). As technologies that enable communication become more prevalent, the applicability of communities of practice theory increases as communities of

practice is centered on the potential of individuals to work together in learning communities (Wenger et al., 2009). Technology therefore provides new opportunities for community and the creation of digital habitats--the intersections of technology and community (Wenger et al., 2009). As digital habitats are created and users experience increased participation and engagement, individual and group identity may be encouraged. Certain practices may be formed that bridge interaction with and between technologies, which may create community agreements (Wenger et al., 2009), thus leading to the construction of sense of community.

Sense of Community

Sense of community is defined as “a feeling that members have of belonging, a feeling that members matter to one another and to the group, and a shared faith that members’ needs will be met through their commitment to be together” (McMillan & Chavis, 1986, p. 9). Sense of community is generally considered to have historically rural roots (Glynn, 1981) based on a geographical location (Palloff & Pratt, 1999). From the times when members of a town would gather to hunt, farm, gather, and feed, the formation of a community, and hence a sense of community, was not a conscious process. These early communities demonstrated several qualities: homogeneity, interdependence, shared responsibility, face-to-face relationships, and common goals (Glynn, 1981; Palloff & Pratt, 1999). The development of a sense of community was essentially a matter of survival; therefore, a high level of sense of community was considered beneficial to society (Glynn, 1981).

Over time, however, sense of community has purportedly declined (Glynn, 1981). This is attributed in part to the breakdown of social supports that have been an inherent

part of communities (Abfalter, et al., 2012; Glynn, 1981). Along with the loss of sense of community, society has experienced loss of autonomy, decreased involvement in the community, and loss of relationships that foster mutual growth and sustainment, thus leading to a decrease and breakdown of integral support systems (Glynn, 1981) and, therefore, sense of community (Koh & Hill, 2009). The efforts to increase opportunities for the building of sense of community, especially among young adults, often times has fallen short of social needs and expectations (Abfalter et al., 2012), thus leading to a need to understand more fully practices that encourage and foster sense of community (Cameron et al., 2009).

Research has shown that sense of community is more than an abstract concept (Glynn, 1981). Glynn (1981) found that sense of community may be defined as a group of attitudes and behaviors that provide a specific set of characteristics for a given community, namely characteristics related to satisfaction and competence, which are essential in development of a mutually responsive community (Glynn, 1981). This supported earlier findings by Hillery (1955) that concluded that the concept of community was rooted in social interaction regardless of geographic situation, which has since been supported by current study (Zhao et al., 2012). Recent research has found that sense of community fosters social identity, a key component of learning (Chiessi et al., 2010; Palloff & Pratt, 2005b), which increases the opportunities for learning within schools (Admiraal & Lockhorst, 2012; Sancho & Cline, 2012).

Sense of community consists of four interacting elements: membership, influence, integration and fulfillment of needs, and shared emotional connection (Abfalter et al., 2012; McMillan & Chavis, 1986). Membership is defined as an individual's

identification and sense of fitting in with other members of a specified group (Abfalter et al., 2012; Palloff & Pratt, 1999). Influence is characterized by not only the influence of the community on the individual, but also the individual's perceived impact on the surrounding community (Abfalter et al., 2012). Integration and fulfillment of needs entails the incentives, rewards, and reinforcements that are essential to becoming a member of a community and maintaining the community (Abfalter et al., 2012; McMillan & Chavis, 1986). Shared emotional connection involves the experiences, history, and identification that members share with the community (Abfalter et al., 2012).

Given the multiple facets of sense of community, Rovai (2002b) identified two overarching components of sense of community within the classroom: connectedness and learning. Connectedness is categorized as interpersonal relationships and is fostered through the building safety and trust among peers (Rovai, 2002b). Connectedness denotes a certain level of care and satisfaction among group members which may lead to development of a learning community (Rovai, 2002b). Likewise, learning is indicated as the active and social construction of knowledge that results from a thriving learning community (Rovai, 2002b). Learning is accomplished through the shared creation and meeting of goals among members of the community (Rovai, 2002b).

While the definition of sense of community in early studies centered on the interpersonal relationships and feelings of loyalty and belonging within a community (e.g. town or neighborhood), society in the modern age has formed sense of community focused more centrally on interests and skills (McMillan & Chavis, 1986). Thus, the concept of community can be extended from a geographic location to a community without spatial boundaries (Palloff & Pratt, 1999). This extends to the community within

specific disciplines or classrooms, forming modern-day face-to-face learning communities (Buch & Spaulding, 2011; Chiessi et al., 2010).

In today's technological world, a community without spatial boundaries entails the concept of the virtual community, a growing topic in the business, social, and educational world (Zhao, Lu, Wang, Chau, & Zhang, in press). Hagel and Armstrong defined virtual community as community constructed through computer-mediated spaces where communication encourages content that is generated not by individuals, but rather by the overall community (as cited in Zhao et al., in press). Just as in a face-to-face community, the component of belonging within the community is essential for positive outcomes in the virtual community (Palloff & Pratt, 1999; Zhao et al., in press).

Research has found many benefits to individuals who possess increased sense of community (Abfalter et al., 2012; Glynn, 1981; Yu et al., 2010). Sense of community has been positively correlated with academic achievement (Wighting et al., 2009). Wighting et al. (2009) also found a correlation between learning community and academic achievement (Glynn, 1981). Research also states that involvement and belonging in a community may provide benefits to adolescent development (Evans, 2007). Benefits to adolescents extend from development of personal identity, increased participation in community activities, and formation of peer groups based on shared characteristics (Chiessi et al., 2010; Pugh & Hart, 1999). The array of experiences coupled with the quality of experiences are paramount to the experience of sense of community, providing opportunities for adolescents to engage in influential and powerful social roles—roles upon which relationships within society are developed (Chiessi et al.,

2010). Social experiences are essential to adolescent development (Evans, 2007) and lead to the creation of a social learning community (Rovai, 2002b).

The interactions between individuals within a community, specifically a learning community, are important in the development of both personal and social identity (Chiessi et al., 2010). Therefore, a strong sense of community within a school may positively impact both students and teachers (Rossi, 1997). Studies involving undergraduate students have found a correlation between increased sense of community and perceived academic achievement (Buraphadeja & Kumnuanta, 2011). At the high school level, sense of community has been found to increase learning and academic achievement by increasing peer involvement (Wighting et al., 2009). Despite current knowledge of sense of community in the classroom that has focused on adult learners, a need exists to examine sense of community more thoroughly among adolescents (Chiessi et al., 2010; Evans, 2007; Wighting et al., 2009). Given that an essential component to successful science communities is an elevated sense of belonging, a more in-depth understanding of sense of community within the adolescent science classroom is necessary (Hsu & Roth, 2010).

Review of Literature

Research has shown that students that engage in a community of practice within the classroom and that experience increased sense of community develop interpersonal relationships that foster mutual respect and furthering of collaborative goals (Kelly, 2011). Research has also supported that sense of community is essential for development of personal identity and is a key component for the social and psychological well-being of adolescents (Chiessi et al., 2010). When adolescents are participatory members of a

group, their emotional needs are often met through their perceived influence on the community and their feelings of belonging (Chiessi et al., 2010). Individuals may come to realization that the product of the community may far outweigh what could be produced by the individual when a rich community exists, thus creating a sense of community (Kelly, 2011). As community is increased within the classroom, the increased interest in the mutual success of the group may transcend the school boundaries and reach into the surrounding neighborhood (Roxas, 2011).

Research on communities of practice and sense of community among adolescents in the traditional brick-and-mortar classroom has tended to focus on students of diversity—refugees and students of differing cultures (Kelly, 2011; Roxas, 2011) and students transitioning from one school to another (Sancho & Cline, 2012). Given the social constructivist view that meaning, learning, and self-identity are forged through social experiences (Vygotsky, 1978; Vygotsky, 1986), understanding how social activities influence adolescent development is important and timely (Evans, 2007). Research has supported that adolescents experience sense of community differently than adults (Evans, 2007) and that sense of community is related to establishing a sense of personal identity, especially in rural communities (Shamah, 2011). Research has also established the important role that schools play in providing support, connection to peers, and relationships with adult mentors (Shamah, 2011). Rural communities in particular have exhibited the need for school-related activities that engage students with their peers, where few opportunities may exist for social engagement otherwise (Shamah, 2011). An increasing need subsists in understanding and identifying methods to foster sense of community among adolescents in the classroom (Sancho & Cline, 2012; Shamah, 2011).

A recent study involving high school students found that increased collaboration through problem-based learning in the general science classroom facilitated the building of a learning community, thus increasing student sense of community (Ferreira & Trudel, 2012). Students participating in online collaborative group activities were found to have an increased level of sense of community as compared to students participating in online paired peer activities only (Ferreira & Trudel, 2012). Therefore, an increased level of interaction may lead to increased learning, academic achievement, and sense of community (Ferreira & Trudel, 2012).

Wighting et al. (2009) found a correlation between sense of community and academic achievement among high school students when examining student achievement as measured by the PSAT. A moderate correlation was also found between learning community and academic achievement (Wighting et al., 2009). However, the study was small-scale and may not be generalizable to other populations. Further suggestions for study included examining the effect of sense of community on academic achievement using a variety of measurement tools (Wighting et al., 2009).

A study involving middle and high school students and their teachers found that a relationship existed between middle school student perceptions of relationships (peer-to-peer and peer-to-teacher) and academic achievement (Schulte, Shanahan, Anderson, & Sides, 2003). However, the same relationship was not found with high school students, warranting further research. A relationship between sense of community, school attendance, and academic achievement was also noted; however, further examination was suggested (Schulte et al., 2003).

Buraphadeja and Kumnuanta (2011) found that increased collaboration through peer tutoring cultivated shared values and beliefs, construction of knowledge, and positive feelings towards peer-to-peer interaction. The enhancement of instruction through such practices as technology implementation, including information communication technologies (ICT) may also increase students' sense of community (Buraphadeja & Kumnuanta, 2011), although research indicates that some students may find the formation of learning communities through technology more difficult and less important than those formed in face-to-face courses (Cameron et al., 2009).

Currently, little research exists that examines community and the social context of learning within the science classroom specifically (Anderson, 2007b; Fraser, 2007; Lunetta et al., 2007). While science knowledge is socially (Anderson, 2007b) and experientially (Atkin & Black, 2007) constructed, the bulk of the research is based on theory rather than practice in the classroom (Roberts, 2007). Given the importance of science literacy to making sound social decisions, an examination of sense of community with goals motivated towards the common good is necessary (Roberts, 2007). Thus, a gap exists within the literature to study sense of community among adolescents (Evans, 2007), the effects of implementation of technology in the classroom on sense of community (Buraphadeja & Kumnuanta, 2011), the effect of community and learning environment on science achievement (Fraser, 2007), and the effects of technology implementation on science literacy (Bell, 2007).

Science Literacy

Science literacy has recently become an educational focus in the literature and in educational reform around the world (Organisation, 2007; Roberts, 2007). Science

literacy is defined in many different ways (Roberts, 2007). Despite the multitude and disparity among definitions, however, science literacy has come to mean education of all students in the area of science; the overarching understanding of science in general rather than a specific preparation for scientific careers (Roberts, 2007). This implies a specific level of science content knowledge and demands increased science learning within secondary education (Roberts, 2007).

Still, what constitutes science education differs widely from nation to nation. A more thorough definition, therefore, of science literacy (and the operational definition used in this study) is the “understanding [of] key scientific concepts and frameworks, the methods by which science builds explanations based on evidence, and how to critically assess scientific claims and make decisions based on this knowledge” (Impey et al., 2011, p. 34). In short, science literacy has been deemed engagement of all individuals with science (Roberts, 2007); the level of science knowledge and understanding that allows application of scientific concepts to real-world issues.

Important to understanding the concept of science literacy is the idea of the detriment caused by common scientific misconceptions (Harvard, 2011), as well as what scientific knowledge learners must attain in order to become competent citizens (Roberts, 2007). Since today’s learners will become tomorrow’s scientists, science literacy also emphasizes the need for lifelong learning (Liu, 2009; Roberts, 2007). The rapid advances in science and technology seen in today’s world warrant a renewed interest in the science literacy of all citizens in order to ensure continued economic development (Liu, 2009). This renewed interest is evident in initiatives worldwide that call for student proficiency in science literacy prior to graduation from high school (Liu, 2009).

The worldwide educational interest in science literacy can be traced to the 1950s and 1960s, when science literacy was deemed necessary for students who would not enter the scientific field post secondary graduation (Liu, 2009; Roberts, 2007). The United States expressed a specific interest in science education through the National Defense Education Act (NDEA), which was signed into law in 1958 and provided opportunities for government grants to fund materials, technology equipment, and minor remodeling of laboratory spaces for student science education in public and nonprofit private schools (Institute for Defense Analyses, 2006). Science literacy was later reasoned in the 1970s to be imperative for all students regardless of desired career path, ability, interest, and background (Liu, 2009). Current opinions of science literacy demand proficiency for all citizens (Liu, 2009; Roberts 2007), with a specific focus on youth who have been documented to be lagging behind in scientific expectations (Organisation for Economic Co-operation and Development, 2007). The importance of science literacy was specifically recognized during the 1980s with the creation of the American Association for the Advancement of Science's Project 2061 in 1985 which identified areas necessary for student understanding of science, mathematics, and technology and prescribed benchmarks that American students should meet or exceed (AAAS, 1990). Subsequently, the number of students participating in continued education increased, the necessity of a scientific work force was noticed, and the need for a citizenry that possessed certain scientific knowledge and skills was discerned (Roberts, 2007), thus solidifying the need for increased science literacy among adolescents and adults in order to participate in full and productive lives (AAAS, 1993).

With the recent advent of initiatives that push scientific learning specifically in the United States, such as the Common Core State Standards (Common, 2012), the National Science Education Standards (National Science Teachers Association, 2012), and STEM learning (Stage & Kinzie, 2009), student achievement level in science has gained great interest. Many experts cite science literacy as being imperative to full participation of citizens within society and the global economy (AAAS, 1991; AAAS, 1993; Organisation for Economic Co-operation and Development, 2007) and to becoming globally competitive citizens who have the knowledge and skills necessary to make sound scientific decisions in a changing world (AAAS, 1991; Impey et al., 2011; Lau 2009; Miller, 2007).

The most recent PISA assessment on international science literacy reported a wide disparity in levels of science literacy among adolescents across the globe (Organisation for Economic Co-operation and Development, 2007). The PISA assessment measures student science literacy on a proficiency scale ranging from 1 to 6, with 1 being the lowest level of science literacy and 6 being the highest level of science literacy. The assessment measured three science competencies: identification of science issues, explanation of phenomena using science, and application of scientific evidence (Organisation for Economic Co-operation and Development, 2007). Results indicated that only 1.3% of the 15-year old students surveyed across the world reached a level 6 (the highest proficiency level of scientific literacy) (Organisation for Economic Co-operation and Development, 2007). In addition, 19.2% of students surveyed across the world scored below a level 2, and 5.2% scored below a level 1 (the lowest proficiency

level of scientific literacy) (Organisation for Economic Co-operation and Development, 2007).

Despite different operational definitions of science literacy, six central elements of science literacy have been identified: “(a) understanding basic science concepts, (b) understanding nature of science, (c) understanding ethics guiding scientists work, (d) understanding between science and humanities, and (f) understanding the relationships and differences between science and technology” (Liu, 2009, p. 302). Among these central elements, research identified three main types of science literacy: practical, civic, and cultural (Roberts, 2007). Practical science literacy was defined as the ability to use science to solve practical problems (Roberts, 2007). Civic science literacy was defined as a general awareness of science in order to appropriately participate in democratic processes (Roberts, 2007). Finally, cultural science literacy was defined as the appreciation of science as a monumental human triumph (Roberts, 2007).

The AAAS, which continues to conduct Project 2061 on the premise of increasing the scientific literacy of American students, defined science literacy as the knowledge and habits of mind related to science, mathematics, and technology that individuals must acquire in order to live interesting, responsible, and productive lives (1993). The result of Project 2061 was the creation of benchmarks that 90% of American students were expected to achieve with a mastery of 90% of the prescribed thresholds in the areas of science, mathematics, and technology, published as *Science for All Americans*. *Science for All Americans* and subsequent supporting publications have striven to balance the scientific needs of society with the scientific needs of the individual by increasing

scientific habits of mind—critical thinking skills that allow a general understanding of scientific concepts that may be applied to everyday living (AAAS, 1993).

Furthermore, the National Science Foundation, using survey data and data obtained from PISA assessments, defined science literacy as the knowing of basic scientific facts and concepts and having a general understanding of how science works (2004) and presented the Science and Engineering Indicators (NSF, 2010). The Science and Engineering Indicators reported the quantitative summary information on the scope, quality, and vitality of the current science environment in an effort to assist in development of future educational policy related to science (NSF, 2012). While the Science and Engineering Indicators do not prescribe specific recommendations or standards for student science achievement, The National Research Council, the National Science Teachers Association, and the American Association for the Advancement of Science, and Achieve created the National Science Education Standards to provide guidance and benchmarks for student science achievement in an effort to increase student science literacy (National Academy of Sciences, 2013).

The benefits of science literacy are numerous and, in many cases, not easily measured, but are generally agreed to include the increased ability to make superior political decisions, the increased ability to reap economic returns, reduction of misconceptions and superstitions, an increased ability to improve the behavior of the individual, and the creation of a morally and ethically advanced world (Liu, 2009). Most experts concur that science literacy will enable citizenship and global competency necessary in a rapidly changing scientific world (AAAS, 1991; AAAS, 1993; Impey et al., 2011; NAS, 2013; Roberts, 2007). As such, the concept of science literacy as a whole

is difficult to tackle in a single study. Thus, this study focused on a factor that plays an integral role in science literacy: the misconceptions of science that adolescent students hold (AAAS, 1993). The identification and reduction of student misconceptions of science has been identified as paramount to increasing student acquisition of science knowledge and understanding (Harvard, 2011) as well as student science literacy (AAAS, 1993). Misconceptions may result from the inadequate teaching of scientific concepts, teacher misconceptions, and preconceived conceptions of science due to student experience (Harvard, 2011). Student misconceptions may often be difficult to correct and may produce barriers to increasing student scientific achievement (Burgoon et al., 2011). Therefore, in order to begin making strides towards realizing national goals towards the attainment of science literacy, a thorough understanding of practices that affect science literacy, such as the identification and reduction of student misconceptions of science, is necessary (AAAS, 1993).

Significance

With the rapidly advancing world of technology that learners experience today (Black, 2010), understanding the effects of online collaborative learning on students' sense of community and science literacy is paramount to providing education that meets the growing needs of today's learner. Research has shown that collaboration provides many benefits to learning (Ding & Harskamp, 2011; Miller & Benz, 2008; Parveen & Batool, 2012; Vaughan et al., 2011; Zhu, 2012). Educational pedagogy has pushed the implementation of collaborative learning activities to increase student learning and achievement (Bell et al., 2010).

In addition, a shift towards increasing learner opportunities to master scientific concepts that will allow global competency and participation in society has led to a renewed interest in student science literacy (AAAS, 1991; Harvard, 2011; Impey et al., 2011; Miller, 2007; Organisation for Economic Co-operation and Development, 2007). Since understanding scientific concepts requires higher order thinking that is independent of rote memorization of facts, a push toward inquiry based learning (Atkin & Black, 2007) that utilizes collaborative activities has been seen recently within the science classroom (Luft et al., 2008). Research has shown that increased levels of collaborative instruction have assisted in peer construction of higher order thinking skills, moving away from rote memorization and simple factual knowledge (Stump et al., 2011). Discussion in a collaborative setting has also been found to assist in making connections to prior knowledge and to reduce misconceptions (Webb, et al., 2008), which is important in identifying student science literacy (Harvard, 2011).

Finally, the social nature of learning is becoming more widely accepted (Lave & Wenger, 1991) and leads to the importance of understanding sense of community in the secondary classroom. When students socially engage (such as through collaborative learning) a learning community is created. Knowledge acquisition is supported and encouraged when a strong learning community exists, thus fostering excitement and motivation to learn (Palloff & Pratt, 1999). A strong learning community that produces an air of enthusiasm for learning may lead to a personal sense of engagement and empowerment (Palloff & Pratt, 1999), thus increasing student sense of community.

Given the push to implement collaborative activities in the classroom (Bell et al., 2010), research that examines the effect of student collaboration on student sense of

community is both necessary and timely. In considering the challenges of face-to-face collaborative learning, such as the geographical distance some students now experience, the encouragement of technology integration in the classroom, and time constraints, computer-mediated collaboration may be helpful in overcoming those challenges and in enhancing the learning experience through the use of new teaching tools. However, weaknesses have also been reported in computer-mediated learning, as the appropriateness of technology is limited to certain learning tasks, the tools of technology are inherently structured by the teacher, and the challenges of learning new skills may be overwhelming for some (Zhao et al., 2004). Furthermore, the implementation of technology that has shifted how learners communicate and learn (Black, 2010) needs to be examined more fully in regards to student sense of community. This study, therefore, sought to fill the current gap in the literature by examining the effect of online collaboration on both student science literacy and student sense of community among middle school students.

The next section will examine the methodology of the proposed study. The research design will be presented and the questions and hypotheses that this study sought to resolve are defined. The research participants and setting will be detailed. The measurement instrumentation is examined, including the respective rationale for using each instrument. The research procedures are outlined. Finally, the proposed plan for analyzing data is stated.

CHAPTER THREE: METHODOLOGY

Introduction

The purpose of this study was to determine the effects of online collaborative learning on middle school students' science literacy and sense of community. There is a need for research that examines the effect of different modes of teaching activities, such as face-to-face and online collaboration, specific to the field of science education as repeated studies have shown that science literacy amongst adolescents is lacking (AAAS, 1990; Impey et al., 2011; Organisation for Economic Co-operation and Development, 2007). Furthermore, the advantages of collaborative learning (Mäkitalo-Siegl et al., 2011; Zhu, 2012) and sense of community (Wighting et al., 2009) on student achievement have been documented. To date, no current studies exist that explore the effects of face-to-face collaborative learning as compared to online collaborative learning on science literacy or on sense of community in the adolescent population (Anderson, 2007a; Fraser, 2007). This chapter addresses the methodology proposed for this study, beginning with the design. The research questions and hypotheses are discussed followed by a description of the participants and the research setting. As well, measurement instruments, proposed procedures and data analysis procedures are presented.

