Spring 5-2017

A Comparative Study Teaching Chemistry Using the 5E Learning Cycle and Traditional Teaching with a Large English Language Learner Population in a Middle School Setting

Cynthia Nicole McWright
University of Southern Mississippi

A COMPARATIVE STUDY TEACHING CHEMISTRY USING THE 5E LEARNING CYCLE AND TRADITIONAL TEACHING WITH A LARGE ENGLISH LANGUAGE POPULATION IN A MIDDLE-SCHOOL SETTING

by

Cynthia Nicole Pendleton McWright

A Dissertation
Submitted to the Graduate School
and the Center for Science and Mathematics Education
at The University of Southern Mississippi
in Partial Fulfillment of the Requirements
for the Degree of Doctor of Philosophy

Approved:

____

Dr. Sherry S. Herron, Committee Chair
Associate Professor, Science and Mathematics Education

____

Dr. Deborah Booth, Committee Member
Instructor, Chemistry and Biochemistry

____

Dr. Douglas Masterson, Committee Member
Associate Professor, Chemistry and Biochemistry

____

Dr. Kyna Shelley, Committee Member
Professor, Educational Research and Administration

____

Dr. Sarah E. Morgan, Committee Member
Professor, Polymers and High Performance Materials

____

Dr. Sherry S. Herron
Director, Center for Science and Mathematics Education

____

Dr. Karen S. Coats
Dean of the Graduate School

May 2017

Published by the Graduate School

THE UNIVERSITY OF SOUTHERN MISSISSIPPI

ABSTRACT

A COMPARATIVE STUDY TEACHING CHEMISTRY USING THE 5E LEARNING CYCLE AND TRADITIONAL TEACHING WITH A LARGE ENGLISH LANGUAGE POPULATION IN A MIDDLE-SCHOOL SETTING

by Cynthia Nicole Pendleton McWright

May 2017

For decades science educators and educational institutions have been concerned with the status of science content being taught in K-12 schools and the delivery of the content. Thus, educational reformers in the United States continue to strive to solve the problem on how to best teach science for optimal success in learning. The constructivist movement has been at the forefront of this effort. With mandatory testing nationwide and an increase in science, technology, engineering, and mathematics (STEM) jobs with little workforce to fulfill these needs, the question of what to teach and how to teach science remains a concern among educators and all stakeholders. The purpose of this research was to determine if students' chemistry knowledge and interest can be increased by using the 5E learning cycle in a middle school with a high population of English language learners. The participants were eighth-grade middle school students in a large metropolitan area. Students participated in a month-long chemistry unit. The study was a quantitative, quasi-experimental design with a control group using a traditional lecture-style teaching strategy and an experimental group using the 5E learning cycle. Students completed a pre-and post-student attitude in science surveys, a pretest/posttest for each mini-unit taught and completed daily exit tickets using the Expert Science Teaching

Educational Evaluation Model (ESTEEM) instrument to measure daily student outcomes in main idea, student inquiry, and relevancy.

Analysis of the data showed that there was no statistical difference between the two groups overall, and all students experienced a gain in content knowledge overall. All students demonstrated a statistically significant difference in their interest in science class, activities in science class, and outside of school. Data also showed that scores in writing the main idea and writing inquiry questions about the content increased over time.

ACKNOWLEDGMENTS

I have many people to thank for seeing me through this incredible and at times stressful process. I would like to begin by thanking my committee members: Dr. Sherry Herron, who guided me throughout the years of this process and stood by me during my most difficult times; Dr. Sarah Morgan, who peaked my interest to begin this journey by allowing me to be part of the Research Experience for Teachers (RET) program for several years; Drs. Douglas Masterson and Robert Lochhead, who gave me the opportunity to conduct research in their labs; Dr. Kyna Shelley, for teaching me about the dissertation process and gave my dissertation process the jumpstart it needed; and Dr. Deborah Booth, who helped strengthen my chemistry knowledge base.

I would also like to thank my student participants and school and school district personnel for allowing me to conduct this research.

Also, a thank you to Dr. Vicki Tomlin for just being available all times of the day and night to answer my questions about the dissertation process and problem-solving. A special thank you to a host of friends and acquaintances who supported and helped me throughout this journey.