Design

A quasi-experimental, pretest/posttest control group design was used to determine the effects of online collaborative learning on middle school students' science literacy and sense of community. This research design was chosen because the independent variable was manipulated and a control group was used, but randomization of the sample

was not possible due to the educational setting in which the study took place (Gall et al., 2007; Rovai et al., 2013). As randomization of the sample was not possible, statistical analysis was conducted to help control for the selection threat to validity (Gall et al., 2007). A pretest was employed to control for differences in prior science literacy and community; thus, strengthening the internal validity of the study (Campbell & Stanley, 1963; Gall et al., 2007). Homogenous groups, in terms of gender and socioeconomic status, were also used.

Questions and Hypotheses

The research questions of this study were as follows.

Research Question 1: Is there a statistically significant difference in middle school students' misconceptions, an aspect of science literacy, as measured by the MOSART testing instrument when participating in online collaborative learning as compared to students who participate in traditional collaborative learning only?

Research Question 2: Is there a statistically significant difference in middle school students' sense of community as measured by the Classroom Community Scale when participating in online collaborative learning as compared to students who participate in traditional collaborative learning only?

The following were the research hypotheses:

H₁: There is a statistically significant difference in middle school students' misconceptions of science as measured by the MOSART testing instrument when participating in online collaborative learning as compared to students who participate in traditional collaborative learning only while controlling for student prior knowledge.

H₂: There is a statistically significant difference in middle school students' overall sense of community as measured by the Classroom Community Scale when participating in online collaborative learning as compared to students who participate in traditional collaborative learning only.

H₃: There is a statistically significant difference in middle school students' connectedness as measured by the Classroom Community Scale when participating in online collaborative learning as compared to students who participate in traditional collaborative learning only.

H₄: There is a statistically significant difference in middle school students' learning as measured by the Classroom Community Scale when participating in online collaborative learning as compared to students who participate in traditional collaborative learning only.

Alternatively, the following were the null hypotheses:

H₀₁: There is no statistically significant difference in middle school students' misconceptions of science as measured by the MOSART testing instrument when participating in online collaborative learning as compared to students who participate in traditional collaborative learning only while controlling for student prior knowledge.

H₀₂: There is no statistically significant difference in middle school students' overall sense of community as measured by the Classroom Community Scale when participating in online collaborative learning as compared to students who participate in traditional collaborative learning only.

H₀₃: There is no statistically significant difference in middle school students' connectedness as measured by the Classroom Community Scale when participating in

online collaborative learning as compared to students who participate in traditional collaborative learning only.

H₀₄: There is no statistically significant difference in middle school students' learning as measured by the Classroom Community Scale when participating in online collaborative learning as compared to students who participate in traditional collaborative learning only.

Participants

The population of this study included eighth grade middle school students from five intact general physical science classes at a public middle school in central Virginia. The study took place during the third nine weeks of the 2012-2013 school year. Two classes served as the control group and three served as the experimental group. Two classroom teachers were chosen through recommendations from the county superintendent and middle school principal based on their quality teaching methods and history of students' Virginia Standards of Learning scores. Students in the existing classes taught by the chosen teacher were used.

Student participants were selected through convenience sampling. Since students were part of pre-existing groups (classes), the sampling was non-randomized. The sample was identified from the population through accessibility to the researcher and through the school district's willingness to participate. A minimum of 50 students were chosen for this sample to ensure adequate sample size for the quasi-experimental pretest/posttest design (Gall et al., 2007) as well as adequate sample size for the statistical analysis (Cohen, 1988). Statistical texts indicated a minimum sample size of 15 students

per group for design (Rovai et al., 2013) and a minimum of 26-64 students per group for the chosen statistical analysis with a large to medium effect size (Cohen, 1988).

The students in this study completed and returned signed consent and assent forms. The volunteer rate was 66%. A total of 84 students participated in all portions of the study. Forty-eight were female, and 36 were male. Through self-reporting, students were identified as follows: 1.2% Asian/Pacific Subcontinent, 35.3% Black, 2.4% Hispanic, 1.2% Pacific Islander, 47.1% White, 11.8% two or more races, and 1% unreported. Specific descriptive information divided by control and experimental group is shown below (see Table 1).

Table 1

Participant Demographics

	Treatment (n = 57)		Control (n = 27)	
	N	%	N	%
Female	32	56.1	16	59.3
Male	25	43.9	11	40.7
African-American	23	40.4	7	25.9
Caucasian	25	43.9	15	55.6
Hispanic	1	1.8	1	3.7
Asian/Pacific Subcontinent	1	1.8	0	0
Pacific Islander	1	1.8	0	0
Two or more races	6	10.5	4	14.8

Setting

Classroom Teachers

Two veteran classroom teachers were used in this study, each with between 9 and 12 years of teaching experience at the middle school level. The classroom teachers held a professional teaching license in the state of Virginia and were deemed highly qualified teachers in good standing as measured by professional yearly evaluations by the building principal and superintendent during implementation of the study. All of the instruction offered by the classroom teachers was approved by the department chair and aligned with current district curriculum and current state standards. Thus, instruction of the control group and experimental group was the same in content and provided to all students in the same traditional face-to-face format. The medium in which the authentic, collaborative activities (e.g. traditional face-to-face or online collaborative) were completed served as the treatment. The authentic, collaborative assignments were identical for both groups and developed collaboratively by the classroom teachers and researcher. The only difference was the medium in which the collaborative activities were completed. These measures taken helped control for instrumentation threats and construct threats to internal validity.

Overview of the School

The school was an accredited, public middle school in South-Central Virginia and will be referred to by the pseudonym Central Virginia Middle School (CVMS). The school was part of a rural school system that serves approximately 4500 students. At the time of this study, 4453 students were enrolled during the 2012-2013 school year with a ratio of 49% female and 51% male. The demographics of the school system include

5.2% Hispanic, 1% American Indian/Alaska Native, <1% Asian, 34.7% Black/African American, <1% Native Hawaiian/Other Pacific Islander, 54.8% White, and 4.3% two or more races.

Science Classroom

The study took place over a nine week grading period in the eighth grade physical science class, a course required by the school system and the Virginia Department of Education. As such, it is a Virginia Standards of Learning (SOL) course. Students enrolled in physical science are required to complete and successfully pass the Virginia SOL for physical science at the end of the school year. At the time of this study, a score of 400/600 is required to pass.

The physical science curriculum served as the framework for this study. Topics covered in physical science include scientific investigation, force, motion, energy, matter, life processes, living systems, interrelationships in earth and space systems, earth patterns, cycles, and earth resources (Virginia, 2010). These topics were covered in accordance with the Virginia SOL standards. According to the school system pacing guide, the specific topics covered during the study implementation period included thermal energy and heat, work and machines, states of matter, matter change, and atomic structure. These topics coincide with the following Virginia SOL standards: PS.2, PS. 4, PS. 5, PS. 6, PS. 7, and PS. 10 (Virginia, 2010) and the following National Science Education Standards: Physical Science 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, and 11 (National Academy of Sciences, 1996).

The curriculum was held constant across all classrooms for this study. The control group engaged in collaborative activities completed in a traditional, or face-to-

face, manner. The experimental group engaged in collaborative activities facilitated by computer-mediated tools, specifically the use of Edmodo. Further information regarding the specific settings is provided in the next section.

Collaboration Settings

Computer-mediated collaborative activities for the experimental group were conducted through use of Edmodo educational platform. Edmodo is an educational learning platform that allows social networking for teacher and student connection and collaboration (Edmodo, 2012). Students selected a username and passcode and were provided with an access code to gain access to specific course information. Edmodo allowed students to engage in group discussion through creation of posts and allowed the teacher to upload documents and multimedia. Use of the site is free of charge and currently serves approximately 15 million teachers and students worldwide (Edmodo, 2012). A screenshot can be seen in Figure 1.

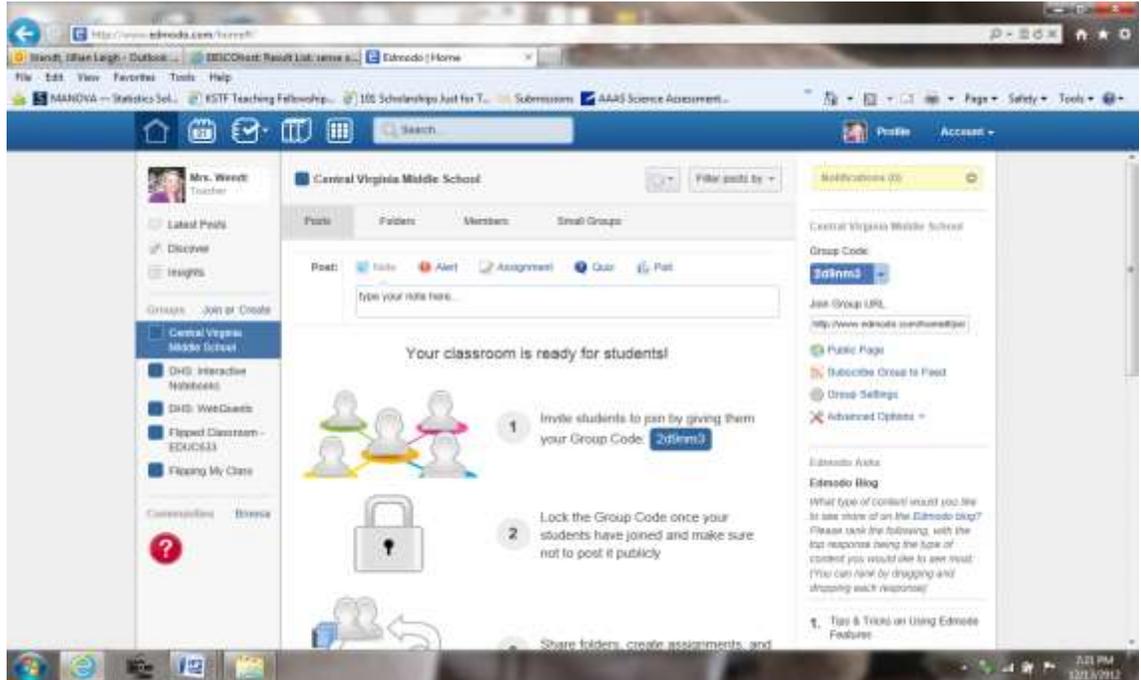


Figure 1. A screenshot of the Edmodo homepage is provided here. Edmodo, an online educational platform, has similarities to common social networking sites and allows collaboration among peers, teachers, and parents. (Retrieved from [http://www.edmodo.com/home#/.](http://www.edmodo.com/home#/))

In the experimental group, students completed the collaborative activities in a combination synchronous and an asynchronous manner. Students participated in collaborative activities through the use of the Edmodo educational platform with members of a small group that was created at the discretion of the classroom teacher. In addition, students participated in collaborative activities through the use of the Edmodo educational platform with members outside of their small group and outside of their immediate class. Thus, students were able to collaborate through discussion, inquiry, and reflection with the entire experimental group sample pool of students and were not limited by the physical walls of the classroom. Students were monitored by the

classroom teacher as the classroom teacher ensured that all activities were completed through observations and marking completed activities in the gradebook. The teacher encouraged peer-to-peer collaboration with classmates through verbal promotion to consider alternative student viewpoints and ideas. The teacher did not provide immediate feedback and re-direction via Edmodo; instead, due to the nature of the asynchronous learning environment, rather concepts were discussed during instructional class time.

In the control group, students completed the collaborative activities using traditional face-to-face collaborative methods. Students were divided into small groups at the discretion of the classroom teacher using pre-existing, intact groups, and were encouraged through verbal means to complete activities collaboratively, engaging in discussion, inquiry, and reflection. Students were monitored by the classroom teacher, who provided immediate feedback and re-direction when appropriate.

The arrangement of desks was similar for each classroom, with desks being arranged in rows facing the front of the classroom and the teacher (see Figure 2). Students in the control group were allowed to move their desks for collaborative activities to facilitate communication. One classroom teacher was available for each group. Although due to the nature of the settings, the control group teacher provided immediate feedback while the experimental group teacher provided delayed feedback through whole-class discussion after the conclusion of the collaborative activities.

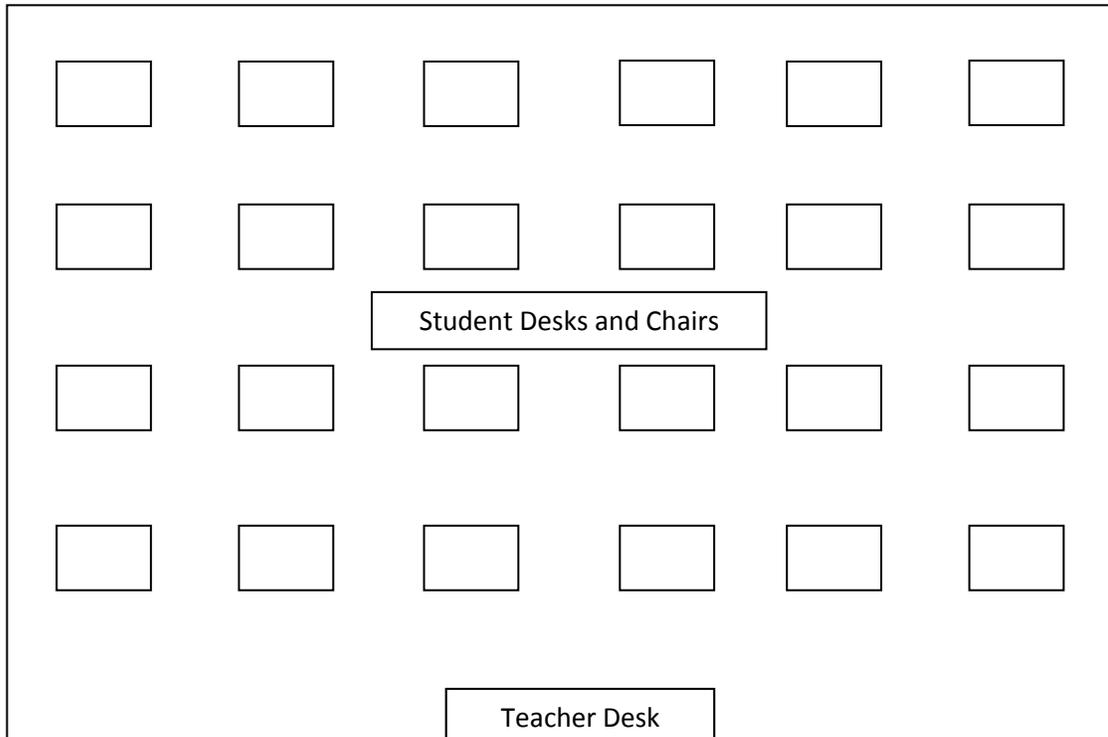


Figure 2. Approximate arrangements of student desks and chairs arranged in rows facing the front of the classroom and the teacher in the physical classroom environment.

Explanation of Collaborative Activities

The collaborative activities in this study employed group discussion and sharing of ideas in order to build upon individual members' histories and experiences. Both the experimental and control groups completed equivalent activities—in many cases, the activities consisted of the same figures and questions. The activities in this study were selected to be convenient for normal classroom instruction; that is, the activities chosen for inclusion in this study were meant to be completed in fifteen minutes or less and were intended to reiterate teacher-presented material through discussion and brief reflection.

A minimum of two activities were completed per week for a total of nine weeks (one grading period). Permission to use, distribute, and copy materials was provided by

Pearson, and a letter of permission is included in Appendix M. Table 2 shows the sequence of activities for both the experimental and control groups and is found below.

In addition, examples of each activity are provided in Appendix N.

Table 2

Description of Sequence, Content, and Corresponding VA Standards of Learning of Collaborative Activities

	Topics Covered	Corresponding VA Standard of Learning
Activity 1	The Meaning of Work; Calculating Work	PS.6, PS.10
Activity 2	Identifying Resistance and Effort	PS.6, PS.10
Activity 3	What is a Machine?	PS.6, PS.10
Activity 4	Mechanical Advantage and Efficiency	PS.6, PS.10
Activity 5	Structure of an Atom	PS.3, PS.4
Activity 6	The Role of Electrons	PS.3, PS.4
Activity 7	The Periodic Table; Organizing the Elements	PS.3, PS.4
Activity 8	Why the Periodic Table Works	PS.3, PS.4
Activity 9	Metals and Alloys	PS.4
Activity 10	Nonmetals and Metalloids	PS.4
Activity 11	Families of Nonmetals	PS.4
Activity 12	Particles of Matter; States of Matter	PS.2, PS.5
Activity 13	Describing Matter	PS.2, PS.5
Activity 14	Changes in State	PS.2, PS.5
Activity 15	Changes of State; Thermal Energy	PS.2, PS.5, PS.6
Activity 16	Thermal Expansion	PS.6
Activity 17	Heat Engines	PS.6, PS.7
Activity 18	Refrigerators	PS.7

All activities were correlated with the Virginia Standards of Learning as well as the National Science Standards. National Science Standards are listed and numbered in Table 3. Virginia Standards of Learning are listed and numbered in Table 4.

Table 3

National Science Education Standards as published by the National Academy of Sciences

Standard	Description of Standard
1	A substance has characteristic properties, such as density, a boiling point, and solubility, all of which are independent of the amount of the sample. A mixture of substances often can be separated into the original substances using one or more of the characteristic properties.
2	Substances react chemically in characteristic ways with other substances to form new substances (compounds) with different characteristic properties. In chemical reactions, the total mass is conserved. Substances often are placed in categories or groups if they react in similar ways; metals is an example of such a group.
3	Chemical elements do not break down during normal laboratory reactions involving such treatments as heating, exposure to electric current, or reaction with acids. There are more than 100 known elements that combine in a multitude of ways to produce compounds, which account for the living and nonliving substances that we encounter.
4	The motion of an object can be described by its position, direction of motion, and speed. That motion can be measured and represented on a graph.
5	If more than one force acts on an object along a straight line, then the forces will reinforce or cancel one another, depending on their direction and magnitude. Unbalanced forces will cause changes in the speed or direction of an object's motion.
6	Energy is a property of many substances and is associated with heat, light, electricity, mechanical motion, sound, nuclei, and the nature of a chemical. Energy is transferred in many ways.
7	Heat moves in predictable ways, flowing from warmer objects to cooler ones, until both reach the same temperature.
8	Light interacts with matter by transmission (including refraction), absorption, or scattering (including reflection). To see an object, light from that object—emitted by or scattered from it—must enter the eye.
9	Electrical circuits provide a means of transferring electrical energy when heat, light, sound, and chemical changes are produced.
10	In most chemical and nuclear reactions, energy is transferred into or out of a system. Heat, light, mechanical motion, or electricity might all be involved in such transfers.
11	The sun is a major source of energy for changes on earth's surface. The sun loses energy by emitting light. A tiny fraction of that light reaches earth, transferring energy from the sun to the earth. The sun's energy arrives as light with a range of wavelengths, consisting of visible light, infrared, and ultraviolet radiation.

(National Academy of Sciences, 1996, p. 165-166)

Table 4

Virginia Standards of Learning for Physical Science as listed by the Virginia Department of Education

Standard	Description of Standard
PS.1	<p>The student will demonstrate an understanding of scientific reasoning, logic, and the nature of science by planning and conducting investigations in which</p> <ol style="list-style-type: none"> chemicals and equipment are used safely; length, mass, volume, density, temperature, weight, and force are accurately measured; conversions are made among metric units, applying appropriate prefixes; triple beam and electronic balances, thermometers, metric rulers, graduated cylinders, probeware, and spring scales are used to gather data; numbers are expressed in scientific notation where appropriate; independent and dependent variables, constants, controls, and repeated trials are identified; data tables showing the independent and dependent variables, derived quantities, and the number of trials are constructed and interpreted; data tables for descriptive statistics showing specific measures of central tendency, the range of the data set, and the number of repeated trials are constructed and interpreted; frequency distributions, scatterplots, line plots, and histograms are constructed and interpreted; valid conclusions are made after analyzing data; research methods are used to investigate practical problems and questions; experimental results are presented in appropriate written form; models and simulations are constructed and used to illustrate and explain phenomena; and current applications of physical science concepts are used.
PS.2	<p>The student will investigate and understand the nature of matter. Key concepts include</p> <ol style="list-style-type: none"> the particle theory of matter; elements, compounds, mixtures, acids, bases, and salts; solids, liquids, and gases; physical properties; chemical properties; and characteristics of types of matter based on physical and chemical properties.
PS.3	<p>The student will investigate and understand the modern and historical models of atomic structure. Key concepts include</p> <ol style="list-style-type: none"> the contributions of Dalton, Thomson, Rutherford, and Bohr in understanding the atom; and the modern model of atomic structure.
PS.4	<p>The student will investigate and understand the organization and use of the periodic table of elements to obtain information. Key concepts include</p> <ol style="list-style-type: none"> symbols, atomic numbers, atomic mass, chemical families (groups), and periods; classification of elements as metals, metalloids, and nonmetals; and formation of compounds through ionic and covalent bonding.
PS.5	<p>The student will investigate and understand changes in matter and the relationship of these changes to the Law of Conservation of Matter and Energy. Key concepts include</p> <ol style="list-style-type: none"> physical changes; chemical changes; and nuclear reactions.
PS.6	<p>The student will investigate and understand forms of energy and how energy is transferred and transformed. Key concepts include</p> <ol style="list-style-type: none"> potential and kinetic energy; and

Standard	Description of Standard
PS.7	<p>b) mechanical, chemical, electrical, thermal, radiant, and nuclear energy.</p> <p>The student will investigate and understand temperature scales, heat, and thermal energy transfer. Key concepts include</p> <p>a) Celsius and Kelvin temperature scales and absolute zero;</p> <p>b) phase change, freezing point, melting point, boiling point, vaporization, and condensation;</p> <p>c) conduction, convection, and radiation; and</p> <p>d) applications of thermal energy transfer.</p>
PS.8	<p>The student will investigate and understand the characteristics of sound waves. Key concepts include</p> <p>a) wavelength, frequency, speed, amplitude, rarefaction, and compression;</p> <p>b) resonance;</p> <p>c) the nature of compression waves; and</p> <p>d) technological applications of sound.</p>
PS.9	<p>The student will investigate and understand the characteristics of transverse waves. Key concepts include</p> <p>a) wavelength, frequency, speed, amplitude, crest, and trough;</p> <p>b) the wave behavior of light;</p> <p>c) images formed by lenses and mirrors;</p> <p>d) the electromagnetic spectrum; and</p> <p>e) technological applications of light.</p>
PS.10	<p>The student will investigate and understand the scientific principles of work, force, and motion. Key concepts include</p> <p>a) speed, velocity, and acceleration;</p> <p>b) Newton's laws of motion;</p> <p>c) work, force, mechanical advantage, efficiency, and power; and</p> <p>d) technological applications of work, force, and motion.</p>
PS.11	<p>The student will investigate and understand basic principles of electricity and magnetism. Key concepts include</p> <p>a) static electricity, current electricity, and circuits;</p> <p>b) relationship between a magnetic field and an electric current;</p> <p>c) electromagnets, motors, and generators and their uses; and</p> <p>d) conductors, semiconductors, and insulators.</p>

(Virginia Department of Education, 2010, p. 6-8)

Furthermore, activities were correlated with the National Science Standards that the MOSART Physical Science Assessment specifically tested for as shown in Table 5.

Table 5

MOSART Physical Assessment Item Correlations with National Science Standards and Virginia SOL Standards

Item # (Form 921)	Item # (Form 922)	National Science Standard	Virginia SOL Standard
1	18	1	PS.2, PS.7
2	13	3	PS.2
3	16	7	PS.7
4	7	9	PS.11
5	9	11	PS.9
6	17	2	PS.4, PS.5
7	14	4	PS.10
8	20	6	PS.6
9	4	8	PS.9
10	19	10	PS.6
11	5	11	PS.9
12	8	7	PS.7
13	15	2	PS.4, PS.5
14	12	4	PS.10
15	10	3	PS.2
16	6	5	PS.10
17	2	8	PS.9
18	3	9	PS.11
19	11	1	PS.2, PS.7
20	1	1	PS.2, PS.7

Instrumentation

Student science literacy was measured using the Misconceptions-Oriented Standards-Based Assessment Resources for Teachers (MOSART) assessment (Harvard, 2011), which is designed to measure misconceptions as an aspect of science literacy (H. Coyle, personal communication, January 24, 2013). The Harvard-Smithsonian Center for Astrophysics, with funding from the National Science Foundation (NSF), completed development of the first MOSART assessments in 2001 (Harvard-Smithsonian Center for Astrophysics, 2012; Smith, n.d.). The purpose of the project was to develop a diagnostic

tool to assist science instructors at the elementary, middle, and high school levels in identifying student misconceptions of science concepts and to evaluate the extent of mastery of national science standards and AAAS Benchmarks in Physical Science and Earth and Space Science (Center for School Reform at TERC, 2012). The scope of the MOSART assessments has since extended to Astronomy, Life Science, Chemistry, and Physics. The resulting MOSART assessments are divided into appropriate grade level (K-4, 5-8, and 9-12) assessments and further subdivided by subject area (Astronomy/Space Science, Earth Science, Life Science, Physical Science, Chemistry, and Physics) (Harvard, 2011).

Each MOSART assessment contains multiple choice questions for each of the correlating K-12 National Science Standards, with five student answer choice options for each question. Assessment questions were chosen from a test bank with over 2000 questions compiled over ten years. These questions were created by research experts in the science field in tandem with a development team and then were reviewed by one literacy expert to ensure readability and grade appropriateness (Harvard, 2011; Sadler et al., 2010; Smith, n.d.). Pilot versions of the tests were then created and administered to elementary, middle, and high school students. Results were analyzed and field tests of the revised assessment instruments were conducted. The KR-20 score of 0.85, a measure of high test item reliability, was found for grades 9-12 (Sadler et al., 2010). Cronbach's alpha ranged from 0.7-0.9 for all tests, thus indicating internal reliability (Smith, n.d.). Validity of the MOSART assessments was ensured through a scientific review process, item fit review, and uni-dimensionality review (Smith, n.d.). For this study, Cronbach's $\alpha = .98$, indicating increased internal reliability (Tabachnick & Fidell, 2013).

Access to the MOSART assessments requires completion of online tutorials provided on the MOSART Self-Service website. These tutorials include information on the definition of misconceptions, how classroom teachers may identify student misconceptions of science, the intent of the MOSART assessments, scoring of the MOSART assessments, analyzing data obtained from MOSART assessments, and how to use data to influence the practice of teaching science in the classroom. Upon completion of the tutorials, the MOSART assessments are available by request in digital format. An answer key is provided for each publicly released MOSART assessment, which is typically scored by the classroom teacher (Harvard, 2011). Assessment follows a distractor analysis approach, meaning the classroom teacher scores the assessments through counting the number of students who choose each response option (Harvard, 2011). It is possible that allowing the classroom teacher to score the assessment while having access to the test forms may introduce bias. However, the intent of the MOSART assessment is to assist the classroom teacher in identifying student misconceptions in order to make sound improvements in science teaching practice, thus negating any benefit of “teaching to the test”. The classroom teacher then determines areas of misconceptions by identifying questions where one incorrect response is more prevalent than other incorrect responses. Scores may be expressed as percentages correct with a range from 0%-100%, with approximately 25% of the assessment questions expected to be easy, 25% difficult, and 50% moderate (Harvard, 2011). Additionally, each MOSART assessment consists of two parallel tests to promote use in a pretest/posttest design (Harvard, 2011). The parallel tests have identical content and psychometric characteristics.

The MOSART assessments are publicly available for classroom and research use once online tutorial completion requirements have been met. However, additional permission to use the MOSART assessments as part of this study was granted by Mr. Hal Coyle, Manager of MOSART Projects through email correspondence (Appendix A). The MOSART assessments were provided to students as a pencil and paper test. A printed copy of the MOSART assessment is found in Appendix C. Student answers were marked on a bubble-sheet that is compatible with the Reports Online Systems (ROS) ®. The ROS® system provided a means for aggregation of results; results were then imported into the SPSS program for data analysis.

To measure student sense of community, the Classroom Community Scale was used in this study (Rovai, 2002a). The Classroom Community Scale was developed from elements of classroom community identified through an extensive review of the literature (Rovai, 2002a); elements consisted of “feelings of connectedness, cohesion, spirit, trust, and interdependence among members” (Rovai, 2002a, p. 201). A set of 20 questions was created to address the identified elements of sense of community. Additional questions were later added in order to address community issues specific to either the traditional or virtual classroom, thus the final Classroom Community Scale is appropriate for use in both traditional face-to-face classrooms as well as virtual or online classrooms (Rovai, 2002a). The questions were then rated by a panel of educational psychology experts to determine relevancy and identify issues of factor loading (correlation between factors and variables), resulting in the deletion of non-relevant items. The final Classroom Community Scale was then created with a total of 20 questions with a range of responses using a 5-point Likert-type scale.

The Classroom Community Scale was empirically tested for reliability with a Cronbach's coefficient α of .93 (Rovai, 2002a). Validity of the Classroom Community Scale was ensured through the ratings of three university professors who taught educational psychology, as well as grounding each item in the professional literature (Rovai, 2002a). Furthermore, the readability and ease of understanding of the Classroom Community Scale were made certain through a Flesch Reading Ease score of 68.4 and Flesch-Kincaid grade level score of 6.6 (Rovai, 2002a).

Finally, two subscales of the Classroom Community Scale have been identified: connectedness and learning (Rovai, 2002a). Internal consistency was estimated for each subscale, with a Cronbach's α of .92 for the connectedness subscale and a Cronbach's α of .87 for the learning subscale. Thus, both subscales showed reliability (Rovai, 2002a). The Classroom Community Scale is appropriate for use on adult populations (Rovai, 2002a) and adolescent students (Rovai, Wighting, & Lucking, 2004; Wighting et al., 2009). For this particular study, reliability for overall sense of community was calculated as Cronbach's $\alpha = .80$ for the pre-test survey, indicating high reliability (Rovai et al., 2013). Reliability for the subscale connectedness was calculated as Cronbach's $\alpha = .75$ and for the subscale learning as Cronbach's $\alpha = .68$, indicating moderate to high reliability among the subscales. Reliability for overall sense of community was calculated as Cronbach's $\alpha = .80$ for the post-test survey, indicating high reliability. Reliability for the subscale connectedness was calculated as Cronbach's $\alpha = .77$ and for the subscale learning as Cronbach's $\alpha = .65$, indicating moderate to high reliability among the subscales (Rovai et al., 2013).

Scoring of the Classroom Community Scale is completed by instructing students to mark the area on the Likert-type scale that most appropriately describes their feelings about the item; then the researcher computing scores by adding points that are pre-assigned to each of the items, with the most favorable choice being assigned a value of 4 and the least favorable choice being assigned a value of 0 (Rovai, 2002b). Possible scores may range from 0 to 80. A higher score reflects a strong sense of community while a lower score reflects a low sense of community (Rovai, 2002b). Scores for each of the subscales may range from 0 to 40.

Permission to use the Classroom Community Scale is provided, as “researchers may use this instrument [the Classroom Community Scale] for studies they conduct provided they give proper attribution by citing this article” (Rovai, 2002a, p. 202). In addition, specific permission was granted by Rovai through email correspondence (Appendix B). A print version of the Classroom Community Scale is found in Appendix D. The Classroom Community Scale, including additional questions to gather data on gender and ethnicity was completed as an online survey utilizing the SurveyMonkey® online survey program. An overview of the testing instruments is provided in Table 6.

Table 6

Description of Measurement Instruments

	MOSART	Classroom Community Scale
Construct Measured	Misconceptions of science	Sense of community
Format of Assessment	Multiple choice	Survey; Likert-type scale
Reliability	Cronbach's $\alpha = 0.7-0.9$	Cronbach's $\alpha = 0.93$
Validity	Reported as verified through item fit, uni-dimensionality	Reported as possessing high content and construct validity
Score Range	0-100 (percentage)	0-40 (points) per subscale
Subscales	None	Learning and Connectedness

Procedures

After submitting the dissertation proposal packet and gaining IRB approval, execution of the study began. Consent and assent forms (Appendices E & F, respectively) were provided to all potential students and collected by the classroom teachers; those students included in the study had signed students informed consent and assent forms. The researcher and classroom teachers met on two days to choose collaborative activities to provide to the students for this study. The two classroom teachers participating in administration of the testing materials and instruction were provided with MOSART training prior to implementation of the study through the use of four online tutorials publicly available at the MOSART Self-Service Site (Harvard, 2011). Instructions for how to complete the MOSART training were provided to the

classroom teachers through Word document and email correspondence (Appendix I). In addition, approximately one hour of face-to-face training was provided to the experimental group's classroom teacher by the researcher on the use of the Edmodo educational platform.

At the beginning of the study, the classroom teachers instructed students in both the experimental and control groups to complete the pretest materials consisting of the MOSART assessment and the Classroom Community Scale survey. The classroom teachers were provided a script to use in administration of both the MOSART assessment and Classroom Community Scale survey for both groups (Appendices G & H, respectively); this was used in both the pretesting and posttesting. The completed tests and surveys were given to the researcher for scoring and analysis. The classroom teachers provided normal in-class instruction to both the experimental and control groups. The teacher assigned to the control group provided students with assignments that they were instructed to complete collaboratively in a traditional face-to-face manner. The teacher assigned to the experimental group provided students with the same assignments as the control group. However, the experimental group was given the instruction to complete the assignments in class collaboratively through the use of Edmodo. Collaborative assignments were given to both groups at a minimum of two times weekly at the discretion of the classroom teachers and on days determined by the classroom teachers. Completed assignments for both the experimental and control group were marked in the teachers' grade book by the classroom teachers to ensure minimum participation of two completed assignments for each participant per week. This continued for nine weeks (one grading period). Fidelity of treatment was ensured

through equivalent classroom instruction provided by the classroom teachers to all students to the best of their ability as measured by review of teacher lesson plans by the researcher.

At the end of the nine-week grading period, the classroom teachers instructed students in both groups to complete the posttest materials consisting of the MOSART assessment and the Classroom Community Scale survey. The completed tests and surveys were given to the researcher for scoring and analysis. No incentive was provided for student students as the completion of the MOSART assessments were considered part of the normal curriculum. Students whose consent forms were not returned to the classroom teacher still participated since the MOSART assessment was considered part of the established curriculum; however, their data was not included in the final data analysis. Furthermore, students whose consent forms were not returned to the classroom teacher did not participate in completion of the Classroom Community Scale survey as the survey was not considered part of the normal curriculum.

Data Analysis

Research Question One

One-way analysis of covariance (ANCOVA) was used to examine the null hypothesis: There is no statistically significant difference in middle school students' misconceptions of science as measured by the MOSART testing instrument when participating in online collaborative learning as compared to students who participate in traditional collaborative learning only, while controlling for student prior knowledge. The type of medium for collaboration served as the independent variable for both analyses. Misconceptions, an aspect of science literacy measured via the MOSART

served as the dependent variables. No subscales have been reported in regards to the MOSART assessment within the literature. The MOSART pretest served as the covariate. The ANCOVA analysis was deemed most appropriate when one or more covariates exist and are used to adjust for differences in pre-test scores (Tabachnick & Fidell, 2013; Rovai et al., 2013).

Independent *t*-tests for the pre-test scores were conducted to determine if there was a significant difference in MOSART pretest assessment scores based on group assignment prior to interventions. A statistically significant difference was found on the pretest suggesting pre-existing differences between groups in science misconceptions; thus, an ANCOVA analysis was most appropriate in order to examine posttest differences while controlling the pretest. A scatterplot was also inspected which revealed a correlation, although weak, between variables. This further confirmed the choice of the ANCOVA.

Prior to the analysis, assumption testing was completed. Normality was tested by examination of histograms, which showed a distribution that indicated normality among the control group pre-test and posttest MOSART data and negative skewness among the experimental group pre-test and posttest data. Furthermore, Shapiro-Wilk and Kolmogorov Smirnov were used to verify the assumptions of normality. Linearity, the assumption that the rate of change between the scores of two variables is constant, was assessed using a scatterplot (Rovai et al., 2013). The assumption of linearity was met as an approximate straight line existed between the variables. Homogeneity of variance, also known as error variance, was tested for through Levene's test. It assessed the null hypothesis that the variance of the dependent variables were equal across groups

(Levene, 1960; Rovai et al., 2013). Analysis for this indicated that the assumption of homogeneity of variance was tenable. Homogeneity of regression slopes, which is used to examine whether the slopes of the regression lines are the same for each group (Rovai et al., 2013), was examined since covariates were found. The assumption of homogeneity of regression slopes was tenable. Additional assumption testing was conducted and is discussed in Chapter 4.

The overall F-test was examined for the ANCOVA (Rovai, et al., 2013). Effect size, the practical significance of the magnitude of the treatment, was calculated as eta square (η^2) (Rovai, et al., 2013) and interpreted using Cohen's *d* (Cohen, 1988; Rovai, et al., 2013). The 0.05 significance level was used to determine whether the null hypotheses were rejected (Rovai et al., 2013). A significance level of 0.05 is generally accepted within social science research and indicates the probability of making a Type I error or falsely rejecting the null hypothesis (Rovai et al., 2013). An overview of the test of statistical analyses is provided in Table 7.

Research Question Two

One-way multivariate analyses of variance (MANOVA) and individual one-way analyses of variance (ANOVA) were used to analyze null hypotheses 2 through 4. Since the subscales of the CCS were analyzed, and the subscales were found to be correlated during assumption in this study, a MANOVA was appropriate as it evaluates the significance of group differences between two or more groups when there are correlated dependent variables (Tabachnick & Fidell, 2013). Additionally, there was not a need to control covariates. An independent *t*-test for the pre-test scores was conducted to determine if there was a significant difference in scores based on group assignment prior

to interventions. No differences were found indicating that there was not a need to control for pre-existing difference in community. Prior to conducting the analysis, assumption testing was completed and is discussed in Chapter 4.

While MANOVA analysis is typically robust in regards to normality (Tabachnick & Fidell, 2013), normality and multivariate normality were tested for by completing histograms (Gall et al., 2007). Inspection of the histograms showed a distribution that indicated normality among the control group learning and connectedness and experimental group learning posttest data. However, inspection of the histograms showed that the experimental group connectedness data was slightly positively skewed. Furthermore, Shapiro-Wilk and Kolmogorov Smirnov were used to verify that assumptions of normality were not violated. Multivariate normality was examined through Mahalanobis distance, a measure of the multivariate outliers (Tabachnick & Fidell, 2013). Mahalanobis distance creates points at the intersection of the means of all variables, thus creating a swarm of points around the centroid which also indicates multivariate normality (Tabachnick & Fidell, 2013). Points that lie outside of the swarm are considered outliers and are generally removed from data. For this study, one extreme outlier was found and removed.

Linearity, the assumption that the rate of change between the scores of two variables is constant, was assessed using a scatterplot (Rovai et al., 2013). The assumption of linearity would be met if an approximate straight line existed between the variables, which was indicated through inspection of data for this study. Furthermore, a matrix of scatterplots was examined to ensure the assumptions of multicollinearity and singularity were upheld.

Homogeneity of covariance and variance, also known as error variance, was tested for through Box's M test and Levene's respectively (Rovai, et al., 2013). A significance level of $p < .001$ indicates a violation exists (Tabachnick & Fidell, 2013). Box's M tests MANOVA's assumption of homogeneity of covariance matrices using the F distribution. In order for the assumption of homogeneity of covariance matrices to be upheld, the probability value should be greater than 0.05, meaning that M is found to be not significant (Rovai et al., 2013). For this study, the assumption of homogeneity of covariance was not violated. Levene's test assessed the null hypothesis that the variance of the dependent variables was equal across groups (Rovai et al., 2013). Levene's test is generally accepted to be robust when departures from normality are seen (Rovai et al., 2013). Levene's test was not significant in this study.

The overall F-test was examined for the MANOVA and individual ANOVA analyses (Rovai, et al., 2013). Effect size, the practical significance of the magnitude of the treatment, was calculated as eta square (η^2) (Rovai, et al., 2013) and interpreted using Cohen's *d* (Cohen, 1988; Rovai, et al., 2013). The 0.05 significance level was used to determine whether the null hypothesis for the MANOVA was rejected (Rovai et al., 2013). A significance level of 0.05 is generally accepted within social science research and indicates the probability of making a Type I error or falsely rejecting the null hypothesis (Rovai et al., 2013). A more stringent alpha, Bonferroni correction, was set to control for Type I error (Rovai et al., 2013). Bonferroni was calculated as $\alpha = .025$ ($.05/2$).

Statistical convention requires that the sample size for MANOVA analysis exceed the number of dependent variables in each of the cells (Tabachnick & Fidell, 2013),

which was met for this study. The number of students needed for each group was 15 for the experimental design (Rovai et al., 2013). Cohen (1988) suggests that the number of students needed for each group to be 26 for the MANOVA statistical analysis. This study aimed to use approximately 50 students in each group. An overview of the test of statistical analyses is provided in Table 7.

Table 7

Organization of Statistical Analysis of Data

Statistical test	Purpose
ANCOVA	Analysis of hypothesis for research question one
MANOVA	Analysis of the hypothesis two for research question two
ANOVA	Analysis of hypothesis three and four for research question two
Independent <i>t</i> Tests	Test for significant differences in scores based on group assignment prior to interventions
Scatterplot and correlation coefficient	Correlation, linearity, multicollinearity, singularity
Histograms	Normality
Shapiro-Wilk	Normality
Kolmogorov-Smirnov	Normality
Mahalanobis Distance	Normality
Box plots	Normality
Levene's Test	Homogeneity of variance
Scatterplot	Homogeneity of regression slopes
Effect Size	Practical significance of the magnitude of the treatment (calculated as eta square; interpreted using Cohen's <i>d</i>)
Box's M	Homogeneity of covariance

The aim of this quasi experimental pre-test/posttest control group design experiment was to determine the effects of online collaboration on middle school students' science literacy and sense of community among a representative sample of middle school physical science students in a rural public school system in South-Central Virginia. In the next section, the findings of the research study are presented. The results of each hypothesis tested will be discussed.

CHAPTER FOUR: FINDINGS

Restatement of the Purpose

The purpose of the study was to investigate the effect of online collaborative learning on middle school student science literacy and sense of community. Students were eighth grade students enrolled in pre-existing general education physical science classes at an accredited public middle school in South-Central Virginia. Given the current push to increase adolescent science literacy and to improve understanding of best practices in the science classroom, this study was timely. In addition, in light of current efforts to increase technology implementation in the classroom and the move towards addition of distance education courses in the public school systems, this study was timely. This study contributed to the body of knowledge in regards to the effect online collaboration may have on student science literacy with a specific focus on misconceptions. This study also provided relevant literature that investigated the effect of online collaboration on adolescent sense of community, with particular emphasis on the science classroom.

Research Questions and Hypotheses

The following research questions were investigated:

Research Question 1: Is there a statistically significant difference in middle school students' misconceptions, aspect of science literacy, as measured by the MOSART testing instrument when participating in online collaborative learning as compared to students who participate in traditional collaborative learning only?

Research Question 2: Is there a statistically significant difference in middle school students' sense of community as measured by the Classroom Community Scale

when participating in online collaborative learning as compared to students who participate in traditional collaborative learning only?

The following were the corresponding research hypotheses:

H₁: There is a statistically significant difference in middle school students' misconceptions of science as measured by the MOSART testing instrument when participating in online collaborative learning as compared to students who participate in traditional collaborative learning only, while controlling for student prior knowledge.

H₂: There is a statistically significant difference in middle school students' overall sense of community as measured by the Classroom Community Scale when participating in online collaborative learning as compared to students who participate in traditional collaborative learning only.

H₃: There is a statistically significant difference in middle school students' connectedness as measured by the Classroom Community Scale when participating in online collaborative learning as compared to students who participate in traditional collaborative learning only.