Lastly, and certainly not least, I would like to thank my mom, Grace Pendleton, who always encouraged me to do my best, and my husband Anthony for being supportive. Now we can enjoy home-cooked meals again.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

LIST OF ABBREVIATIONS

ACCESS	Assessing Comprehension and Communication in English State State
ANOVA	Analysis of Variance
BSCS	Biological Sciences Curriculum Study
CCSS	Common Core State Standards
CREATE	Center for Research on Educational Accountability and Teacher Evaluation
ELL	English Language Learners
ESTEEM	Expert Science Teaching Educational Evaluation Model
MAP	Measures of Academic Progress
NAEP	National Assessment of Educational Progress
NCLB	No Child Left Behind
NGSS	Next Generation Science Standards
NRC	National Research Council
RTTT	Race to the Top
SCIS	Science Curriculum Improvement Study
SPSS	Statistical Package for the Social Sciences
STEM	Science Technology Engineering and Mathematics
WIDA	World Class Instructional Design and Assessment
ZPD	Zone of Proximal Development

CHAPTER I – INTRODUCTION

The creation of the Next Generation Science Standards (NGSS) and implementation of Common Core education have been in the spotlight as ways to improve K-12 education. Many goals set forth in these initiatives do not necessarily explain what to teach but, more importantly, how to teach. The purpose of NGSS is to better prepare students for the workforce and college by developing critical-thinking skills and scientific literacy and building interest in science, technology, engineering, and mathematics—also known as STEM.

Common Core standards, while not specifically designed for science, emphasize the importance of reading and writing in all subject areas including science. How to teach science and what to teach have been a discussion and research topic as far back as Comenius.

According to Woellert (2012), the United States Department of Labor estimated between 2 and 3 million jobs are not filled because of deficient skills in the STEM area. Most individuals with a bachelor's degree in STEM have higher incomes than individuals with a Doctor of Philosophy (Ph.D.) degree and/or a master's degree in non-STEM fields. Despite the fact that millions of Americans are unemployed, it is estimated that 600,000 jobs in manufacturing cannot be filled due to the lack of STEM-related skills (Engler, 2012). As the demand for STEM jobs is increasing, the number of students entering STEM fields, especially nonwhites and gifted students, is not increasing. Not only is the number of students entering STEM fields majoring in STEM fields in college low, the number of students taking science classes, such as physics and chemistry, is extremely low for many states. Many skills required for STEM jobs and other low-income jobs can be developed in inquiry science classrooms such as chemistry (Bybee, 2013), which tends to be a difficult subject for students to learn because it is abstract in nature. Current research in science education focuses on scientific inquiry, such as the 5E learning cycle.

Problem Statement

Since passage of the No Child Left Behind (NCLB) legislation in 2001, there has been a continuous effort to restructure how students are taught, particularly in the sciences. Since the 1957 launch of Sputnik, a Russian satellite (Cavanagh, 2007), the United States (U.S.) has been eager to remain viable in producing scientists. To meet this goal, the federal government encouraged the development of new science curricula; to meet this challenge such curricula as Chemical Education Materials Study (Chem Study) and the Biological Sciences Curriculum Study (BSCS) were developed. One commonality each of these programs focused on was the learning process and how students learn. The learning cycle has shown to be effective in teaching over the course of decades (Bybee et al., 2006). In the 1980s, the 5E learning cycle was developed by modifying the Science Curriculum Improvement Study (SCIS) learning cycle (Bybee et al., 2006).

It should be noted, however, that the 5E learning cycle teaching model is more commonly found in materials produced by the BSCS. Although the model has been deemed successful, it has not been as widely researched as the previous learning cycles (Bybee et al., 2006). According to the National Research Council's (2006) report, America's Lab Report, the 5E learning model (a) has been shown to increase mastery of subject matter, (b) is linked to increasing attitudes and interest towards science, and (c) helps in increasing scientific reasoning. However, there is limited and inadequate evidence using the 5E learning cycle regarding understanding the nature of science and developing students' skills in science or teamwork. Furthermore, literature is lacking in research conducted with high school chemistry students, the achievement gap, and the use of the 5E learning cycle in low-performing schools.