H₄: There is a statistically significant difference in middle school students' learning as measured by the Classroom Community Scale when participating in online collaborative learning as compared to students who participate in traditional collaborative learning only.

Alternatively, the following null hypotheses were tested:

H₀₁: There is no statistically significant difference in middle school students' misconceptions of science as measured by the MOSART testing instrument when

participating in online collaborative learning as compared to students who participate in traditional collaborative learning only, while controlling for student prior knowledge.

H₀₂: There is no statistically significant difference in middle school students' overall sense of community as measured by the Classroom Community Scale when participating in online collaborative learning as compared to students who participate in traditional collaborative learning only.

H₀₃: There is no statistically significant difference in middle school students' connectedness as measured by the Classroom Community Scale when participating in online collaborative learning as compared to students who participate in traditional collaborative learning only.

H₀₄: There is no statistically significant difference in middle school students' learning as measured by the Classroom Community Scale when participating in online collaborative learning as compared to students who participate in traditional collaborative learning only.

Demographics

A total of 84 students were part of this study, all of whom were eighth grade physical science students enrolled in an accredited public middle school in central Virginia—Central Virginia Middle School (CVMS). All students were existing members of pre-existing general education physical science classes. The regular classroom teachers provided classroom instruction.

Of the 84 students, 48 were female and 36 were male. None of the students had a formal educational plan on file, which indicated that none of the students were students with disabilities. Within the experimental group, $n = 57$ and within the control group, $n =$

27. Specific descriptive data detailing the race and gender of each of the participant students within each group is presented in Chapter 3. Information regarding socioeconomic status was not collected as part of this study due to the likelihood of false self-reporting due to the age of the students involved and the chance of students being unaware of an accurate report of family income.

Research Question One

Research question one was as follows: Is there a statistically significant difference in middle school students' misconceptions, an aspect of science literacy, as measured by the MOSART testing instrument when participating in online collaborative learning as compared to students who participate in traditional collaborative learning only? An analysis of covariance (ANCOVA) examines whether the means of groups are statistically different from one another while controlling for the effects of a potentially confounding variables (Rovai et al., 2013). An ANCOVA analysis was used to analyze the first null hypothesis. H_{01} : There is no statistically significant difference in middle school students' misconceptions of science as measured by the MOSART testing instrument when participating in online collaborative learning as compared to students who participate in traditional collaborative learning only, while controlling for student prior knowledge. Assumption testing was conducted prior to running the analysis and is explained in the next section.

Assumption Testing

An independent *t*-test was first conducted to ensure that no statistically significant difference existed among the means of the control and experimental group's pretest scores on the MOSART (Rovai et al., 2013). Statistically significant difference in scores

for the control group ($M = 4.81$, $SD = 1.80$) and the experimental group ($M = 6.17$, $SD = 2.31$); $t(88) = 2.86$, $p = .005$ were found. The magnitude of the differences in the means (mean difference = 1.36, 95% CI: -2.31 to -.42) was moderate to large (eta square = .09); thus, analysis of covariance (ANCOVA) was used to control for preexisting differences (Tabachnick & Fidell, 2013).

Upon inspection of a scatterplot of MOSART pre-test and posttest data, a weak correlation was found (see Figure 3). Therefore, controlling for the covariate was further deemed appropriate (Rovai et al., 2013).

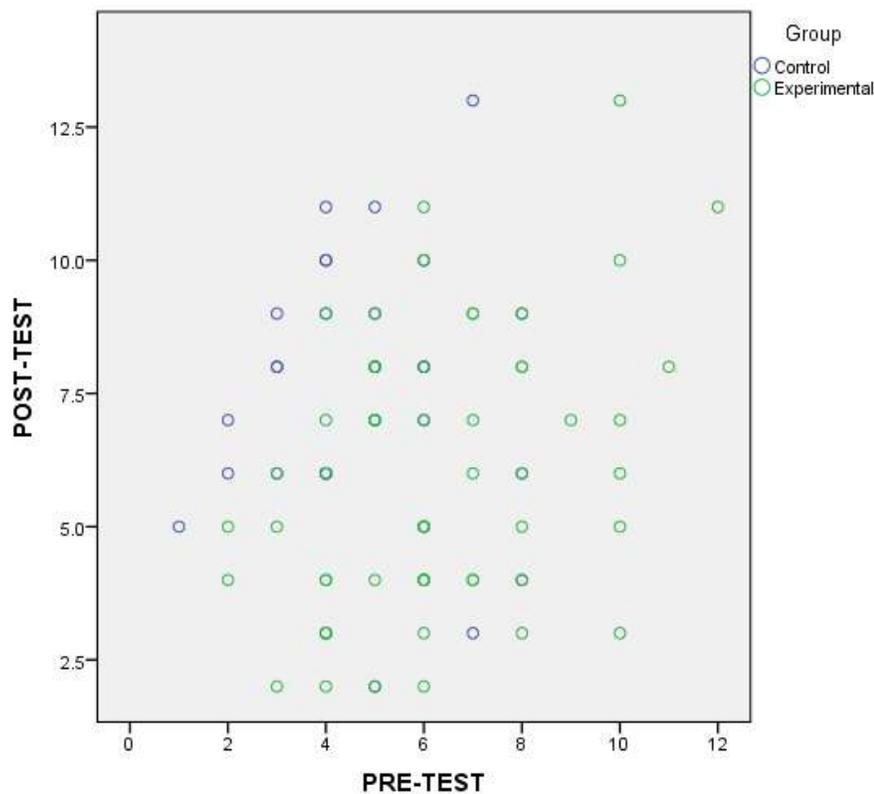
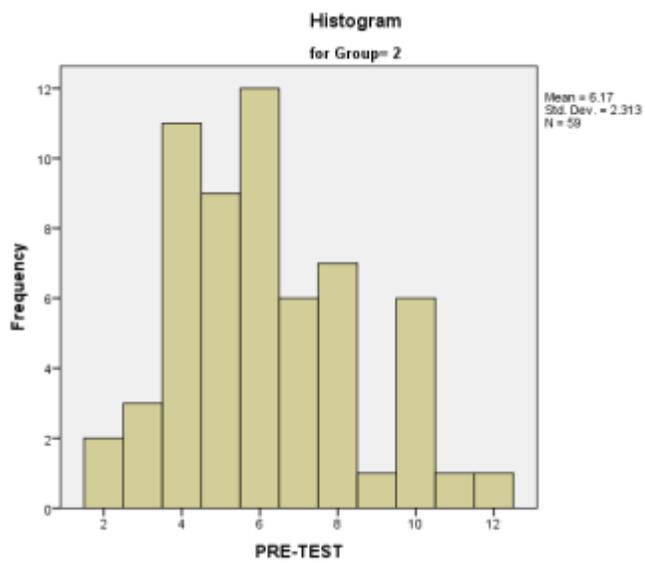
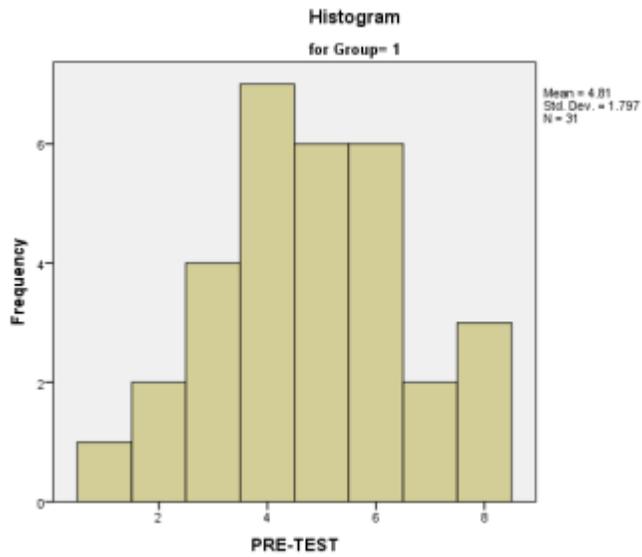


Figure 3. Scatterplot of MOSART pre-test and posttest data showing a weak correlation.

Normality

Normality was tested for through construction of histograms. Histograms showed a normal distribution in the control group pre-test and posttest MOSART data and

negatively skewed distribution among the experimental group pre-test and posttest data (Tabachnick & Fidell, 2013) (see Figure 4).



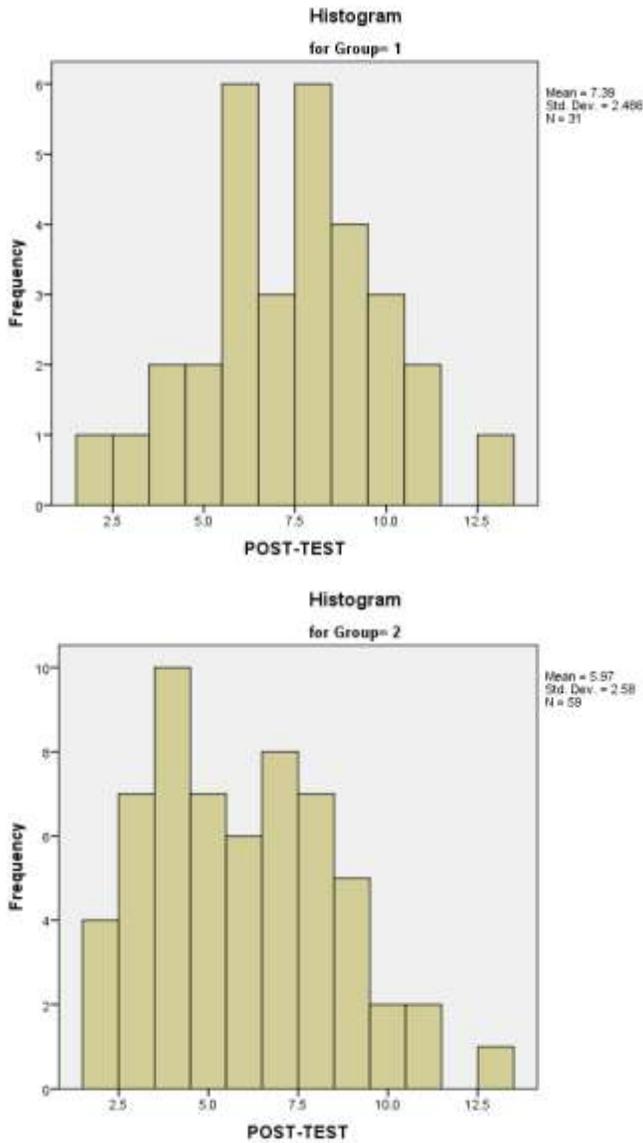


Figure 4. Histograms for normality testing of research question one.

Normality for the MOSART data was also tested for through use of Shapiro-Wilk and Kolmogorov-Smirnov (Tabachnick & Fidell, 2013). Since the control group contained less than 50 participants, results of Shapiro-Wilk (Tabachnick & Fidell, 2013) were used to determine that the control group did not violate assumptions of normality ($p = .351$ which was greater than $\alpha = .05$). Since the experimental group contained more than 50 participants, results of Kolmogorov-Smirnov (Tabachnick & Fidell, 2013) were

used to determine that the experimental group did violate assumptions of normality ($p = .001$ which was less than $\alpha = .05$). However, the ANCOVA is still considered robust when the number of participants exceeds 20 (Tabachnick & Fidell, 2013). Additionally, inspection of boxplots indicated that no violation of assumptions of extreme outliers for the MOSART data; thus, the assumption of no extreme outliers was tenable.

Linearity

Linearity was examined through inspection of a scatterplot of MOSART pre-test and posttest data (see Figure 3). The assumption of linearity was not violated; the relationship between the variables was linear.

Variance

The assumption of homogeneity of variance for the MOSART data was examined with Levene's test. Levene's test assesses the null hypothesis that the variance of the dependent variables were equal across groups (Rovai et al., 2013). Levene's test is generally accepted to be robust when departures from normality are seen (Rovai et al., 2013). Levene's test was not significant, and; thus, the assumption of homogeneity of variance was tenable for the MOSART posttest data, $F(1, 88) = 2.01, p = .16$.

Homogeneity of regression slopes

Homogeneity of regression slopes was tested for the MOSART data. Homogeneity of regression slopes is used to examine whether the slopes of the regression lines are the same for each group (Rovai et al., 2013). When this assumption is violated, the probability of making Type I errors by use of the covariate procedure increases (Rovai et al., 2013). A two-way between-groups ANOVA was conducted to analyze homogeneity of regression slopes. The results indicated $F(1, 86) = 2.7, p = .10$. Since p

= .10 is greater than $\alpha = .05$, the assumption of homogeneity of regression slopes was not violated.

Reliability of Covariates

The reliability measure of the MOSART assessment was found to be a Cronbach's $\alpha = .98$, indicating appropriate internal consistency (Tabachnick & Fidell, 2013).

Results

A summary of the assumption testing for the MOSART data (research question one), as described in the previous section, is shown in Table 8. Normality for the experimental group was not tenable. However, no other assumptions were violated.

Table 8

Results of Assumption Testing for Research Question One (MOSART data).

Assumption	Result
Measurement of Covariate	Covariate
Reliability of the Covariate	Cronbach's $\alpha = .98$; appropriate (Tabachnick & Fidell, 2013)
Normality	Assumption Not Violated for Control Group
Linearity	Assumption Not Violated
Homogeneity of regression slopes	Assumption Not Violated
Homogeneity of Variance	Assumption Not Violated

Hypothesis Testing

Descriptive Statistics

Descriptive statistics for the MOSART pre-test data are presented in Table 9. Descriptive statistics for the MOSART post-test data before adjusting for the pre-test data are presented in Table 10. $N = 90$ for the MOSART testing, which differs from the

previously reported $N = 84$ for the overall study. Thus, $N = 6$ did not complete both the MOSART and CCS posttests or were removed due to outliers or incomplete data as explained throughout this chapter.

Table 9

Descriptive statistics for the MOSART pre-test data by group.

Group	<i>n</i>	<i>M</i>	<i>SD</i>
Control Group	31	4.81	1.80
Experimental Group	59	6.17	2.31

Table 10

Descriptive statistics for the MOSART posttest data by group.

Group	<i>n</i>	<i>M</i>	<i>SD</i>
Control Group	31	7.39	2.49
Experimental Group	59	5.97	2.58

The posttest data with adjusted means, taking into account the covariate, for the control group was 7.67 ($SD = .46$) and the experimental group was 5.82 ($SD = .33$).

Analysis

After adjusting for the pretest data, the ANCOVA demonstrated that there was a statistically significant difference between groups at an $\alpha = .05$ level, $F(1, 86) = 7.38$, $p = .008$, $\eta^2 = .08$, with an observed power of .77. Since $p = .008$ is less than $\alpha = .05$. The effect size ($\eta^2 = .08$) is considered a medium to large effect size (Tabachnick & Fidell, 2013), thus indicating a medium to large magnitude of treatment effect (Rovai et al.,

2013). The observed power of .77 is near the desired observed power of .8, thus reducing the likelihood of a Type I error, or rejecting the null hypothesis when it should not be rejected (Rovai et al., 2013).

Results of Hypothesis One

The first hypothesis stated that there is no statistically significant difference in middle school students' misconceptions of science as measured by the MOSART testing instrument when participating in online collaborative learning as compared to students who participate in traditional collaborative learning only, while controlling for student prior knowledge. Results of this study indicated that the first null hypothesis was rejected. Inspection of the means (control group $M = 7.67$, $SD = .46$ and experimental group $M = 5.8$, $SD = .33$) indicated that a statistically significant difference existed between the posttest scores of the two groups, with the control group's mean being greater than the experimental group's mean; thus indicating that the control group's mean scores were higher than the experimental group's mean scores.

Research Question Two

Research question two was as follows: Is there a statistically significant difference in middle school students' sense of community as measured by the Classroom Community Scale when participating in online collaborative learning as compared to students who participate in traditional collaborative learning only? A one-way multivariate analysis of variance (MANOVA) examines whether multiple dependent variables are changed when the independent variable is manipulated (Rovai et al., 2013). Since multiple correlated dependent variables were present in regards to research question two (the Classroom Community Scale subscales of learning and connectedness), a MANOVA analysis and follow up analyses were used to analyze the second, third, and fourth null hypotheses: H_{02} : There is no statistically significant difference in middle school students' overall sense of community as measured by the Classroom Community Scale when participating in online collaborative learning as compared to students who participate in traditional collaborative learning only. H_{03} : There is no statistically significant difference in middle school students' connectedness as measured by the Classroom Community Scale when participating in online collaborative learning as compared to students who participate in traditional collaborative learning only. H_{04} : There is no statistically significant difference in middle school students' learning as measured by the Classroom Community Scale when participating in online collaborative learning as compared to students who participate in traditional collaborative learning only. Prior to conducting the analysis, assumption testing was conducted as explained in the next section.

Assumption Testing

An independent *t*-test was first conducted to ensure that no statistically significant difference existed among the mean CCS scores of the control and experimental group (Rovai et al., 2013). Results of the independent *t*-test indicated that there was no statistically significant difference in the scores for the control group ($M = 48.22$, $SD = 11.04$, $n = 27$) and the experimental group ($M = 44.23$, $SD = 11.04$, $n = 57$). The magnitude of the differences in the means (mean difference = 3.99, 95% CI: -.45 to 8.44) was small to medium (eta square = .038).

The Pearson product-moment correlation coefficient, *r*, was calculated to determine if the dependent variables of the Classroom Community Scale (CCS) survey (the subscales of learning and connectedness) were correlated. Pearson's *r* was the most appropriate test of correlation as the data was Likert-type scale data and Pearson's *r* indicates relationships between the variables (Warner, 2013). A moderate, positive correlational relationship between the two dependent variables learning and connectedness, $r(83) = .48$, $p < .05$ was found. Given the significant correlations among the dependent variables, the MANOVA was conducted and deemed appropriate as the MANOVA considers the interrelationship between variables and determines whether groups differ on more than one dependent variable (Gall et. al., 2007).

Normality

Normality was tested for through the construction of histograms. Histograms showed a normal distribution among the CCS data for both the control group and the experimental group connectedness variable (see Figure 5). However, the histogram for the experimental group for the learning subscale appeared slightly positively skewed.

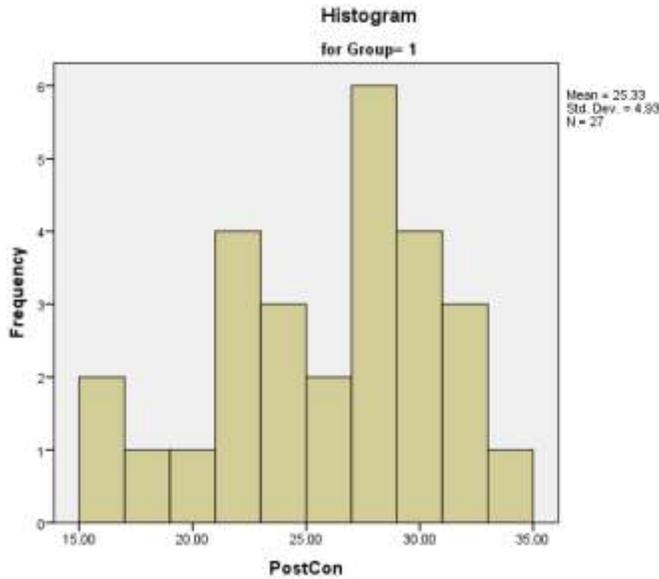
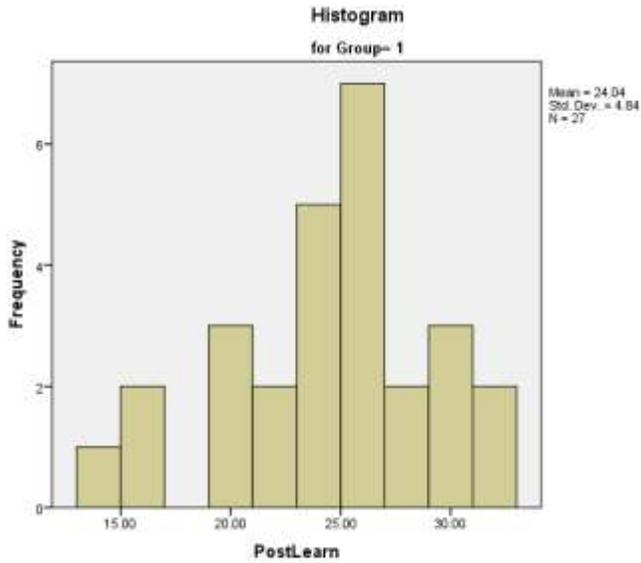


Figure 5. Histograms for normality testing of research question two.

Normality for the CCS data was also tested for through use of Shapiro-Wilk and Kolmogorov-Smirnov (Tabachnick & Fidell, 2013). Since the control group contained less than 50 participants, results of Shapiro-Wilk (Tabachnick & Fidell, 2013) were used to determine that the control group did not violate assumptions of normality ($p = .23$ for learning and $p = .221$ for connectedness, which were both greater than $\alpha = .05$). Since

the experimental group contained more than 50 participants, results of Kolmogorov-Smirnoff (Tabachnick & Fidell, 2013) were used to determine that the experimental group did not violate assumptions of normality for the subscale of Connectedness ($p = .20$ which was above $\alpha = .05$) but did violate assumptions of normality for the subscale of learning ($p = .02$ which was below $\alpha = .05$). However, the test is still considered robust when the number of participants exceeds 20 (Tabachnick & Fidell, 2013). Further, inspection of boxplots indicated no extreme outliers.

Multivariate normality for CCS data was examined through Mahalanobis distance analysis. Analysis showed that the assumption for multivariate normality was not tenable due to one extreme outlier. One case in the experimental group (case 85) exceeded the critical value of 13.82 (Tabachnick & Fidell, 2013) and was removed. The data was found tenable for multivariate normality after the removal of the one case. One case was removed due to incomplete data. In four cases, the individuals completed the MOSART pre-test and posttest data but did not complete the CCS pre-test and posttest data. This resulted in an $n = 84$ for the CCS analysis.

Linearity

Inspection of a scatterplot of CCS dependent variables indicated that the assumption of linearity was upheld (see Figure 6). A straight-line relationship existed between each pair of the dependent variables (Rovai et al., 2013); thus indicating that the amount or rate of change between scores for the dependent variables of learning and connectedness were approximately constant for this study. Assumptions of multicollinearity and singularity were examined through inspection of the scatterplot and consideration of Pearson's r (discussed above). Multicollinearity occurs when dependent

variables are highly correlated ($r = .90$ and above) and indicates redundancy of variables, thus is an important assumption in MANOVA analysis (Rovai et al., 2013). Likewise, singularity occurs when dependent variables are perfectly correlated ($r = 1.00$) and indicates redundancy of variables, thus is an important assumption in MANOVA analysis (Rovai et al., 2013). Given that $r = .48$, neither assumption was violated.

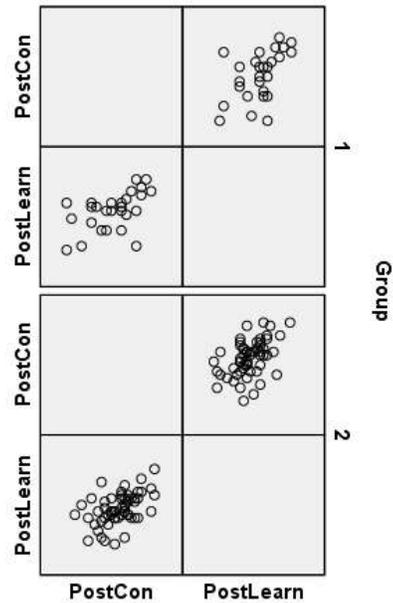


Figure 6. Scatterplot of Classroom Community Scale data.

Homogeneity of Variance and Covariance

Homogeneity of variance and covariance is the assumption that two groups have the same variance (Rovai et al., 2013). Box's M test was used to determine homogeneity of covariance for the CCS data. Analysis of the data using Box's M test indicated that the assumption of homogeneity of covariance was not violated, $F(1, 3) = .18, p = .908$, (Rovai et al., 2013).

The assumption of homogeneity of variance for the CCS data was examined through the use of Levene's test. Levene's test assessed the null hypothesis that the

variance of the dependent variables were equal across groups (Rovai et al., 2013).

Results for the learning subscale were $F(1, 82) = .002, p = .97$. Since $p = .97$ is greater than $\alpha = .05$, the assumption of homogeneity of variance was not violated. Results for the connectedness subscale were $F(1, 82) = .10, p = .75$. Since $p = .75$ is greater than $\alpha = .05$, the assumption of homogeneity of variance was not violated.

Results

A summary of the assumption testing for the CCS data (research question two), as described in the previous section, is shown in Table 11. Normality was slightly positively skewed for the control group's learning subscale scores and one extreme outlier in the experimental group was noted and removed. No additional violations of assumptions were noted.

Table 11

Results of assumption testing for research question two (CCS data).

Assumption	Result
Measurement of Covariate	No Covariate
Presence of correlation between the DVs	Yes
Normality	Assumption Not Violated
Outliers	Assumption Not Violated
Multivariate Normality	One Extreme Outlier (Removed)
Linearity	Assumption Not Violated
Homogeneity of Variance and Covariance	Assumption Not Violated
Multicollinearity	Assumption Not Violated
Singularity	Assumption Not Violated
Cronbach's α	Cronbach's $\alpha = .80$; acceptable

Hypothesis Testing

Descriptive Statistics

The N for this analysis was 84. One case was removed due to incomplete data. One additional case was removed due to extreme outliers. In four cases, the individuals completed the MOSART pre-test and posttest data but did not complete the CCS pre-test and posttest data. Descriptive statistics for the CCS pre-test data are presented in Table 12.

Table 12

Descriptive Statistics for the CCS Community Subscale Pre-test Data by Group.

Subscale	Group	<i>n</i>	<i>M</i>	<i>SD</i>
Connectedness	Control	27	25.70	5.96
	Experimental	57	21.67	5.02
Learning	Control	27	22.52	7.29
	Experimental	57	22.56	4.91

Descriptive statistics for the CCS post-test data are presented in Table 13.

Table 13

Descriptive Statistics for the CCS Overall Community Subscale Post-test Data by Group

Subscale	Group	<i>n</i>	<i>M</i>	<i>SD</i>
Composite Community	Control	27	48.22	11.04
	Experimental	57	44.23	8.79
Connectedness	Control	27	25.33	4.93
	Experimental	57	22.16	5.41
Learning	Control	27	24.04	4.84
	Experimental	57	23.72	4.76

Analysis

Wilk's lambda was used to interpret results of the MANOVA analysis (Tabachnick & Fidell, 2013). Although sample sizes were different among groups, no assumptions of homogeneity of variance or covariance were violated as indicated by Box's M; thus use of Wilk's lambda was considered appropriate (Tabachnick & Fidell, 2013). Results of the MANOVA Wilk's lambda = .91, $F(2, 81) = 3.92$, $p = .02$, $\eta^2 = .09$, observed power = .69, revealed a significant difference in the composite community scores between groups. This indicated that the students who engaged in face-to-face collaborative activities and students who engaged in online collaborative activities did differ in their sense of community. As reported in the descriptive statistics above, the means of the control group scores were higher than the means of the experimental group scores. The effect size ($\eta^2 = .09$) is considered a medium to large effect size (Tabachnick & Fidell, 2013), thus indicating a medium to large magnitude of treatment effect (Rovai

et al., 2013). Although the observed power of .69 is lower than the desired power of .8, the observed power is considered reasonable, thus indicating a low probability of a Type I error (Rovai et al., 2013).

Results of Hypothesis Two

The second hypothesis stated that there is no statistically significant difference in middle school students' overall sense of community as measured by the Classroom Community Scale when participating in online collaborative learning as compared to students who participate in traditional collaborative learning only. Given the statistical analysis as explained above, the second null hypothesis was rejected. Since the F statistic was significant, individual analyses of variance (ANOVAs) for each dependent variable were performed (Gall et. al., 2007). When results for the dependent variables were considered separately, a Bonferroni adjusted alpha level of .025 (.05/2) was used to determine significance to help control for Type I error (Rovai et al, 2013; Tabachnick & Fidell, 2013).

Hypothesis Three

The third hypothesis stated that there is no statistically significant difference in middle school students' connectedness as measured by the Classroom Community Scale when participating in online collaborative learning as compared to students who participate in traditional collaborative learning only. An analysis of variance (ANOVA) was used to analyze the third null hypothesis.

The analysis revealed, $F(1, 82) = .08$, $p = .78$, $\eta^2 = .001$, observed power = .06 that control group $M = 25.33$, $SD = 4.93$ and experimental group $M = 22.16$, $SD = 5.41$, did not statistically significant differ in their connectedness scores (see Table 13).

The observed power of .06 is lower than the desired power of .8, thus indicating an increased probability of a Type II error (the researcher can say with only 6 percent confidence that the correct decision was made) (Rovai et al., 2013).

Results of Hypothesis Three

The third hypothesis stated that there is no statistically significant difference in middle school students' connectedness as measured by the Classroom Community Scale when participating in online collaborative learning as compared to students who participate in traditional collaborative learning only. This hypothesis was not rejected.

Hypothesis Four

The fourth hypothesis stated that there is no statistically significant difference in middle school students' learning as measured by the Classroom Community Scale when participating in online collaborative learning as compared to students who participate in traditional collaborative learning only. An ANOVA was used to analyze the third null hypothesis.

An ANOVA analysis revealed $F(1, 82) = 6.68, p = .01, \eta^2 = .08$, observed power = .72, control group $M = 24.04, SD = 4.84$ and experimental group $M = 23.72, SD = 4.77$, thus indicating that a statistically significant difference in the means was present (see Table 13). The control group mean scores were higher than the experimental group mean scores. The effect size ($\eta^2 = .08$) is considered a medium to large effect size (Tabachnick & Fidell, 2013), thus indicating a medium to large magnitude of effect (Rovai et al., 2013). The observed power of .72 is close to the desired power of .8, thus indicating a reduced probability of a Type I error (Rovai et al., 2013).

Results of Hypothesis Four

The fourth hypothesis stated that there is no statistically significant difference in middle school students' learning as measured by the Classroom Community Scale when participating in online collaborative learning as compared to students who participate in traditional collaborative learning only. The fourth null hypothesis was rejected.

Summary

Four hypotheses were examined to compare students' misconceptions of science, an aspect of science literacy, and students' sense of community. Mean scores from the MOSART assessments were analyzed using ANCOVA analysis and the Classroom Community Scale surveys were analyzed using MANOVA analyses. Results of each analysis for the corresponding hypothesis are shown in Table 14.

Table 14

Results of Statistical Analysis per Hypothesis

Hypothesis	Rejected	Failed to Reject
H₀₁: There is no statistically significant difference in middle school students' misconceptions of science as measured by the MOSART testing instrument when participating in online collaborative learning as compared to students who participate in traditional collaborative learning only, while controlling for student prior knowledge.	X	
H₀₂: There is no statistically significant difference in middle school students' overall sense of community as measured by the Classroom Community Scale when participating in online collaborative learning as compared to students who participate in traditional collaborative learning only, while controlling for student community.	X	
H₀₃: There is no statistically significant difference in middle school students' connectedness as measured by the Classroom Community Scale when participating in online collaborative learning as compared to students who participate in traditional collaborative learning only, while controlling for student community.		X
H₀₄: There is no statistically significant difference in middle school students' learning as measured by the Classroom Community Scale when participating in online collaborative learning as compared to students who participate in traditional collaborative learning only, while controlling for student community.	X	

The results showed that there was no statistically significant difference in the level of science literacy of students who participated in online collaborative learning and

students who participated in traditional face-to-face collaborative learning only; thus hypothesis one was not rejected. Furthermore, the results showed that there was statistically significant difference in the overall sense of community experienced by students who participated in online collaborative learning and students who participated in traditional face-to-face collaborative learning only; thus hypothesis two was rejected. However, the results showed that there was no statistically significant difference in the connectedness experienced by students who participated in online collaborative learning and students who participated in traditional face-to-face learning; thus hypothesis three was not rejected. The results showed that there was a statistically significant difference in the learning experienced by students who participated in online collaborative learning and students who participated in traditional face-to-face learning; thus hypothesis four was rejected.

Additional Analysis

After assumption testing was deemed acceptable, a mixed between-within subjects analysis of variance (ANOVA) was conducted to examine the impact of the two interventions (face-to-face collaboration and online collaboration) on misconceptions as an aspect of science literacy, as measured by the MOSART assessment, from the pretest to posttest. An examination of interaction effects is important as a statistically significant interaction effect may be an indication that the overall pattern of differences across groups may not be consistent over time. As discussed previously, a statistically significant difference was found between the control group and experimental group posttest MOSART scores; with the control group mean scores for the MOSART being higher than the experimental group mean scores, $p = .005$. There was also a significant

main effect over time, Wilk's lambda = .86, $F(1, 88) = 14.0$, $p = .000$, $\eta^2 = .18$, observed power = .138. There was a significant interaction between programs from pretest to posttest, Wilk's lambda = .82, $F(1, 88) = 19.28$, $p = .000$, $\eta^2 = .18$, observed power = .99.

Upon inspection of the means (see Table 15), the control group showed a significant increase in their mean scores from pre-test to posttest; whereas, the experimental group demonstrated a significant reduction from pretest to posttest.

Table 15

Descriptive Statistics for Additional Analysis

Test	Group	<i>n</i>	<i>M</i>	<i>SD</i>
Pre-test	Control	31	4.81	1.80
	Experimental	59	6.17	2.31
Posttest	Control	31	7.39	2.49
	Experimental	59	5.97	2.58

The results of this study are important to the current understanding of the effects of online collaboration on students' science literacy, given the limited amount of research within the education literature. Likewise, the results of this study are important to the current understanding of the effects of online collaboration on students' sense of community with a particular emphasis on adolescent students who are participants in the science classroom. Therefore, the next chapter will discuss the results, the implications, and the need for future research to broaden educational understanding and knowledge of best practices as a result of this study.

CHAPTER FIVE: DISCUSSION

Introduction

This chapter provides a summary and discussion of the findings of the study, beginning with the statement of the problem and the purpose of the study. Next, a summary of the results of each of the research questions is provided and discussed. Theoretical implications, implications for practice, methodological implications, and implications for future research are explained. Limitations are discussed and, finally, a conclusion is made based on the research findings of this study.

Statement of the Problem

Utilizing the conceptual frameworks of constructivism, social development theory, and community, this quasi-experimental study sought to determine the effects of online collaborative learning on middle school students' science literacy as measured by the Misconceptions-Oriented Standards-Based Resources for Teachers (MOSART) assessment (Harvard, 2011) and sense of community as measured by Rovai's (2002a) Classroom Community Scale.

The independent variable was the type of learning (traditional face-to-face collaboration or online collaborative learning). Traditional learning was defined as learning that occurs face-to-face in the classroom. Collaborative learning was defined as learning that occurs as part of a group where all learners are mutually involved in the learning process (Bernard, Rubalcava, & St-Pierre, 2000). More specifically, online collaborative learning was operationally defined as computer-mediated learning that occurs as part of a group where all learners are mutually involved in the learning process (Dewiyanti et al., 2007).

The dependent variables were middle school student science literacy and student sense of community. Science literacy was defined as “understanding key scientific concepts and frameworks, the methods by which science builds explanations based on evidence, and how to critically assess scientific claims and make decisions based on this knowledge” (Impey et al., 2011, p. 34), with a specific focus on the identification of scientific misconceptions (Harvard, 2011). Sense of community was generally defined as “a feeling that members have of belonging, a feeling that members matter to one another and to the group, and a shared faith that members’ needs will be met through their commitment to be together” (McMillan & Chavis, 1986, p. 9).

Review of Methodology

This study was a quantitative study and used a quasi-experimental pretest/posttest control group design. This design was most appropriate as the independent variable was manipulated and a control group was utilized; however, randomization of the sample was impossible as students were part of pre-existing groups (classes) (Gall et al., 2007). Since the quasi-experimental design is the next strongest experimental design to true experimental and true experimental design requires randomization of the sample population, a quasi-experimental design was utilized (Rovai, Baker, & Ponton, 2013). A convenience sample of eighth grade physical science students (overall $N = 90$) at a rural public middle school in South-Central Virginia were assigned to an experimental and a control group based on intact pre-existing class assignment. Each group received equivalent instructional content. However, the experimental group received collaborative assignments that were completed collaboratively through the use of the Edmodo educational platform while the control group received assignments that were completed collaboratively face-to-face. The MOSART (Harvard, 2011) assessment and Sense of

Community Scale (Rovai, 2002a) survey were administered to all students prior to the treatment and post-treatment. Results were statistically analyzed and reported.

Summary of Results

Research Question One

Research question one was as follows: Is there a statistically significant difference in middle school students' misconceptions, aspect of science literacy, as measured by the MOSART testing instrument when participating in online collaborative learning as compared to students who participate in traditional collaborative learning only? Prior to the primary analysis, an independent *t*-test was used to determine if there was a statistically significant difference in pre-test scores across groups and the need to control for the covariate was present. An analysis of covariance (ANCOVA) analysis was used to examine whether a statistically significant difference existed between the control group and experimental group MOSART scores. Results indicated that there was a statistically significant difference in middle school students' misconceptions of science as measured by the MOSART testing instrument when participating in online collaborative learning as compared to students who participate in traditional collaborative learning only. Examination of the mean MOSART scores between groups indicated that the control group's MOSART scores were higher than the experimental group's MOSART scores; thus, students participating in face-to-face collaboration experienced higher levels of science literacy (or, alternatively, reduced misconceptions) than students participating in online collaboration.

Research Question Two

Research question two was as follows: Is there a statistically significant difference in middle school students' sense of community as measured by the Classroom Community Scale when participating in online collaborative learning as compared to students who participate in traditional collaborative learning only? An independent *t*-test was used to determine if there was a statistically significant difference in pre-test scores across groups and the need to control for the covariate was not present. A multivariate analysis of variance (MANOVA) was used to examine whether a statistically significant difference existed between the control group and experimental group overall CCS scores. Results indicated that a statistically significant difference did exist in middle school students' sense of community as measured by the Classroom Community Scale when participating in online collaborative learning as compared to students who participated in traditional collaborative learning only. Examination of the mean CCS scores between groups indicated that the control group's CCS scores were higher than the experimental group's CCS scores; thus, students participating in face-to-face collaboration experienced a higher sense of community compared to students participating in online collaboration.

A follow up analysis of variance (ANOVA) was used to examine whether a statistically significant difference between the control group and experimental group connectedness existed. Results indicated that no statistically significant difference existed between middle school students' connectedness as measured by the Classroom Community Scale when participating in online collaborative learning as compared to students who participate in traditional collaborative learning only.

An analysis of variance (ANOVA) was also used to examine whether a statistically significant difference between the control group and experimental group learning existed. Results indicated that a statistically significant difference existed between middle school students' learning as measured by the Classroom Community Scale when participating in online collaborative learning as compared to students who participate in traditional collaborative learning only. Examination of the mean learning scores between groups indicated that the control group's learning scores were higher than the experimental group's learning scores; thus, students participating in face-to-face collaboration experienced an increased sense of learning compared to students participating in online collaboration.

Additional Analysis

A mixed between within subjects analysis of variance (ANOVA) was conducted to examine the impact of the two interventions (face-to-face collaboration and online collaboration) on misconceptions as an aspect of science literacy, as measured by the MOSART assessment, from the pretest to posttest. Both main effects and the interaction effect were found significant. The control group showed a significant increase in their mean scores on the MOSART from pre test to post test; whereas, the experimental group demonstrated a significant reduction in their mean scores on the MOSART from pretest to posttest.

Discussion of Results

Research Question One

The difference in the mean scores on the MOSART, with the face-to-face group scoring higher than the online group, can be understood in light of the research on Computer Mediated Communication (CMC) and the challenges documented for

asynchronous communication provide an explanation for the significant difference. Four qualities have been identified that are fundamental for CMC technologies: temporality, identity, modality, and spatiality (Zhao et al., 2004). In synchronous learning, individuals are able to communicate directly and immediately with other individuals, thus engaging in real-time discussion and receiving immediate feedback. In asynchronous learning, the communication of individuals is limited to a one-way channel, thus discussion and feedback are delayed. While some research has demonstrated the benefits of these features of online asynchronous learning, the challenges are well documented also.

The delayed feedback and interaction of asynchronous communication requires the learner to “back up to answer a question” once they may have moved onto another discussion (Zhao et al., 2004, p. 27). Miscommunication can occur and discussion may become confusing if multiple replies on multiple topics are posted at different times (Conrad & Donaldson, 2004). Ahern et al. (2006) found that communication that requires time, such as that afforded in asynchronous communication, increases the difficulty in engaging in dialogue and peer-to-peer interactions and the quality of interactions that require higher order thinking skills may be reduced (Kanuka, Rourke, & Laflamme, 2007). Although asynchronous communication methods create a sense of anonymity that may increase students’ attention on the responses of fellow students, it at the same time decreases the quality of students’ work (Zhao et al., 2004). In the current study, students participating in online discussion may have experienced these phenomenon and, thus, had a lower MOSART score than the students participating in face-to-face discussion.

Further, the finding may be explained by the lack of nonverbal cues within an asynchronous text based environment. In research comparing face-to-face and online learning environments, Meyer (2007) found that students not only preferred the face-to-face environment but also were able to “capture the feel, tone, and emotion” (p. 66) of communication exchanges, thus leading to an increase in retention. Asynchronous discussion, therefore, may limit verbal and social cues that are necessary for effective communication, and ultimately, learning. Garrison et al. (2001) suggested that the asynchronous, text based medium may “not support this [resolution response] kind of activity” (p. 13), and Thomas (2002) suggested that “the attainment of a discourse that is...academic in nature is difficult within the online environment of the traditional threaded discussion” (p. 359). The collaborative science activities may have been better suited for the face-to-face environment rather than the online environment.

Additional analysis for the study also indicated that the overall mean MOSART scores of the experimental group significantly decreased from pre-test to posttest, indicating that online collaborative learning led to an increase in misconceptions (or a decrease in science literacy). The CoI framework provides some insight into this finding. Lack of teaching presence in design and instruction are attributable to low levels of learning or lack of critical thinking (Garrison, et al, 2001). The lack of immediate teacher feedback, due to the asynchronous nature of the online learning environment, may have provided an increased opportunity for reinforcement of peer misconceptions rather than immediate redirection and reduction of student misconceptions. The synchronous nature of the face-to-face collaborative learning environment provided opportunities for immediate teacher feedback, thus reducing peer generated misconceptions. In the

asynchronous online collaborative learning environment, students participated in online activities with one another, and the teacher discussed them and corrected misconceptions in the following days' instruction. Teacher's redirection and corrections of misconceptions were delayed and occurred after significant number of peer interactions that sometimes supported a misconception. The findings of this study support research that indicates the importance of teacher immediacy and presence in online learning environments. It is possible that decreased teacher immediacy in the experimental group may have impacted the results of this study. Thus, increased teacher immediacy in future studies may provide different results. Teacher presence has been found to be an important aspect of the quality of discussions and has been found to be lacking in asynchronous environments, thus leading to a breakdown in communication (Kucuk, 2009). Additionally, the findings of this study support the proposal that asynchronous environments may make it difficult to collaborate as a group and negotiate responses (Garrison & Anderson, 2003).

Research Question Two

Sense of community is multi-dimensional. Connectedness is defined as "the feeling of belonging and acceptance and the creation of bonding relationship" (Rovai, 2002, p. 322). This study indicated that no difference existed between groups participating in face-to-face learning and online learning in terms of connectedness, thus indicating that the learning environment for each group fostered feelings of belonging and acceptance.

However, students who participated in face-to-face collaboration experienced higher gains in the learning aspect of community than those who participated in online

collaboration. Learning is defined as “the feeling that knowledge and meaning are actively constructed within the community, that the community enhances the acquisition of knowledge and understanding, and that the learning needs of its members are being satisfied” (Rovai, 2002, p. 322). This aspect of community is correlated with critical thinking and learning outcomes; research on sense of community has supported that an increased sense of community may facilitate increased learning outcomes (Rovai, 2002; Rovai, Wighting, & Liu, 2005). This was supported by this study as students participating on face-to-face collaboration experienced increased learning community as well as increased learning as measured by level of misconceptions by the MOSART assessment.