Purpose Statement and Research Questions

The purpose of this research was to determine if middle-school students' chemistry knowledge and interest can be increased by using the 5E learning cycle. This research will explore the following:

1. Compare the change in pre- and post-physical and chemical changes knowledge scores of students learning with the 5E learning cycle and students learning with the lecture teaching strategy.
2. Compare the change in pre- and post-phase changes knowledge scores of students learning with the 5E learning cycle and students learning with the lecture teaching strategy.
3. Compare the change in pre- and post-elements, compounds, and mixtures knowledge scores of students learning with the 5E learning cycle and students learning with the lecture-teaching strategy.
4. Determine if there is a difference in students' attitudes about science when using the 5E learning cycle compared to the lecture teaching strategy.
5. Compare the change in whether the students captured the main idea as it was presented during the lesson with the 5E learning cycle and students learning with the lecture teaching strategy.

6. Compare the change in the relationship of the students' question(s) to the lesson with the 5E learning cycle and students learning with the lecture teaching strategy.
7. Compare the change in whether the students could make the class material relevant to their respective lives about the main idea with the 5E learning cycle and students learning with the lecture teaching strategy.

Theoretical Framework

According to De Houwer, Barnes-Holmes, and Moors (2013), *learning* is defined as "changes in behavior that result from experience or mechanistically as changes in the organism that result from experience" (p. 631). Learning theories are divided into three main parts: cognitive constructivist, behaviorist, and social constructivist. This study is grounded in the constructivist learning theory as well as Krashen's theory of second-language acquisition.

Constructivism is a model of learning which focuses on students constructing knowledge based on prior knowledge and /or experiences. In a constructivist setting, learning is student-centered. The teacher acts as a facilitator for the learning process. A few early constructivist theorists are Jean Piaget, Jerome Bruner, John Dewey, and Lev Vygotsky. The theorists focused on for this research were Jean Piaget, Lev Vygotsky, and John D. Bransford. The common thread among these theorists is how students learn.

Justification

If this study shows that by embedding the 5E learning cycle in chemistry topics will increase students' knowledge of chemistry and improve their attitudes toward chemistry, this study might be used to provide guidance to high school and middle-school chemistry teachers regarding a more effective way to teach chemistry topics. Students might develop an increased interest in chemistry. The STEM fields could benefit from an increase of minority students in chemistry-related fields. Schools may benefit with an increase in test scores in content areas. The information may also be helpful to school districts by guiding district personnel on the development of professional development workshops to focus on how to teach chemistry in high school and middle school science. Furthermore, chemistry professors at the college level might see a benefit by an increase in student retention in college introductory chemistry classes. Professors would not have to use the methods but benefit because students who have gained a stronger foundation in high school chemistry tend to perform better and stay the course in college chemistry.

CHAPTER II – REVIEW OF THE LITERATURE

This chapter is divided into three main sections. The first section will give an overview of educational reform influencing science education to include NCLB, NGSS, Common Core State Standards (CCSS), National Science Education Standards (NSES), and Race to the Top (RTTT). The second section will include a brief overview of the development of the learning cycle and highlight the 5E learning model. The third section will focus on constructivist learning—the theoretical framework used for this research project. This section will also provide an overview of prior research using constructivist learning as a theoretical framework model as well as a brief overview on how students learn science.

Since the launching of Sputnik by the Russians in 1957 (Cavanagh, 2007), science education has gone through a myriad of educational and curriculum reform. The launching of Sputnik caused great concern from scientists and politicians to change science and mathematics education. The launching of Sputnik even today sparks interest in educational reform because of the fear that we as a country are not preparing students for a technical workforce and students are just memorizing facts and not learning to apply science to real-life applications (Bybee & DeBoer, 1994). Similar to today, the federal government through the National Science Foundation (NSF) felt compelled to act upon this lack of preparedness by initiating curriculum reform. Sputnik-era science curriculum reform was primarily focused on the secondary level; whereas, beginning in the 1990s up until recently, the focus has been on all levels K-12 (Bybee, 1995). Science curriculum reform between the 1960s and 1990s was more of a trickle-down effect. Since the late 1800s until recently, how science should be taught in secondary schools has been of great concern. Should it be taught as a noun only to include raw facts and memorization or taught as a verb where students are active participants in the learning process?

Theoretical Framework

Constructivism is a theory based on how people learn. Constructivism is defined as a learning theory based on students constructing their own learning from prior knowledge and past experiences. It should be an active process *(*Brandon & All, 2010*)*. According to Colburn (2000), the word *constructivism* can have two meanings. Theory is not only explaining how people learn, but it can also be viewed as a variety of teaching strategies.

There are two types of constructivist learning—cognitive and social constructivism. In order to have an effective constructivist classroom, teachers should have an understanding of both cognitive and social constructivism (Powell & Kalina, 2009). Although both are different, the end result is the same. Students will construct meaning from personal knowledge.

Jean Piaget is considered the father of cognitive constructivism. The premise of cognitive constructivism is that students learn from constructing their own knowledge. Piaget believed that there are four stages of development: sensorimotor, preoperational, concrete operational, and formal operation. Piaget believed that a child's learning is based on assimilation and accommodation as a child progresses through the four stages (Powell & Kalina, 2009).

Piaget's four stages are dependent upon the age of a child. The sensorimotor stage is from birth to the age of 2 years. During this period a child discovers their surroundings through their senses. From the age of 2 years to 7 years even a child is in the preoperational stage. During this period, children are developing language skills but cannot synthesize others' thoughts. Concrete operational is the stage between 7 years and 11 years. During this time children begin to develop logical reasoning. The final phase of development is the formal operational stage between 11 years and adulthood. This is a period of time in which an individual can think critically and abstractly (Powell & Kalina, 2009). Piaget's developmental stages have been criticized because they were developed from his children. Still, his theory is acknowledged true to this day and is highly respected among numerous theorists.

Social constructivism is the second type of constructivist learning. It followed cognitive constructivism. Lev Vygotsky is the pioneer of social constructivism. This theory is based on students interacting and collaborating with each other. A classroom that models Vygotsky's theories is high in social interactions which allow students to develop language skills as well as content knowledge. The zone of proximal development (ZPD), a main theory of Vygotsky, controls how a child learns. This is the easiest time for a child to learn because the child is learning with assistance from a peer or adult (Powell & Kalina, 2009). During the ZPD phase, a student has undeveloped knowledge. This is a zone where students do not know the material but can learn the material with guidance from an individual who knows more about the content. As students are guided through this phase, their undeveloped knowledge decreases, and their developed knowledge or skills increases (Rolloff, 2010). In order for students to be successful during the ZPD time period, teachers should uncover the skills students do not know or understand in order for them to ascertain new content information. To demonstrate this in a classroom setting, a teacher would use scaffolding and cooperative learning. Since socializing among students is important for learning to take place, it is also critical for the teacher to embrace the diversity of his or her class and the many different backgrounds of the various students in order to foster the social aspect of learning the content.

Although these theories are different, both agree that the classroom should not be teacher-centered but rather student-centered. The teacher should be a facilitator of learning and guide students to discover new knowledge for them based on their prior knowledge and experiences.

According to Colburn (2000), a teacher should make the classroom a constructivist classroom by providing students with lab activities before giving all of the information needed for a particular content area and have pre-lab discussions before implementing a lecture on the topic. Next, teachers should have students develop their own data tables for lab activities. Tests or assessments should include more application type questions. Lastly, teachers should use questioning techniques that require students to think critically and explain their reasoning.

John D. Bransford is another notable cognitive constructivist theorist. Bransford's primary focal point is that learning takes place based on a student's prior knowledge. Teachers must engage students in their misconceptions in order for them to dispel them and understand concepts correctly. If not, students just memorize information for a test and revert back to their preconceived notions that are incorrect. Based on this strong belief, Bransford established the concept of anchored instruction. Anchored instruction is the technique of framing a learning activity or lesson around a particular problem, story, or some type of adventure. This is often done by using some type of video presentation (Bransford, Brown, & Cocking, 2000). Another very important contribution to learning was development of the how people learn framework, which is composed of four lenses vital to a classroom. The four lenses are knowledge-centered, learner-centered, assessment centered, and community environment (Bransford et al., 2000).

In a classroom driven by the constructivist learning theory, the teacher behaves as a facilitator of learning. The teacher provides structure and guidance for learning. If students are distressed about not knowing the correct answer to a question, the teacher does not immediately rescue them with the answer. The teacher will provide guiding questions to help probe students to an answer. The teacher provides some type of learning experience to build students' prior knowledge or activate previous knowledge. This process is valuable in order for students to attain optimal levels for learning new information and making essential connections to learning new content or dispelling misconceptions. The teacher is not just a deliverer of notes, and the students are not just passive listeners to lectures and completing worksheets. Students are actively engaged in the learning process. Students are not just memorizing random facts about content that may or may not connect with the essential question(s) for the unit. Students make essential connections to further their learning and understanding of the content.