Although some research has demonstrated that sense of community is equivalent for online and face-to-face learners at the higher education level (Rovai, 2002; Rovai, Wighting, & Liu, 2005), adolescent sense of community experiences are different given the changing relationships and life experiences that occur as students transition to adulthood. Opportunities to influence and interpret social roles, experience power, and interact are key to the experience of sense of community (Chiessi, Cicognani, & Sonn, 2010), and adolescents given their development may have difference experiences in creating online community as compared to adults.

Results of this study indicated that students’ overall sense of community was higher when engaging in face-to-face collaborative learning as compared to online collaborative learning. These results are explained by the research that suggests that some students prefer face-to-face communication as computer-mediated communication decreases the individual’s ability to determine how others feel and decrease likelihood of

consensus (Palloff & Pratt, 1999) as indicated by the greater gains in sense of community exhibited by students who participated in face-to-face collaboration as compared to those who participated in online collaboration. Further, nonverbal cues, human reassurance, and robustness of dialogue may be present in the face-to-face environment but lacking in the online environment (Vaughan & Garrison, 2005). Face-to-face communication facilitates the process of negotiation and resolution of conflict, both of which are necessary for group cohesiveness and the forming of connectivity. Through synchronous face-to-face discussion, alternative ideas may be expressed, questioned, and supported, reducing unresolved conflict that may not be appropriately addressed in asynchronous online environments, thus leading to decreased community (Palloff & Pratt, 1999).

Additionally, research on community has found that “a major challenge facing educators using CMC is the creation of the critical community of inquiry...within a virtual text based environment” (Garrison et al., 2001, p. 1). This study, therefore, supports that asynchronous learning environments pose challenges in creating community in the middle school environment.

Implications

Theoretical Implications

The results of this study support social development theory, which purports that individuals learn through social experiences (Vygotsky, 1986). Given that the control group mean MOSART scores increased from pre-test to posttest, this study indicates that face-to-face collaborative learning in a social learning environment decreases misconceptions of science. This upholds the tenets of social development theory that an increase in learning occurs through social learning activities that occur in

the face-to-face format. Considering that overall group means of CCS scores increased for both the control and experimental group, this study supports that collaborative learning results in an increase in sense of community, thus upholding the theory of communities of practice (Wenger, 1998); however, the control group had a higher sense of community and mean MOSART scores than the treatment group.

In regards to community of inquiry theory, the effective educational experience occurs when cognitive presence, social presence, and teaching presence overlap (Garrison, Anderson, & Archer, 2010); thus, suggesting that face-to-face collaborative learning environment involved appropriate cognitive presence, social presence, and teaching presence, whereas the online collaborative learning environment did not. This may be further explained by media richness theory, which purports that face-to-face communication has advantages over other forms of communication in which immediacy of feedback is delayed (Daft, Lengel, Trevino, & Kiebe, 1987). Loss of nonverbal cues may lead to a breakdown in communication, thus resulting in less effective learning. With the synchronous nature of the face-to-face collaborative environment, students were able to receive immediate feedback from peers and the teacher. Nonverbal communication was readily observed and led to an increase in understanding. However, with the asynchronous nature of the online collaborative environment, feedback from peers and the teacher was not immediate, but rather delayed. This coupled with the lack of nonverbal cues may have resulted in miscommunication; thus lower levels of learning and confusion. The treatment groups' decrease in MOSART scores, an increase in student misconceptions, as compared to the control group's increase in MOSART score,

a decrease in misconceptions, can be explained by and confirms Media Richness theory .

A summary of these findings are provided in Table 16.

Table 16

Description of organization of theoretical framework, research questions, design, and data with outcomes

Research Question	Theoretical Framework	Data Sources	Outcomes	Contribution
RQ 1	Social Development Theory	MOSART	Increased MOSART scores of the control group	Supports Social Development Theory
	Media Richness Theory	MOSART	Higher MOSART scores for the control group over the experimental group	Supports Media Theory
RQ 2	Communities of Practice Theory	Classroom Community Scale	Higher Sense of Community for the control group over the experimental group	Supports Communities of Practice Theory
	Media Richness Theory	Classroom Community Scale	Higher Sense of Community in the Face-to-Face Environment	Supports Media Richness Theory

Limitations

Several limitations existed in this study. Non-randomization was a limitation of this study (Rovai et al., 2013). The lack of randomization of the study provides a slightly weaker design than desirable and becomes an internal threat to validity (Rovai et al.,

2013). Since randomization of the sample was not possible in this study due to intact groups (classes), a quasi-experimental design was used. A pretest was, therefore, administered to assist in controlling for lack of randomization (Campbell & Stanley, 1963). Use of a pretest addressed the internal threats of selection, participant history, maturation, and regression (Rovai et al., 2013); however, it introduced the testing threat to validity.

Generalizability may have been a limitation of this study (Rovai et al., 2013). The results of the study may not be generalizable to other populations or grade levels, or may not be generalizable to other subject areas within the science field. It was assumed that the sample population is representative of all middle school science students in Virginia. However, this may not be the case and leads to external threats of validity. Further studies to determine generalizability would need to be conducted including future longitudinal studies.

Student history may have been a limitation of this study (Rovai et al., 2013). The prior knowledge of students may not have been the same. This presented a threat to internal validity. Therefore, prior knowledge was statistically controlled for through the use of a pretest-posttest design to reduce threat to internal validity (Gall et al., 2007).

Non-equivalence of groups however was the primary limitation of this study (Rovai et al., 2013). Although measures were taken to control for this threat to validity through the use of a pretest and homogenous groups, the threat still existed (Campbell & Stanley, 1963).

Participant non-accordance with prescribed research guidelines may have been a limitation of this study. Students were assumed to have correctly follow guidelines

presented by the respective classroom teacher. Specifically, those in the experimental group were assumed to have completed assignments collaboratively using a computer and those in the control group were assumed to have completed assignments collaboratively in a traditional or face-to-face manner. Experimental treatment diffusion, when communication occurs between groups, may have been a limitation of this study (Rovai et al., 2013), thus students were instructed to have no communication between the groups. An access code to Edmodo was provided for students in the experimental group, thus preventing access by the control group.

Implementation may have been a limitation of this study (Rovai et al., 2013). It is possible that students in the experimental and control groups may have been treated differently by the two classroom teachers and may have been provided with different experiences despite efforts to reduce this likelihood. Since both groups were subject to the same curriculum requirements and pacing guides, it was assumed that all instructional content provided to the experimental group and the control group was equivalent, therefore providing treatment fidelity. This included both in-class face-to-face instructional content as well as the content of the collaborative activities. Two classroom teachers were used for this study. However, to ensure treatment fidelity, the teachers were instructed to provide equivalent instruction to both groups as provided by the county curriculum and pacing guide. Strict instructions to the classroom teachers regarding the need to retain homogenous instruction for multiple classes was provided by the researcher. In addition, training was provided to the classroom teacher assigned to the experimental group on the use of Edmodo prior to beginning the study.

Finally, the treatment fidelity of the MOSART assessment and Classroom

Community Scale may have provided an additional threat to internal validity. It is possible that the MOSART assessment and Classroom Community Scale may have been administered by the classroom teachers differently among the groups. Measures to ensure treatment fidelity were taken, including requiring the classroom teachers to complete online tutorials on the administration and use of the MOSART assessment, providing a script to ensure that administration of the MOSART assessment was the same for each group, and providing a script to ensure that administration of the Classroom Community Scale survey was the same for each group.

Implications for Practice and Methodological Implications

The mode of instruction has also been shown to be an indicator of the quality of communication and, thus, the quality of online learning (Conrad & Donaldson, 2004). Some tasks are better suited for some modes of instruction than others; technology is no exception (Zhao et al., 2004). The teacher must choose the mode of technology to suit the learning task (Conrad & Donaldson, 2004). Results of this study demonstrated that collaborative learning activities may have been best-suited for face-to-face learning in future practice and study.

Thus, current practices of encouraging technology implementation in the middle school classroom may not produce positive benefits for students as students participating on face-to-face collaboration experienced increases in MOSART scores as well as sense of community whereas those participating in online collaboration experienced decreases in MOSART scores and a smaller increase in sense of community. As indicated by the decrease in MOSART scores for students participating in online collaboration, technology implementation may actually prove to detrimental to reducing misconceptions

in the science classroom. Thus, prior to integrating technology as a tool in the classroom, further study should be conducted to determine advantages and disadvantages in the science classroom among the adolescent population.

In this, consideration of the teacher's role in structuring learning tasks to most effectively meet the goals of social presence, cognitive presence, and teaching presence must also occur prior to technology implementation in any online learning environment. As evidenced by this study, students in the face-to-face environment who experienced greater teacher presence and immediacy of feedback exhibited greater increases in MOSART scores as well as sense of community as compared to those who participated in the online environment. Thus, recommendations for future practice to increase teacher presence include providing examples and opportunities for developing the elements of setting climate, supporting discourse, and selecting content to foster learning and providing feedback and ongoing support for instructors (Swan 2004). Furthermore, increasing teacher verbal immediacy, especially in the asynchronous environment, may lead to increased teacher presence and increased sense of community (Ni & Aust, 2008).

Implications for Future Research

Future research should focus on replication of the results of this study as well as study of the effects of online collaboration as compared to face-to-face collaboration in other science areas. A variety of MOSART assessments are available for teacher use in the areas of life sciences, earth science, physics, and chemistry; thus, in order to determine the generalizability of the results found in this study, further study is needed that makes use of different MOSART assessments. Further study may also explore the generalizability of this study to other populations as the students who participated in this

study were primary Caucasian and were from a rural public school. Additional study may examine if similar results are found with other ethnicities, with suburban or urban communities, and public and private schools.

Further study may consider the role of the teacher in providing feedback; that is, the immediacy of the feedback, and how immediacy may influence student sense of community and reduction of misconceptions with a media richness theoretical framework. This may provide a greater understanding as to why the MOSART scores of students participating in online collaboration decreased while those of the students participating in face-to-face communication increased and how teacher immediacy is related to sense of community (Ni & Aust, 2008) and student participation (Kucuk, 2009). Specifically, a study that examines the relationship between the frequency of teacher interaction and student knowledge is recommended.

Further study in the area of misconceptions may also provide information related to how misconceptions may be most effectively reduced in the science classroom. Research has shown that student misconceptions may increase with computer mediated learning (Tutty & Klein, 2008) as supported in this study; thus, further investigation to identify methods of decreasing student misconceptions in the science classroom would be beneficial.

Research has supported that teachers must encourage group cohesion so that all members of the group feel obligated to participate in order to improve online education (Ahern et al., 2006). The results of this study support this conclusion and also provide further implications to study instructional design and online collaborative design,

ensuring that teachers monitor students appropriately to foster complete participation as well as encourage group cohesion.

In regards to research design, future methodology may include a non-random sample as this study employed a convenience sample of students in order to strengthen the design of the study (Gall, Gall, & Borg, 2007). In addition, a true experimental design could be employed rather than a quasi-experimental design, thus increasing the strength of the experimental design and validity of the results (Gall, Gall, & Borg, 2007).

Conclusion

The purpose of this study was to determine the effect of online collaboration on middle school students' sense of community and science literacy. Results indicated that there was a statistically significant difference in sense of community and science literacy of students participating on online collaborative learning as compared to face-to-face collaborative learning, with students participating in face-to-face collaborative learning experiencing higher sense of community and levels of science literacy. Furthermore, results of this study indicated that there was a statistically significant difference in sense of learning of students participating in online collaborative learning as compared to face-to-face collaborative learning, with students participating in face-to-face collaborative learning experiencing higher sense of learning. Results of this study indicated that there was no statistically significant difference in sense of connectedness. Based on these results, traditional face-to-face collaboration was found to produce an increase in positive student outcomes as compared to online collaboration, suggesting the need for further examination of current pedagogy utilizing technology in the middle school classroom and

increased attention to feedback immediacy to foster student sense of community and reduction of misconceptions of science.

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APPENDIX A

PEARSON

ALWAYS LEARNING

January 10, 2013

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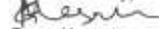
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APPENDIX B

Name: _____ Date: _____ Class: _____

COLLABORATIVE ACTIVITY #1

CHAPTER 12

WORK AND MACHINES

SECTION What Is Work? 12-1 (pages 374-377)

This section explains the scientific meaning of work and describes how to calculate the work done on an object.

► The Meaning of Work (pages 374-378)

1. In scientific terms, when do you do work? _____

2. Complete the following table by classifying each example as either work or no work.

Work?	
Example	Work or No Work?
You pull your books out of your book bag.	
You lift a bin of newspapers.	
You push on a car stuck in the snow.	
You hold a heavy piece of wood in place.	
You pull a sled through the snow.	
You hold a bag of groceries.	

3. In order for you to do work on an object, the object must move some _____ as a result of your force.

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Name: _____ Date: _____ Class: _____

CHAPTER 12, Work and Machines (continued)

4. Explain why you don't do any work when you carry an object at a constant velocity. _____

5. When you pull a sled through the snow, why does only part of your force do work? _____

► **Calculating Work** (pages 376–377)

6. The amount of work you do depends on both the amount of _____ you exert and the _____ the object moves.

7. Is the following sentence true or false? Lifting a heavier object demands greater force than lifting a lighter object. _____

8. Is the following sentence true or false? Moving an object a shorter distance requires more work than moving an object a greater distance.

9. What formula do you use to determine the amount of work done on an object? _____

10. What is the SI unit of work? _____

11. What is the amount of work you do when you exert a force of 1 newton to move an object a distance of 1 meter? _____

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Name: _____ Date: _____ Class: _____

COLLABORATIVE ACTIVITY #2

Exercise 51 Analysis Identifying Resistance and Effort

Name _____ Date _____

For each picture, identify the *effort force* (whatever is doing the work), the *resistance force* (the force that must be overcome to do the work), and the *load* (the object that must be moved). The effort force and load will be things you see in the picture. The resistance force will be either gravity, friction, or inertia. Write your answers on the lines below each picture.



Effort force: _____

Resistance force: _____

Load: _____



Effort force: _____

Resistance force: _____

Load: _____



Effort force: _____

Resistance force: _____

Load: _____



Effort force: _____

Resistance force: _____

Load: _____

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COLLABORATIVE ACTIVITY #3

SECTION **Mechanical Advantage and Efficiency**
12-2 (pages 378-383)

This section explains how machines make work easier and describes how to calculate how efficient a machine is.

► What Is a Machine? (pages 378-380)

1. What is a machine? _____

2. Is the following sentence true or false? A machine decreases the amount of work needed to do a job. _____
3. Circle the letter of each sentence that is true about how a machine makes work easier.
 - a. A machine makes work easier by multiplying force you exert.
 - b. A machine makes work easier by reducing the amount of force needed to do the job.
 - c. A machine makes work easier by multiplying the distance over which you exert force.
 - d. A machine makes work easier by changing the direction in which you exert force.
4. The force you exert on a machine is called the _____.
5. The force exerted by the machine is called the _____.
6. Is the following sentence true or false? In some machines, the output force is greater than the input force. _____
7. If a machine allows you to use less force to do some amount of work, then you must apply the input force over a greater _____.
8. Is the following sentence true or false? In some machines, the output force is less than the input force. _____

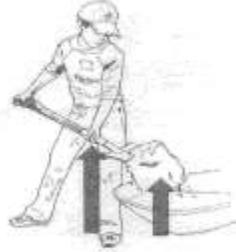
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COLLABORATIVE ACTIVITY #4

CHAPTER 12. Work and Machines (continued)

9. Write labels on the illustration below to show which arrow represents the input force and which represents the output force.



► Mechanical Advantage (page 301)

10. What is a machine's mechanical advantage? _____

11. What is the formula you use to determine the mechanical advantage of a machine?

12. In a machine that has a mechanical advantage of more than 1, the _____ force is greater than the _____ force.

► Efficiency of Machines (pages 302-303)

13. In any machine, some work is wasted overcoming _____
14. The comparison of a machine's output work to its input work is _____
15. What is the formula you use to calculate the efficiency of a machine?

16. The mechanical advantage that a machine provides in a real situation is called the _____ mechanical advantage.
17. The mechanical advantage of a machine without friction is called the machine's _____ mechanical advantage.

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COLLABORATIVE ACTIVITY #5

CHAPTER 3

ATOMS AND THE PERIODIC TABLE

SECTION 3-1 Inside an Atom

(pages 76-80)

This section describes the structure of an atom and explains the role that valence electrons play in forming chemical bonds.

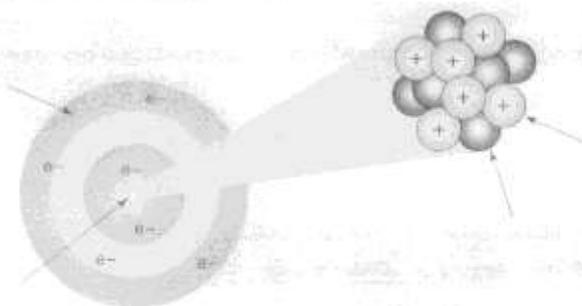
► Structure of an Atom (pages 76-77)

1. What does an atom consist of? _____

Match the particle with its charge.

- | | |
|-------------------|-------------|
| _____ 2. neutron | a. positive |
| _____ 3. proton | b. negative |
| _____ 4. electron | c. neutral |

5. Label the parts of an atom on the drawing.



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Name: _____ Date: _____ Class: _____

CHAPTER 3. Atoms and the Periodic Table *(continued)*

6. The number of protons in the nucleus of an atom is called the _____.
7. Why is an atom neutral? _____

8. What is a unit of measurement for the mass of particles in atoms?

9. Most of an atom's mass is in its _____.
10. Circle the letter of each sentence that is true about atoms.
- a. Atoms of a particular element can have different numbers of neutrons.
 - b. Atoms of a particular element always have the same number of protons.
 - c. The mass of atoms of a particular element can vary.
 - d. Neutrons play an important role in chemical reactions.

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COLLABORATIVE ACTIVITY #6

► The Role of Electrons (pages 77-80)

11. The space in which the electrons move is huge compared to the space occupied by the _____.
12. What are the electrons farthest from the nucleus called?

13. What moves between two atoms when a chemical bond forms between the atoms? _____
14. What are two ways in which valence electrons move between atoms?
 - a. _____
 - b. _____
15. A way to show the number of valence electrons an atom has, using dots around the symbol of an element, is a(n) _____.
16. According to the dot diagram in Figure 3 on page 80, how many valence electrons does neon (Ne) have? _____

17. What are two things that can happen when an atom forms a chemical bond?
 - a. _____
 - b. _____
18. When atoms end up with eight or zero valence electrons, how are they different than they were before? _____

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COLLABORATIVE ACTIVITY #7

SECTION Organizing the Elements

3-2 (pages 81-88)

This section explains how the elements are organized in a chart called the periodic table. It also explains what information the periodic table contains.

► Looking for Patterns in the Elements (pages 81-82)

1. What did Dmitri Mendeleev recognize in 1869? _____

2. What is the atomic mass of an element? _____

3. What are the two especially important properties that Mendeleev noted about the elements? _____

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Name: _____ Date: _____ Class: _____

CHAPTER 3, Atoms and the Periodic Table (continued)

► The Periodic Table (pages 82–85)

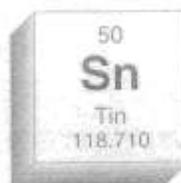
- Mendeleev noticed that patterns appeared when he arranged the elements in what way? _____

- A chart of the elements showing the repeating pattern of their properties is called the _____.
- What does the word *periodic* mean? _____
- How many missing elements did Mendeleev predict would be discovered? _____
- In the modern periodic table, the elements are arranged according to their _____.
- Look at *Exploring the Periodic Table* on pages 84–85. Where does the periodic table become wider? _____
- From an element's position on the periodic table, you can predict its _____.

► Reading the Periodic Table (pages 86–87)

- What does each square of the periodic table usually include? _____

- Use the square from the periodic table to fill in the blanks below.
Name of element: _____
Chemical symbol: _____
Atomic mass: _____
Atomic number: _____



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Name: _____ Date: _____ Class: _____

13. The atomic number for the element calcium (Ca) is 20. How many protons and electrons does each calcium atom have? _____

14. How can an element's properties be predicted? _____

15. Circle the letter of each term that refers to the elements in a column of the periodic table.
a. period b. family c. group d. symbol
16. Group 15 of the periodic table is the _____ family.
17. Circle the letter of the sentence that is true about elements in each group.
a. They all have the same atomic mass.
b. They all have similar characteristics.
c. They all have similar atomic numbers.
d. They all have the same chemical symbol.
18. Each horizontal row across the periodic table is called a(n)

19. Is the following sentence true or false? The elements in each period are not alike in properties. _____

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COLLABORATIVE ACTIVITY #8

► Why the Periodic Table Works (page 88)

20. Why does the periodic table work? _____

21. The number of valence electrons in a row of eight increases from one
to _____.

CHAPTER 3, Atoms and the Periodic Table (continued)

22. Why do elements in a family have similar properties? _____

23. Circle the letter of each sentence that is true about elements.
- a. All elements have the same number of valence electrons.
 - b. The number of valence electrons an element has increases from left to right across a period.
 - c. The properties across a period change in a regular way.
 - d. All elements in a family have the same number of valence electrons.

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COLLABORATIVE ACTIVITY #9

SECTION 3-3 Metals
(pages 89-94)

This section describes the properties of metals and the characteristics of the different groups, or families, of metals.

► What is a Metal? (pages 89-90)

1. Chemists classify an element as a metal based on what physical properties? _____
2. Is the following sentence true or false? Most metals are solids at room temperature because they have the property of very low melting points. _____

Match the term with its definition.