There is opposition to the constructivist learning model when it comes to pure discovery learning. Mayer (2004) conducted a meta-analysis of the literature from the 1960s to the 1980s to determine which is better: guided inquiry or pure discovery learning. Both models are considered forms of constructivist learning. Based on Mayer's findings, educational leaders are extremely supportive of discovery learning because constructivist theorists, such as Piaget and Bruner, say that students need to construct their own learning based on prior knowledge and experience. According to Mayer (2004), there is no empirical evidence to support such claims that students learn best through classrooms taught with a pure discovery learning approach or philosophy.

Mayer's (2004) research concluded that based on analyses of all studies comparing the two learning modes, students learn best in a classroom taught using guided inquiry. Findings suggest that pure discovery learning leaves too much for interpretation by students during the learning process that the intended learning outcomes are not meant and sometimes completely misunderstood or missed altogether.

An example in which programming concepts were studied, students who were taught using guided inquiry outperformed their counterparts taught with a pure discovery approach. The students who learned programming using the guided inquiry method were given worksheets that guided them through various tasks in computing. These students performed better with debugging and problem solving with the programs that generated better computer programs. They were also better able to apply their new knowledge. Students were also provided feedback from instruction and were given clues to the correct answers as well as being told whether or not their answers were correct or incorrect. These procedures are more likely to be seen in a teacher-centered classroom which is atypical of a constructivist classroom. This is not indicative of a pure discovery classroom. Mayer (2004) strongly suggested that teachers reevaluate how the constructivist learning theory is viewed and not dismiss the theory completely. Overall, Mayer (2004) suggested students learn best with assistance from a teacher and that guidance is necessary for the intended learning to take place. It is also believed that constructivism is limited in some chemistry topics, such as electromagnetic radiation and atomic structure, due to students' lack of prior knowledge and experiences with these abstract topics (Khan, 2013). In Chall's (2000) review of empirical research, a student-centered classroom is not productive for students of low socioeconomic backgrounds. Chall's review of the literature revealed that students performed higher academically when led by a teacher and when group learning was involved.

Matthews (2003) is perplexed by the idea that reliable research has been conducted and concluded that a teacher-centered classroom is more conducive to learning; yet, educational institutions have all but ignored the data. Moreover, American students continue to lag behind in mathematics and science when compared to other industrialized countries.

History of the 5E Instructional Model

The current 5E instructional model is grounded in the work and ideas from Johann Friedrich Herbart, John Dewey, J. Myron Atkin, and Robert Karplus (Bybee et al., 2006). Herbart's work dates back to the beginning of the 20th century. There are two main components to Herbart's philosophy of teaching: interest and conceptual understanding. Herbart's philosophy was one of the first approaches to teaching that resembles a learning cycle. During his instructional cycle, students would first discover and make connections to prior experiences. Secondly, the teacher would guide them through experiences to further make connections. Next, the teacher would conduct a lesson in a style similar to a lecture to explain the information to the students. Lastly, the students would have to take what they had learned and apply their new knowledge to a new experience. More importantly, Herbart suggested that if a child could discover his or her learning, then the student would have more understanding and knowledge of the subject matter at hand.

John Dewey was from the school of thought that learning should not only be hands-on but also minds-on. Students would experience science through a process similar to the scientific method. After students define a problem to solve, they would make an hypothesis, make observations, evaluate the observations for feasibility, and finally, run a test. Students would follow this process and reflect on their experience.

The final learning cycle to preclude the 5E instructional model was the SCIS developed by Robert Karplus and J. Myron Atkins during the late 1950s through the early 1960s. This time period was a heightened time for educational reform, especially in science (Bybee et al., 2006). Karplus was a theoretical physicist, but he applied Jean Piaget's philosophy of learning to science instruction. Atkins shared Karplus' ideas of teaching but applied his ideas about instructing science to elementary age students. The two collaborated and developed the Atkin-Karplus Learning Cycle. The learning cycle was composed of three phases: exploration, invention, and discovery. Unlike today's 5E model, the exploration stage was an unstructured learning experience.

The 5E instructional model was developed by the BSCS in the 1980s. The model has five components to learning in the following order: engagement, exploration, explanation, elaboration, and evaluation. These stages are defined as follows:

1. During the *engagement* stage, the teacher activates students' prior knowledge.
2. During the *explore* stage, students are involved in activities to explore the topic
3. *Explain* is the opportunity for the teacher to introduce the content to students.

4. During the *elaboration* phase, students make connections between prior knowledge and new experiences.
5. Finally, during the *evaluation* phase, teachers evaluate students to see if they have achieved the instructional objectives.

According to Duran, Duran, Haney, and Scheurmann (2011), this instructional model is helpful in student learning although they suggested the inclusion of more students who understand the process and are able to benefit more deeply from the earlier phases of the model. According to Eisenkraft (2003), our knowledge on how people learn has changed. He suggested, based on specific suggestions presented by Duran et al. (2011), this should be reflected in lesson plans and curriculum. Eisenkraft suggested an expansion of the 5E model to a 7E model. The new model would include the following steps: elicit, engage, explore, explain, elaborate, evaluate, and extend (Eisenkraft, 2003).

Several studies have proposed that the 5E learning model is the best method of instruction for increasing scientific understanding as opposed to a more traditional style of teaching. Wilson, Taylor, Kowalski, and Carlson (2010) supported the 5E learning cycle as more effective than commonplace teaching methods and concluded that inquiry-based learning was most effective across many individual variables including race, gender, and socioeconomic status.

The 5E learning cycle has also been recommended to help alleviate student misconceptions. Tuna's (2013) work confirmed that this may be the case and concluded that other studies should be conducted to determine if the 5E model will have an effect on critical-thinking skills and the ability for students to be more creative. Secondly, Tuna (2013) suggested that the learning strategy should be used in all math textbooks. This is an important statement due to NGSS's focus on building student critical-thinking skills and inquiry problem-solving skills.

Two other constructivist learning strategies that have been deemed effective in student learning are cooperative groups and problem-based learning. The problem-based learning study conducted by Wong and Day (2009) follows a constructivist learning theory based on John Dewey and Gagne. In a study conducted by Apedoe, Ellefson, and Schunn (2012) where project-based learning was studied, a major concern about group size was raised. The study also raised the concern as to how the abilities of the students and whether or not the students have prior knowledge of content play a factor and not necessarily group size. According to Wong and Day (2009), students saw the relevance and were able to construct their own learning as the teacher behaved as a facilitator of learning. Wong and Day (2009) concluded that problem-based learning is just as effective as lecture-based learning at the knowledge level of Bloom's taxonomy.

Beskeni, Yousuf, Awang, and Ranjha (2011) stated that prior knowledge of students has an incredible amount of impact or potential on content taught and learned in chemistry. It is suggested that the amount of prior knowledge students bring with them could affect their chemistry understanding. It is recommended that teachers should adopt a constructivist learning style to help access and develop students' prior knowledge in chemistry. However, in a study by Chen, Wong, and Wang (2014) with eighth graders learning chemical formulas, background knowledge was a factor. Students in groups with higher background knowledge showed more motivation than their counterpart in the group with lower background knowledge of chemistry. This finding is important because students in science sometimes have low attitudes in learning the content.

In determining which teaching method is most effective, Patrick (2013) compared lecturing, concept mapping, cooperative learning, or the 5E learning cycle using high school biology classes. Although each of these strategies had been studied individually, they had not been studied to address a particular subject area. According to Patrick (2013), all teaching strategies had an effect on student achievement but at varying degrees. An instructional method with more student interaction leads to higher student achievement. Students taught using the 5E learning cycle and cooperative learning demonstrated more achievement and retention over the long-term. However, Patrick found no significant difference between students taught with the 5E learning cycle and cooperative learning. More importantly, Patrick (2013) does stress the need for training of students and teachers before using either instructional strategy.

English language learners' (ELLs) teaching strategies follow the constructivist construct. They have been used effectively to teach students whose second language is English (Beltran, Sarmiento, & Mora-Flores, 2013). Just like the 5E learning cycle, ELL strategies promote student engagement in the classroom. However, the teacher is more involved in developing students learning by using techniques such as modeling. With ELL strategies, when applied to English as a second language, the student must be explicit and incorporated into the learning objectives daily. For example, students should speak, read, write, and listen daily. The primary goal for using ELL strategies is for students to acquire academic language, which is also true for all chemistry students. Another commonality between the 5E learning cycle and ELL strategies is activating students' prior knowledge.