Term	Definition
_____ 3. malleable	a. The process of reaction and wearing away of a metal element
_____ 4. ductile	b. A characteristic of those metals that are attracted to magnets or can be made into magnets
_____ 5. magnetic	c. A term used to describe a material that can be pulled out, or drawn, into a long wire
_____ 6. corrosion	d. A term used to describe a material that can be pounded or rolled into shape

7. Why are most metals called good conductors? _____
8. Is the following sentence true or false? Metals show a wide range of chemical properties. _____

► Alloys (page 91)

9. A mixture of metals is called a(n) _____
10. Bronze is a mixture of what two metals? _____

► Metals in the Periodic Table (pages 91-94)

11. How do the properties of each family of metals change as you travel across the table? _____
12. Circle the letter of each sentence that is true about alkali metals.
 - a. They are never found as elements but only in compounds.
 - b. Each atom of an alkali element has one valence electron that is easily transferred.
 - c. They are often found as pure elements in sea water.
 - d. They are extremely reactive.

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Name: _____ Date: _____ Class: _____

CHAPTER 3. Atoms and the Periodic Table (continued)

13. What are the two most important alkali metals?

14. Circle the letter of each sentence that is true about alkaline earth metals.

- a. Each is a good conductor of electricity.
- b. They are never found uncombined in nature.
- c. They easily lose their valence electrons in chemical reactions.
- d. They are much less reactive than most metals.

15. What are the two most common alkaline earth metals?

16. Circle the letter of each element that is a transition metal.

- a. gold b. iron c. copper d. lithium

17. Is the following sentence true or false? The transition metals are fairly stable, reacting slowly or not at all with air and water. _____

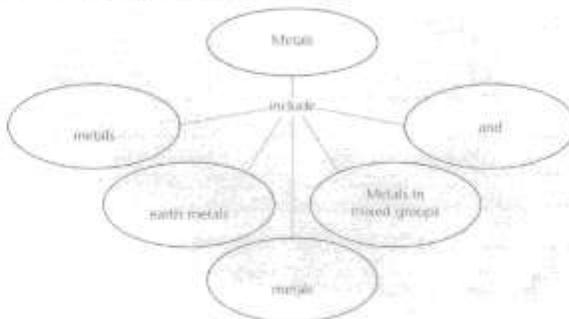
18. What are the most familiar metals in groups 13 through 16? _____

19. What is another name for the lanthanides and actinides?

20. Where are the lanthanides and actinides placed on the periodic table?

21. Uranium has an atomic number of 92. How were all the elements with atomic numbers higher than 92 created? _____

22. Complete the concept map about metals.



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Name: _____ Date: _____ Class: _____

COLLABORATIVE ACTIVITY #10

SECTION **Nonmetals and Metalloids**
3-4 (pages 98-103)

This section describes properties of the elements on the periodic table that are not metals.

► **What is a Nonmetal?** (pages 98-99)

1. The elements that lack most of the properties of metals are called _____.
2. Where are the nonmetals located on the periodic table? _____
3. Is the following sentence true or false? Many of the nonmetals are gases at room temperature. _____
4. Circle the letter of each sentence that is true about the physical properties of nonmetals.
 - a. Solid nonmetals are brittle.
 - b. They usually have lower densities than metals.
 - c. Most are shiny.
 - d. They are good conductors of both heat and electricity.

CHAPTER 3, Atoms and the Periodic Table (continued)

5. Except for the Group 18 elements, most nonmetals readily form _____.
6. What happens when nonmetals and metals react? _____
7. A molecule composed of two identical atoms is called a(n) _____.

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Name: _____ Date: _____ Class: _____

► **The Metalloids** (page 103)

20. What are metalloids? _____

21. What is the most common metalloid? _____

22. What is the most useful property of the metalloids? _____

23. What are semiconductors? _____

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Name: _____ Date: _____ Class: _____

COLLABORATIVE ACTIVITY #11

► Families of Nonmetals (pages 100-103)

8. Circle the letter of the number of valence electrons that an atom in the carbon family has.
- a. 1 b. 4 c. 5 d. 6
9. All living things contain what kind of compounds? _____

10. Circle the letter of the number of valence electrons that an atom in the nitrogen family has.
- a. 2 b. 7 c. 5 d. 3
11. The atmosphere is almost 80 percent _____
12. Circle the letter of the number of valence electrons that an atom in the oxygen family has.
- a. 6 b. 7 c. 5 d. 2
13. Circle the letter of each sentence that is true about oxygen.
- a. The oxygen you breathe is a diatomic molecule.
 - b. Oxygen rarely combines with other elements.
 - c. Oxygen is the most abundant element in Earth's crust.
 - d. Ozone collects in a layer in the upper atmosphere.

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Name: _____ Date: _____ Class: _____

14. Circle the letter of the number of valence electrons that an atom in the halogen family has.

- a. 4 b. 7 c. 6 d. 3

15. Is the following sentence true or false? Most halogens are dangerous to humans. _____

16. Circle the letter of each sentence that is true about the noble gases.

- a. They exist in large amounts in the atmosphere.
b. They are chemically very stable and unreactive.
c. They readily share their valence electrons.
d. They are used in glowing electric lights.

17. Complete the table about families of nonmetals.

Nonmetals		
Family	Group	Nonmetals in Family
Carbon family		
Nitrogen family		
Oxygen family		
Halogen family		
Noble gases		

18. How many protons and electrons does a hydrogen atom contain?

19. Why can't hydrogen be grouped in a family? _____

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Name: _____ Date: _____ Class: _____

COLLABORATIVE ACTIVITY #12

Particles of Matter

◆ Understanding Main Ideas

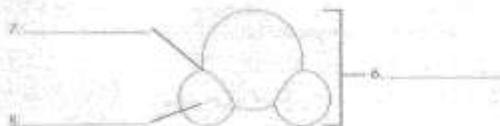
The following statements refer to Dalton's ideas on atomic theory. If the statement correctly describes Dalton's ideas, write true. If the statement does not describe Dalton's ideas correctly, change the underlined word or words to make the statement correct. Write the characteristic of atoms from Dalton's theory that supports your answer.

- _____ 1. The element oxygen and the element hydrogen are made from the same kind of atom.
Characteristic: _____
- _____ 2. The hydrogen and oxygen atoms chemically bond to form the mixture called water.
Characteristic: _____
- _____ 3. The hydrogen atoms in the water molecule are identical to all other hydrogen atoms.
Characteristic: _____
- _____ 4. Dalton believed that atoms could be divided into smaller pieces.
Characteristic: _____
- _____ 5. The mass of a hydrogen atom is different from the mass of an oxygen atom.
Characteristic: _____

◆ Building Vocabulary

Use the following terms to label the parts of the illustration.

atom
molecule
chemical bond



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Name: _____ Date: _____ Class: _____

► **Three States of Matter** (page 450)

1. Is the following sentence true or false? Most matter can exist in three states.

2. Circle the letter of the terms that identify states of matter.

a. water b. gas c. liquid d. solid

3. The particles that make up a(n) _____ are packed together in a relatively fixed position.

4. Circle the letter of each sentence that is true about liquids.

a. Liquids have a definite volume.

b. Liquids have a fixed shape.

c. Liquid particles can move around.

d. Liquid particles are moving around so fast that they don't even stay close together.

5. In which state of matter can the particles only vibrate back and forth?

6. In which state of matter do the particles expand to fill all the space available? _____

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Name: _____ Date: _____ Class: _____

COLLABORATIVE ACTIVITY #13

Describing Matter

◆ Understanding Main Ideas

Use the illustration below to answer questions 1 and 2. Write your answers to all the following questions in the spaces provided.



1. Label the state of matter represented by water in each figure in the blanks provided.

a. _____

b. _____

c. _____

2. Are the changes from a to b and from b to c physical or chemical changes?

Explain your answer.

3. Explain how a compound differs from a mixture.

4. What is chemistry?

◆ Building Vocabulary

Give an example of each of the terms below. Write your answer on the line next to the term.

5. an element _____

6. a formula _____

7. a mixture _____

8. a compound _____

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Name: _____ Date: _____ Class: _____

COLLABORATIVE ACTIVITY #14

Changes in State

◆ Understanding Main Ideas

Check the type of change in the energy of the particles of matter that applies to each description.

Description	Thermal Energy Increases	Thermal Energy Decreases
1. As you breathe on a mirror, a film of water briefly forms on the mirror.		
2. "Dry ice" seems to disappear.		
3. A puddle dries up on a sunny day.		
4. Water freezes.		
5. Butter melts.		

◆ Building Vocabulary

From the list below, choose the term that best completes each sentence.

- melting sublimation thermal energy freezing
 vaporization evaporation boiling condensation
- The higher the temperature of something, the greater its _____.
 - The change in state from gas to liquid is called _____.
 - The change in state from liquid to gas is called _____.
 - Gas bubbles forming throughout the liquid is called _____.
 - Liquid changing to gas only at the surface is called _____.
 - The change in state from solid to liquid is called _____.
 - The change in state from liquid to solid is called _____.
 - In _____, particles pass directly from solid to gas.

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Name: _____ Date: _____ Class: _____

COLLABORATIVE ACTIVITY #15

► Changes of State (pages 450–451)

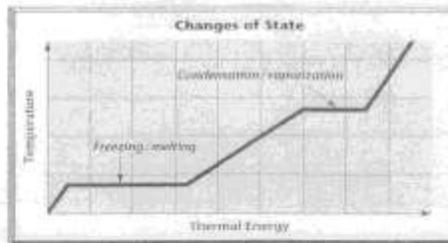
7. What is a change of state? _____

8. Circle the letter of each sentence that is true about matter.

- a. The particles of a gas move faster than the particles of a liquid.
- b. The particles of a solid move faster than the particles of a gas.
- c. The particles of a liquid move faster than the particles of a solid.
- d. The particles of a gas move faster than the particles of a solid.

9. Matter will change from one state to another if _____
_____ is absorbed or released.

10. On the graph below, write labels for the regions of the graph that represent the gas, liquid, and solid states of matter.



► Solid-Liquid Changes of State (pages 451–452)

11. The change in state from a solid to a liquid is called _____

12. The temperature at which a solid changes to a liquid is called the _____

13. The change in state from a liquid to a solid is called _____

14. The temperature at which a substance changes from a liquid to a solid is called its _____

► Liquid-Gas Changes of State (pages 452–453)

15. What is vaporization? _____

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Name: _____ Date: _____ Class: _____

Thermal Energy and States of Matter

◆ Understanding Main Ideas

Answer the following questions on a separate sheet of paper.

1. A glass of ice at 0°C changes to a glass of water at 0°C. What caused the ice to change to water?
2. Why didn't the temperature of the water change in Question 1?
3. Lengths of railway tracks have small gaps between them. Why are the tracks built this way and what might happen if there were no gaps?

◆ Building Vocabulary

From the list below, choose the term that best completes each sentence.

state change of state boiling evaporation
thermal expansion thermostat freezing
bimetallic strip freezing point condensation

4. The change from a gas to a liquid is called _____.
5. A solid, a liquid, and a gas are all examples of a(n) _____ of matter.
6. The temperature at which matter changes from a liquid to a solid is called the _____.
7. A(n) _____ is a device that regulates heat.
8. The expansion of matter when it is heated is known as _____.
9. The physical change from one state of matter to another is called _____.
10. A strip of two different metals joined together is called a(n) _____.
11. When vaporization takes place on the surface of a liquid, the process is called _____.
12. When vaporization takes place on and below the surface of a liquid at higher temperature, the process is called _____.

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Name: _____ Date: _____ Class: _____

COLLABORATIVE ACTIVITY #16

► Thermal Expansion (pages 453–454)

20. The expanding of matter when it is heated is known as _____.
21. What happens to the liquid in a thermometer when it is heated?

22. Heat-regulating devices are called _____.
23. In thermostats, what are strips of two different metals joined together called? _____
24. In thermostats, bimetallic strips are used because different metals _____ at different rates.

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COLLABORATIVE ACTIVITY #17

► Heat Engines (pages 455–457)

1. To power a steam locomotive, the thermal energy of a coal fire must be converted to the _____ energy of the moving train.
2. The conversion of thermal energy to mechanical energy requires a device called a(n) _____.
3. What is the process of burning a fuel, such as coal or gasoline?

4. How are heat engines classified?

5. Complete the compare/contrast table.

Heat Engines		
Type	Where Fuel is Burned	Example
External combustion engines		
Internal combustion engines		

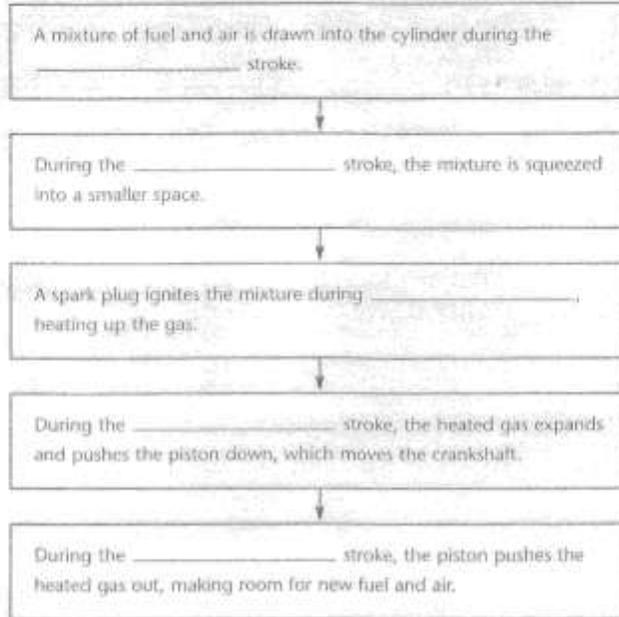
6. In a steam engine, what does the steam move back and forth inside a cylinder? _____
7. In an internal combustion engine, each up or down movement of a piston is called a(n) _____.
8. When a spark ignites the mixture of gas and fuel in a four-stroke engine, stored chemical energy is converted to _____ energy.

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CHAPTER 14: Thermal Energy and Heat *(continued)*

9. Complete the flowchart below to describe the process that occurs in each cylinder of a four-stroke engine.



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Name: _____ Date: _____ Class: _____

COLLABORATIVE ACTIVITY #18

► Refrigerators (page 456)

10. A refrigerator transfers thermal energy from a cool area to a(n) _____ area.
11. What provides the energy for a refrigerator to transfer energy from inside to outside? _____

12. Where does the gas that circulates through the tubes inside the refrigerator walls lose thermal energy? _____

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APPENDIX C

Re: MOSART testing instrument

Re: MOSART testing instrument

Hal Coyle [hcoyle@cfa.harvard.edu]

Sent: Tuesday, July 10, 2012 10:19 AM

To: Wendt, Jillian Leigh

Attachments: Psychometric qualities of ~1.pdf (104 KB)

Dear Jillian,

From your comments you appear to have found the AER article we wrote concerning the K-12 astronomy items. It's unclear to me if you have found our self-service web site, where you can download test sets that parallel those we use with NSF MSPs. The self-service web site is located at: <<http://www.cfa.harvard.edu/smgphp/mosart/index.htm>>. The tests on this site come as PDF files, which you can then use as you desire with your own resources.

The test files contain an answer key and data from our field trials with students. We do not post detailed psychometric data for them on this site. However, the MOSART project psychometrician prepared a general statement (below, with her contact information), as well as a longer explanation that is contained in the attached PDF.

We are currently writing a proposal to NSF to obtain funding to develop the 9-12 life science tests, which is due in December. If that proposal is funded, we expect to have tests completed by 2015 (the award would not be made until about June 2013 and our development plan requires 2.5 years to fully develop the item inventory, and then the tests).

Best regards,

Hal Coyle
Manager, MOSART projects

"The MOSART tests have adequate evidence of reliability and validity. The reliability evidence consists of internal consistency (Cronbach's alpha) and person separability (Rasch model). Both of these are within the acceptable range (0.45 to 0.70). For the content validity of the items, all items have been reviewed by at least 5 faculty or research scientists who are currently active in the relevant field. In addition, the items are reviewed by a readability expert for appropriateness of language for the targeted grade band. Finally, the project psychometrician constructs the tests based on field test data analysis (to ensure an appropriate difficulty range (both classical and Rasch) for each standard addressed."

Nancy Cook Smith, Ph.D.
Project Psychometrician
Science Education Department
Harvard-Smithsonian Center for Astrophysics
60 Garden St., MS 71
Cambridge, MA 02138
Telephone: 617-495-9726
Email: ncook@cfa.harvard.edu

<https://by2prd0511.outlook.com/owa/?ae=Item&t=IPM.Note&id=RgAAAADpYXXL9j5J...> 8/21/2012

APPENDIX D

RE: Classroom Community Scale

Page 1 of 1

RE: Classroom Community Scale

Alfred Rovai [alfrov@regent.edu]

Sent: Thursday, June 28, 2012 6:00 PM

To: Wendt, Jillian Leigh

Hi,

Yes, you may use the instrument as you describe. Just make sure that you cite the 2002 article in any report you write.

Best wishes,

Fred Rovai

From: Wendt, Jillian Leigh [jarnett@liberty.edu]

Sent: Wednesday, June 27, 2012 1:14 PM

To: Alfred Rovai

Subject: Classroom Community Scale

Dr. Rovai,

My name is Jillian Wendt. I am a doctoral candidate at Liberty University in Lynchburg, Virginia. I am currently preparing to complete a dissertation that examines sense of community amongst adolescent science students under the supervision of Dr. Amanda Rockinson-Szapkiw.

I am writing today to kindly request permission to use, reproduce, and distribute your Classroom Community Scale as it appears in Development of an Instrument to Measure Classroom Community (2002) for purposes related to my dissertation research. I would truly appreciate your consideration of my request.

Thank you for your time and consideration.

With Regards,

Jillian Wendt

Doctoral Candidate, Liberty University



<https://webmail.liberty.edu/owa/?ae=Item&t=IPM.Note&id=RgAAAADpYXXL9j5JSZf3...> 6/29/2012

APPENDIX E

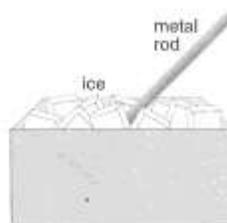
PHYSICAL SCIENCE TEST

For some questions, there may be more than one correct answer. However, each question has only one best answer. Choose the single best answer from the five choices for each question.

- Jack opens a can of soda pop and lets it sit on his kitchen countertop. He goes off to do some chores and forgets about the opened can. When he returns several hours later, the weight of the opened can of soda pop will:
 - be more than the unopened can.
 - be less than the unopened can.
 - be the same as the unopened can.
 - depend on the relative humidity.
 - depend on the type of soda pop.

- Helium gas is used in balloons. When helium gas is cooled enough, it becomes a liquid. What do you think happens when helium turns into a liquid?
 - The helium has turned into water.
 - Some of the helium has turned into water.
 - The helium has turned into a different liquid.
 - Some helium has turned into water, some into another liquid and the rest is helium.
 - It is all still helium, but in a liquid form.

- Sue sticks one end of a metal rod into a box filled with ice. The end of the rod that is covered with ice becomes cold. After a while Sue places her hand on the upper end of the rod outside the box and feels that it is cold. What do you think has happened?
 - Cold has transferred from the lower end of the rod to the upper end.
 - The rod gave up heat to the ice.
 - Cold moved from Sue's hands towards the rod.
 - Heat moved from the rod to Sue's hand.
 - It depends on the original temperature of the rod.



- A light bulb is connected to a battery by wires. The bulb is lit up. Nadia wants to know what is flowing through the wires. If a scientist were to cut the wire and look at it with a powerful magnifying glass, what do you think she would see?
 - Chemicals from the battery flowing through the wire.
 - Light flowing through the wire.
 - The wire will be hollow with nothing flowing through it.
 - Tiny sparks flowing through the wire.
 - The wire will be solid.



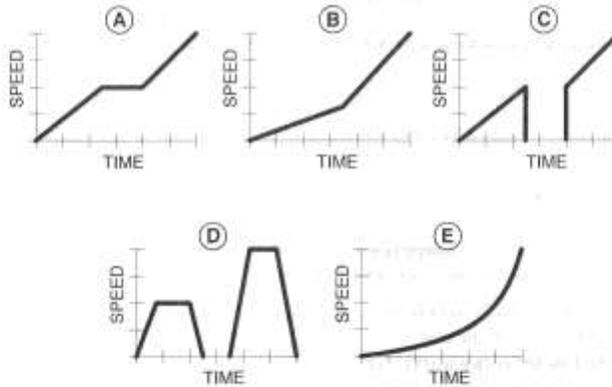
- John has built a special greenhouse in his backyard. By turning a special dial, John can choose which type of sunlight can enter the greenhouse. When only ultraviolet light is allowed to enter the greenhouse, what do you think will happen while John is standing inside the greenhouse?
 - John can see objects inside the greenhouse.
 - It is warmer inside the greenhouse than it is outside.
 - After a few hours, John begins to sunburn.
 - John can see objects outside the greenhouse.
 - John can only see a few objects.

1

6. Suzanne is baking a cake and has placed several ingredients on the countertop to use. She has scooped some baking soda into a measuring spoon. She accidentally knocks over a cup of vinegar and several drops spill onto the spoon with the baking soda. The baking soda begins to fizz where the vinegar spilled on it. When the fizzing stops, Suzanne notices that about half of the baking soda in the spoon is gone and there is now a liquid on the spoon. The baking soda "disappeared" because it:
- melted.
 - combined with the vinegar and produced a new liquid.
 - dissolved in the vinegar, but is still in the liquid.
 - evaporated.
 - was pushed off of the spoon by the fizzing.



7. Carolyn walks a half mile to school. One morning, halfway to school, she stopped to watch a bird building a nest. When she realized she was late, she ran the rest of the way to school to avoid being marked late. Which graph below shows Carolyn's speed during her walk to school?



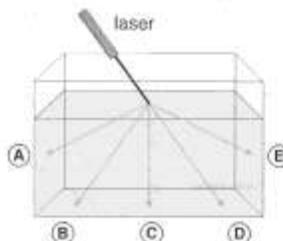
GO TO QUESTION 8 >>

2

8. Two identical jars are placed on a table with a light bulb between them. The bulb is turned on. One jar is filled with water and the other jar is filled with black ink. There is a thermometer hanging in each jar. What do you think will happen?
- The jar with water will be hotter than the jar with black ink.
 - The jar with black ink will be hotter than the jar with water.
 - There will be no difference in the temperature of the two jars.
 - The temperature in both the jars will drop.
 - The temperature in the jar with black ink will first drop and then increase.