The question becomes if research consistently shows the constructivist approach effective in student learning, why it is not used more frequently? Wong and Day's (2009) study was prompted by the disbelief of some teachers, administrators, and parents alike of a different teaching methodology other than lecture-based. The primary reason is due to the abundance of high-stakes testing and entrance exams to colleges and universities. The study made the link between the instructional method and the long-term gains of knowledge retained by students.

Boddy, Watson, and Aubusson (2003) made the point that constructivist methods are not implemented because they are seen as difficult to use by classroom teachers although research suggests constructivist methods are effective in student learning. Teachers also reported that the method is time-consuming in an already full curriculum. Boddy et al. (2003) also concluded that using the 5E learning cycle enabled teachers to motivate students to learn and helped to develop higher level thinking for the students. The students thought the technique created interesting and fun lessons. It was determined from interviews that some students could remember information from the lesson, but they could not use any of the terminology even after being prompted to do so. On the contrary, some students were able to remember content facts and use the vocabulary taught as well as understand the concept work.

Cam and Geban (2011) raised the point of teacher effectiveness. It was recommended that teachers should be trained before implementing new instructional strategies. Lack of training through professional development could be a reason why teachers are not willing to implement new teaching techniques. Akerson et al. (2009) concluded that professional development did influence teachers' views on nature of science, scientific inquiry, and the learning cycle. It was recommended that teachers have a constant support system in place for learning new teaching strategies.

Consistently, the 5E learning model and constructivist learning methods have been shown to be effective in student learning and developing critical thinking skills. The model has been used extensively in various science curricula and other areas. However, student achievement in science remains low, student attitudes are not positive when it comes to the physical sciences, and very few students enter the physical sciences as a career.

Educational Reforms

The Elementary and Secondary Education Act, or otherwise known as Title I, was written by President Lyndon B. Johnson's administration in 1965. This law created a federal footprint in K-12 public education. The main objective of the law was to ensure that school districts could help disadvantaged children with equity in public schools monetarily. The law was primarily written as a civil rights law for education in order to make sure students from minority backgrounds and poverty were given a quality and equal education. The legislation has only been reauthorized less than six times since its inception.

In 2002, the No Child Left Behind Act was signed into law by President George W. Bush. NCLB was an educational policy created by the President's administration and supported by both political parties in order to obtain 100% proficiency by all school-age children in reading and mathematics by the school year 2013-2014. Under this policy states were mandated to test students in Grades 3, 5, and 8 and at least once in high school. Once schools were deemed as failing, the state would have the option of closing the school, allowing students to choose a high-performing school, or allowing the state to take on the day-to-day-operations until the school obtained a satisfactory level of performance determined by the state department of education. The education bill for the first time held schools and school districts accountable for sub-populations, such as students with individualized educational plans and students from various minority groups, such as black, Hispanic, and Native American. Data also had to be segregated by gender and socioeconomic background (free and reduced lunch) as determined by federal guidelines. Also, for the first time, school districts were required to send home a school report card each year detailing or grading the school on these NCLB categories. In order to ensure all students could achieve the goals, at least 95% of teachers in a school were supposed to be highly qualified. Because data were synthesized based on NCLB standards, schools were rated as passing or failing or even approaching.

NCLB was not without flaws. The legislation led to more control by the federal government. Students rarely, if ever, moved from a failing school to a more successful school. For some reason, low-performing students did not take advantage of free tutoring programs offered to assist with their deficiencies. The law was never fully funded. Lastly, many critics thought reading and mathematics were emphasized too much; therefore, schools ignored non-testing subjects.

In 2009, President Obama signed an economic stimulus bill—the American Recovery and Reinvestment Act. Included in the bill was a section to invest in K-12 education called Race to the Top (RTTT). These monies were delegated or allotted based on an application grant process from states and school districts from across the nation.

The purpose was to reward states and districts for being innovative trailblazers in educational reform. The bill had four main components:

1. Adopting standards and assessments that prepare students to succeed in college and the workplace and to compete in the global economy
2. Building data systems that measure student growth and success and that inform teachers and principals about how they can improve instruction
3. Recruiting, developing, rewarding, and retaining effective teachers and principals, especially where they are needed most;
4. Turning around the lowest-achieving schools.

RTTT was not intended to replace or abolish NCLB (Tenam-Zemach & Flynn, 2011). High-stakes testing would still be in play; however, students would be assessed on content learned for the entire year instead of testing to determine if students met certain benchmarks. The assessment would also determine if students are college and career ready, which were not components of NCLB.