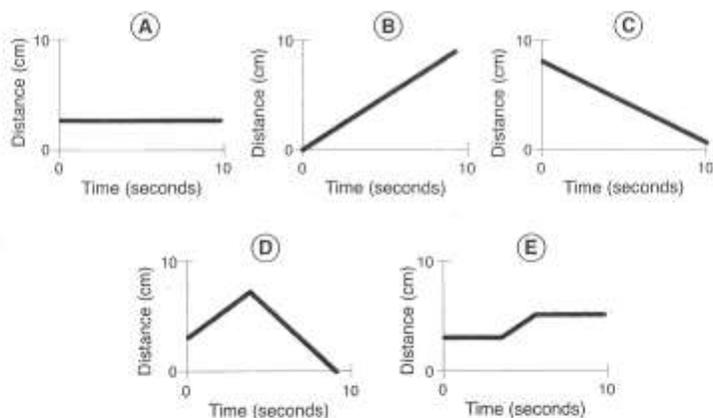


9. Look at the set up below. It shows a fish tank filled with water; the sides and bottom of the tank are all clear glass. If a red laser pointer were aimed into the tank as shown, at which lettered point do you think the laser beam would hit the glass?



10. Someone claims to have invented a system that converts sound energy into electrical energy. The inventor plans to put this system into a portable CD player so that the player's own sound can be used to recharge the player's own batteries. What do you think will happen when this CD player system is tested?
- The system should work fine, allowing unlimited running time for the player.
 - The system will work, but the player's volume will have to be kept in a narrow range, not too low, not too loud.
 - The system will work, but the player's volume will vary from low to high depending on whether or not the battery is being charged.
 - The system will be limited by the design of the battery: if it takes too long to fully charge, the battery may go dead.
 - The system will not work and the CD player will stop running after the battery is fully discharged.
11. It is a sunny day. Sean sits by the window and enjoys the sunshine. His mother tells him not to sit there for too long. However, Sean does not agree with her. Which one of the following statements do you agree with?
- Sean can get skin cancer from the ultraviolet radiation coming in with the sunlight.
 - Ultraviolet radiation is completely blocked by the window glass.
 - Ultraviolet radiation will not affect Sean in any harmful way.
 - Sean's risk depends upon the amount of sunlight.
 - The thickness of the window is important.

12. As part of an experiment, Jason mixes 2 cups of water at 200°F with 10 cups of water at 50°F. The temperature of the combined water is:
- 200°F.
 - closer to 200°F than to 50°F.
 - 125°F.
 - closer to 50°F than to 200°F.
 - impossible to estimate.
13. Mike thinks that he can turn copper into gold. He mixes a small amount of gold with a large amount of copper and heats them up until they melt. What do you think has happened?
- All the copper has turned into gold.
 - Some of the copper has turned into gold.
 - The copper has not changed into gold. It's just a mixture of gold and copper.
 - Copper and gold have turned into something completely new.
 - Not enough information to answer the question.
14. Kaitlyn is watching a wind-up toy walking across a table. She observes that the toy covers 1 cm every second for 10 seconds. Which graph below do you think most closely represents the toy's journey across the table?



15. A person claims that diamonds and the graphite in an ordinary pencil are made of the same material. A scientist's response would be that the claim is:
- False. The two substances are too different to be made of the same material.
 - False. Every substance is unique; no two substances are made of the same material.
 - Not able to be answered with the information given.
 - True. The substances look different because what's inside them is arranged differently.
 - True. The material is held together by a different substance, causing the different properties.

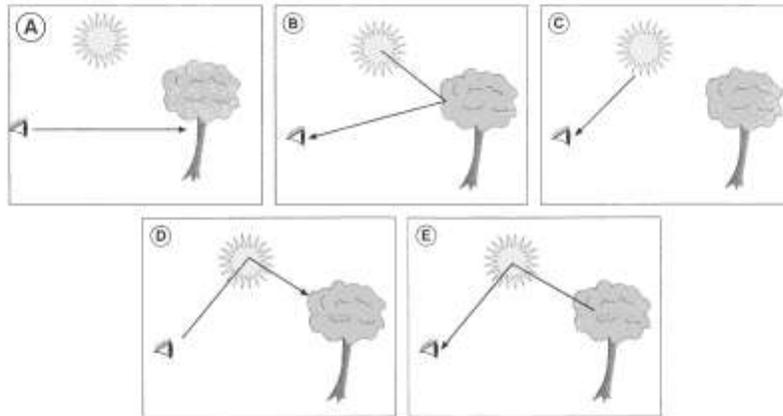
16. A see-saw has cinder blocks attached to it on both ends. The single block weighs 20 pounds and the two small blocks weigh 10 pounds each. What do you think will happen to the see-saw when its allowed to move?

- The side with the single block will move downward.
- The side with two small blocks will move downward.
- The see-saw will not move.
- The side with the single block will first move downward and then upward.
- The side with the small blocks will first move downwards and then upward.



17. Zahra is sitting in her backyard, looking at a tree. With which of the following statements about how she is able to see a tree do you agree?

- Light from her eye reaches the tree and she sees the tree.
- Light from the Sun reaches the tree and then her eye and she sees the tree.
- Light from the Sun reaches her eye and she sees the tree.
- Light from her eye reaches the Sun and then the tree and she sees the tree.
- Light from the tree reaches the Sun and then her eye and she sees the tree.



18. Imagine that you go to leave a room with an overhead light. The light is on. You move the wall switch to turn off the light, but the light stays on. What is probably wrong?

- The battery that powers the switch is dead.
- There is a break in the wire to the light bulb.
- The switch can no longer stop the flow of electricity through the wires.
- The light fixture is broken.
- A surge of electricity is occurring in the building.

GO TO QUESTION 19 >>

19. A solid rubber ball sinks when placed in water. What will happen if the ball is cut in half and one of the smaller pieces is placed underwater?
- The smaller piece will rise.
 - The smaller piece will sink.
 - The smaller piece will stay motionless.
 - The smaller piece will dissolve.
 - There is no way to predict what will happen.
20. A pebble is dropped into a cup of water and sinks to the bottom of the cup. A solid metal bead of exactly the same size is dropped into the same cup and sinks to the bottom of the cup. How do the pebble and the metal bead compare?
- The metal bead and the pebble have the same density.
 - The metal bead and the pebble are the same mass.
 - The metal bead and the pebble are denser than water.
 - The metal bead and the pebble contain the same materials.
 - The metal bead and the pebble are as dense as the water.

APPENDIX F

Classroom Community Scale (Rovai, 2002a)

Directions: Below, you will see a series of statements concerning a specific course or program you are presently taking or have recently completed. Read each statement carefully and place an X in the parentheses to the right of the statement that comes closest to indicate how you feel about the course or program. You may use a pencil or pen. There are no correct or incorrect responses. If you neither agree nor disagree with a statement or are uncertain, place an X in the neutral (N) area. Do not spend too much time on any one statement, but give the response that seems to describe how you feel. Please respond to all items.

	Strongly agree (SA)	Agree (A)	Neutral (N)	Disagree (D)	Strongly disagree (SD)
1. I feel that students in this course care about each other	(SA)	(A)	(N)	(D)	(SD)
2. I feel that I am encouraged to ask questions	(SA)	(A)	(N)	(D)	(SD)
3. I feel connected to others in this course	(SA)	(A)	(N)	(D)	(SD)
4. I feel that it is hard to get help when I have a question	(SA)	(A)	(N)	(D)	(SD)
5. I do not feel a spirit of community	(SA)	(A)	(N)	(D)	(SD)
6. I feel that I receive timely feedback	(SA)	(A)	(N)	(D)	(SD)
7. I feel that this course is like a family	(SA)	(A)	(N)	(D)	(SD)
8. I feel uneasy exposing gaps in my understanding	(SA)	(A)	(N)	(D)	(SD)
9. I feel isolated in this course	(SA)	(A)	(N)	(D)	(SD)
10. I feel reluctant to speak openly	(SA)	(A)	(N)	(D)	(SD)
11. I trust others in this course	(SA)	(A)	(N)	(D)	(SD)
12. I feel that this course results in only modest learning	(SA)	(A)	(N)	(D)	(SD)
13. I feel that I can rely on others in this course	(SA)	(A)	(N)	(D)	(SD)
14. I feel that other students do not help me learn	(SA)	(A)	(N)	(D)	(SD)
15. I feel that members of this course depend on me	(SA)	(A)	(N)	(D)	(SD)
16. I feel that I am given ample opportunities to learn	(SA)	(A)	(N)	(D)	(SD)
17. I feel uncertain about others in this course	(SA)	(A)	(N)	(D)	(SD)

18. I feel that my educational needs are not being met	(SA)	(A)	(N)	(D)	(SD)
19. I feel confident that others will support me	(SA)	(A)	(N)	(D)	(SD)
20. I feel that this course does not promote a desire to learn	(SA)	(A)	(N)	(D)	(SD)

APPENDIX G

Informed Consent Form: The Effects of Online Collaboration on Middle School Students' Science Literacy and Sense of Community

Your student is invited to be part of a research study that is examining the effect of online collaboration on middle school students' science literacy and sense of community. Your student was selected as a possible participant because he/she may fit the criteria for this study (i.e. a middle school student enrolled in a science course). Participation in a research study being conducted may be helpful to increase understanding of the effect of collaborative learning on science literacy.

This informed consent outlines the facts, implications, and consequences of the research study. Upon reading, understanding, and signing this document, you are giving consent for your student to participate in the research study.

Researcher:

Jillian L. Wendt, Ed.S., Doctoral Candidate, Liberty University

Inquiries:

The researcher will gladly answer any inquiries regarding the purpose and procedures of the present study. Please send all inquiries via email to Jillian at jarnett@liberty.edu.

Procedures:

The student is being asked to complete a pre-test and post-test as part of the normal science curriculum. The student is also being asked to complete a survey two times; once at the beginning of the study and once at the end of the study. The length of time needed to complete the test in class is estimated at 20- 30 minutes. The length of time needed to complete the survey in class is estimated at 15-20 minutes. Participation is voluntary. The researcher will take precautions to protect participant identity by not using the names of participants or the name of the school in her results or writing. The researcher will use the assessment results for publications and presentation purposes. Normal classroom instruction will continue for both the experimental and control groups to which your child may be assigned. Your child will be asked to participate in face-to-face collaborative (group) activities or computer-mediated collaborative activities. Computer-mediated activities will be completed through the use of Edmodo, an online educational platform. Online collaboration will occur through the use of the Edmodo learning platform. Each participant will be required to create a free Edmodo account and will be given a code to access the Edmodo class. Activities for both groups will include worksheet and discussion-type activities.

Participant Risks: The study may involve risks to the participant, which include possible identification of the participant in relation to test or survey results. However, this risk is minimized by only the classroom teacher and the researcher having access to student test scores and survey results. All reported scores and results will not include student names; rather, school-issued student identification numbers will be used. In addition, the school

will not be identified in published reports, but rather will be given a pseudonym. Risks of this study are minimal and are not expected to be more than those encountered in everyday life.

Participant Benefits:

Participants may benefit from increased understanding of science literacy, including common scientific misconceptions. Participants may also benefit from increased understanding of the possible benefits of collaborative learning. The potential publication of the findings of this study may prove beneficial to students, faculty, and education administrators as they seek to proactively improve the teaching and learning process in the high school setting.

Compensation:

Participants will not receive any financial compensation for participation in this study.

Confidentiality:

The researchers will take precautions to protect participant confidentiality through the use of school-issued identification numbers. The researcher will not identify participants by name or identify the school in any of their writings or presentations.

The tests and surveys will be provided to participants and completed on paper.

Completed tests and surveys will be stored by the classroom teacher and/or the researcher in a locked file cabinet. The completed tests and surveys will be stored for the duration of three years and will then be destroyed by the researcher.

Online collaboration will occur through the use of the Edmodo learning platform. Each participant will be given a code to access the Edmodo class. Only participants, the classroom teacher, and the researcher will have access to the code. However, it is conceivable that engineering staff at the web hosting company may need to access the database for maintenance reasons. The information will be stored on this site for the duration of three years and will then be deleted by the researchers. The researchers will store all research documentation on a password-protected computer database on their university computers for the duration of three years and will then delete the documentation from the computer database. Any hard copies of the data will be stored in a locked filing cabinet and shredded at the end of three years.

Voluntary Participation:

Participation in this study is voluntary and you or your student may withdraw at any time without penalty. A decision to participate or not participate will not affect the student's relationship with Liberty University or with XXXX.

Disclosure:By signing below I acknowledge the following:

I have read and understand the description of the study and contents of this document. I have had an opportunity to ask questions and have all my questions answered. I hereby acknowledge the above and give my voluntary consent for my student's participation in

this study. I understand that should I have any questions about this research and its conduct, I should contact the researcher listed above.

If I have any questions about rights or this form, I should contact the researcher, Jillian Wendt, XXXX the faculty advisor for this study, Dr. Amanda Rockinson-Szapkiw, Liberty University, 1971 University Blvd., Lynchburg, VA 24502, (434-582-7423) or the current IRB chair for Liberty University, Dr. Fernando Garzon, Liberty University, IRB Review, 1971 University Blvd., Lynchburg, VA 24502.

Student Name (Print): _____

Parent/Guardian Signature: _____

Parent/Guardian Name (Print): _____

Date: _____

APPENDIX H

Assent of Child to Participate in a Research Study

What is the name of the study and who is doing the study?

The name of the study is “The Effect of Online Collaborative Learning on Middle School Student Science Literacy and Sense of Community”. It is being completed by Jillian Wendt, a student at Liberty University.

Why are we doing this study?

We are interested in studying how group activities that are completed using computers might affect science literacy (science knowledge and how students are able to apply science knowledge to real-life situations) and sense of community (how students feel they belong in the classroom). We will compare this to group activities that are completed as normal.

Why are we asking you to be in this study?

You are being asked to be in this research study because you are an 8th grade physical science student at XXXX and your school has agreed to participate.

If you agree, what will happen?

If you are in this study you will receive normal classroom instruction. You may be asked to complete group activities as normal or you may be asked to complete group activities using Edmodo, an online educational program. You will be asked to complete a science pre-test (that will not count as a grade) and a survey about how you feel about your science class. Then, at the end of the study, you will be asked to take another science test (that will not count as a grade) and another survey about how you feel about your science class.

Do you have to be in this study?

No, you do not have to be in this study. If you want to be in this study, then tell the researcher. If you don't want to, it's OK to say no. The researcher will not be angry. You can say yes now and change your mind later. It's up to you.

Do you have any questions?

You can ask questions any time. You can ask now. You can ask later. You can talk to the researcher. If you do not understand something, please ask the researcher to explain it to you again.

Signing your name below means that you want to be in the study.

Signature of Child

Date

Signature of Witness

Date

Jillian Wendt, Doctoral Candidate
Dr. Amanda Rockinson-Szapkiw, Faculty Advisor, Liberty University
1971 University Blvd., Lynchburg, VA 24502
(434) 582-7423
Liberty University Institutional Review Board,
1971 University Blvd, Suite 1837, Lynchburg, VA 24502
or email at irb@liberty.edu.

APPENDIX I

Script for Administration of the MOSART Assessment (Harvard, 2011)

Please read from the following script exactly as the script appears:

Students, please listen to and follow the directions that I am about to provide to you exactly as they are described. You are about to begin completing an assessment on science literacy. Science literacy means how you understand science and scientific principles and how you can apply science to real-life situations. It also means how you might misconceive, or misunderstand, certain science principles. This is not a graded assessment. However, you are asked to answer all questions truthfully and to the best of your ability. Please do not skip any questions or leave any questions blank. You will complete this assessment on pencil and paper. Does everyone have a pencil and an assessment paper? **(Pause for student response)**. You will mark your answer choice by circling the letter that corresponds with your answer. Please make sure all marks can be easily read. When you are finished with your assessment, please turn your paper upside down and wait quietly. Do you have any questions? **(Pause for student response)**.
Now, let's begin.

APPENDIX J

Script for Administration of the Classroom Community Scale (Rovai, 2002a) Survey

Please read from the following script exactly as the script appears:

Students, please listen to and follow the directions that I am about to provide to you exactly as they are described. You are about to begin completing a survey on sense of community. Sense of community means how you feel about fitting into your classroom environment with your peers. The survey will also ask several questions about you and your family, such as your gender and your ethnicity or race. Please answer all questions truthfully. If you do not know the answer to a question, please skip the question. However, you are encouraged to answer each question if possible. Do you have any questions? **(Pause for student response)**. Now let's begin

APPENDIX K

MOSART TEACHER TRAINING

1. Visit <http://www.cfa.harvard.edu/smgphp/mosart/> and sign up for an account.



2. Once you have established an account, sign in. Then, click on the "Tutorials" tab.



If you have questions, please contact me by email or phone (804-938-2226). I will be happy to help you!



APPENDIX L

December 12, 2012

To Whom It May Concern:

This correspondence is to provide approval for Jillian Wendt to conduct her research analysis for her doctoral studies requirements with XXXXX School students at XXXXX Middle School.

If there are other questions and/or concerns, please contact me at XXX-XXX-XXXX or XXXXX@XXXX.org.

Sincerely,

Sharon B. Yates
Director of Secondary Education &
Career Technical Education

APPENDIX M

Jillian L. Wendt, Doctoral Candidate
Liberty University
Lynchburg, VA 24502
January 15, 2013

Dear Parents/Guardians:

I am writing to kindly request your assistance with completion of a research study for which your child may qualify at XXXXXX. As a doctoral candidate at Liberty University, I am completing the research study to fulfill the dissertation requirement. I am also a full-time Biology teacher at XXXX. I understand the importance of minimal disruption to learning as well as the importance of increasing science skills in the classroom.

The purpose of this study will be to examine the influence of online collaborative learning on middle school student science literacy and sense of community. Science literacy is generally considered the ability of an individual to apply science knowledge to current events while reducing misconceptions. With the growing advances in the scientific world, it is important for parents, teachers, and students to be able to use science knowledge learned in the classroom in appropriate ways in the real world. Sense of community is how students feel they fit in and are part of the classroom community. Understanding sense of community is important in ensuring students have a safe, comfortable, and successful experience in the classroom.

As part of this study, your child will be asked to complete a short pre-test and a short post-test that measures science literacy as part of the normal curriculum. Your child will also be asked to complete a short survey at the beginning and the end of the study that measures sense of community that is not part of the normal curriculum. Your child may be assigned to instructional groups that use computer-mediated tools to complete classroom activities. These computer-mediated tools will include the use of Edmodo, a free educational platform that will host worksheet and discussion-type activities, that will require your child to create a free Edmodo account. These activities will be equivalent to those that are part of the normal face-to-face instruction. There are minimal risks to participation in this study, which are not expected to exceed the risks encountered in normal day-to-day life. Confidentiality will be maintained by the classroom teacher and me as the researcher throughout the study. The length of the study is expected to be 9-weeks and all results will be shared with XXXXXX to benefit your student's educational experience.

I would be very appreciative of your willingness to allow your child to participate in this study. I am more than happy to answer any questions that you may have. If you choose to allow your child to participate, please complete and return the attached form to your child's classroom teacher as soon as possible. You may contact me, Jillian Wendt, at

jarnett@liberty.edu at any time prior to or throughout this study. Thank you for your consideration and assistance!

Sincerely,

Jillian L. Wendt, Doctoral Candidate
Liberty University

APPENDIX N



The Graduate School at Liberty University

January 14, 2013

Jillian L. Wendt
IRB Approval 1502.011413: The Effect of Online Collaborative Learning on Middle School Student Science Literacy and Sense of Community

Dear Jillian,

We are pleased to inform you that your above study has been approved by the Liberty IRB. This approval is extended to you for one year. If data collection proceeds past one year, or if you make changes in the methodology as it pertains to human subjects, you must submit an appropriate update form to the IRB. The forms for these cases were attached to your approval email.

Thank you for your cooperation with the IRB and we wish you well with your research project.

Sincerely,

Fernando Garzón, Psy.D.
Professor, IRB Chair
Counseling

(434) 592-4054



Liberty University | Training Champions for Christ since 1971

APPENDIX O

Re: MOSART testing instrument

Page 1 of 4

Re: MOSART testing instrument

Hal Coyle [hcoyle@cfa.harvard.edu]

Sent: Thursday, January 24, 2013 10:35 AM

To: Wendt, Jillian Leigh

Hello Jillian,

You are correct that the MOSART science content assessments--for all science areas and grade bands--are used to measure an aspect of science literacy. Specifically, because a MOSART multiple-choice item contains a choice that is linked to a misconception involving a science concept, test-takers who choose the correct answers in the presence of these strong distractor choices are more likely genuinely holding scientifically accurate ideas compared to test-takers who choose the strong distractor, i.e., the choice based on a misconception. A further aspect of test performance is that test-takers who choose the strong distractor are more likely to at least have been thinking about the scientific idea compared to test-takers who simply choose a random wrong answer, making the assessments useful as a diagnostic tool at the start of a course or professional development program when one does not know the background of the participants, whether students or teachers.

We also use the MOSART tests with science teachers to not only measure their subject matter knowledge, but we also ask teachers to predict the most common wrong answer that they think their own students will choose as a measure of a type of pedagogical content knowledge. We recently had a paper accepted by AERJ that discusses a full-year study carried out with MOSART-based tests of middle school physical science courses; we do not yet know when it will be published, but I will let you know when we find out.

Best,

Hal Coyle

On Jan 24, 2013, at 9:55 AM, Wendt, Jillian Leigh wrote:

Mr. Coyle,

I am continuing progress on my dissertation that involves use of the MOSART Physical Science assessment. I am in need of verification from you that the MOSART assessment measures misconceptions of science as an aspect of science literacy. Could you please verify that I am understanding the purpose of the MOSART correctly? I would be very grateful.

I hope all is well and appreciate your help,

Jillian Wendt

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From: Harold Coyle [hcoyle@cfa.harvard.edu]

Sent: Tuesday, August 21, 2012 11:44 AM

<https://by2prd0511.outlook.com/owa/?ae=Item&t=IPM.Note&id=RgAAAADpYXXL9j5J...> 1/24/2013