After 3 years of implementing programs supported by the RTTT, legislation states have encountered problems. According to Weiss-Weiss (2013), states made promises that were not realistic The policy focused too much on developing teacher evaluations but did not provide a clear link on how to use the data collected to improve teacher instruction to enhance student achievement. Finally, districts discovered that they did not have enough time to implement their ideas and, therefore, would be lacking resources as time was soon to expire with the grant.

The National Research Council has played a significant role in shaping education in the U.S. (National Research Council, 2006). The National Research Council is a nonprofit private sector founded in 1916 to assist the National Academies of Science, Engineering and Medicine with research to shape policies among the various science and engineering fields as well as inform the public. This organization played a major role in the development of the National Science Education Standards and A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas. This section will introduce five major reforms in education.

The National Science Education Standards were established in 1996 after 4 years of work and $7 million in expenses (Yager, 2000). The standards consisted of four goals for students to obtain:

1. Experience the richness and excitement of knowing about and understanding the natural world;
2. Use appropriate scientific process and principles in making personal decisions;
3. Engage intelligently in public discourse and debate about matters of scientific and technological concern; and
4. Increase their economic productivity through the use of knowledge, understanding, and skills or the scientifically literate person in their careers. (Yager, 2000, p. 52)

As a result of these standards, classroom teachers were expected to change their teaching methods and/or styles. According to Yager (2000), teachers were more accepting of changing their teaching methods than the organization of learning called for in the science standards. Scientific inquiry in all science classrooms was a major tenant as a result of these standards. In light of these new standards, science was to be taught based on real-life experiences students could relate to unlike the previous science reforms from the 1960s. Another aspect of these standards was to incorporate technology into the science classroom. Technology had been eliminated from the science curricula the previous 40 years (Yager, 2000). The standards were written based on research completed by the National Research Council's book, *How People Learn: Bridging Research and Practice* (1999). The mission was to introduce classroom instruction to produce students who would be proficient at problem-solving and critical thinking and able to make scientific explanations. According to this book, if science educators taught based on its principles, all students should become "scientifically literate" (Yager, 2000, p. 54).

In 2013, the National Science Education Standards were replaced with the Next Generation Science Standards (NGSS) which were developed from National Research Council's (2012) *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* and finalized in 2011. The goal of the new science framework was started for Grades K-12 to improve science education instruction by limiting the number of core disciplinary ideas taught. Students would build this knowledge over subsequent years. Based on the committee recommendations, science was divided into three major areas: science and engineering practices, crosscutting concepts, and the four main disciplinary core ideas (i.e., physical science, life science, earth and space science, and technology and engineering). Once again, the National Research Council produced a framework that included making science instruction relevant to students' lives as an overarching theme. Another major goal of the framework was to ensure that by the end of a student's senior year in high school he or she would have an appreciation for science content as well as be able to experience science like a scientist. Unlike the previous science framework, technology and engineering concepts were highly emphasized. Due to this lack of skills, schools in the U.S. were failing to meet these goals in science education (National Research Council, 2012).

According to the new K-12 Science Framework, science content from Grades K-12 covers too much information in too much detail (National Research Council, 2012). Students were learning too many facts instead of experiencing science in a practical way. The current science framework addresses these concerns by implementing science in Grades K-12 and consists of three dimensions. All three dimensions of the new framework are expected to be implemented into every step of the learning cycle from writing new state and/or district standards to classroom instruction and incorporated into the final assessment. The three dimensions are as follows:

1. Scientific and engineering practices,
2. Crosscutting concepts that unify the study of science and engineering through their common application across fields, and
3. Core ideas in four disciplinary areas: physical sciences; life sciences; earth and space sciences; and engineering, technology, and applications of science. (National Research Council, 2012, p. 2)

The NGSS are seen as necessary because students in the U.S. are lagging in science performance when compared globally with other industrialized countries. According to the National Research Council (2012), the U.S. was ranked 17th in the world in science and 25th in mathematics based on the Programme for International Student Assessment given in 2009. Over one-third of American eighth-graders performed below the basic level on the National Assessment of Educational Progress science assessment given in 2009. It is the belief of the National Research Council (2012) that states working together to implement the NGSS will help eliminate poor performance in science and lead to students being college and career ready.

Another educational initiative developed to help prepare students for college and the workforce was the CCSS. The CCSS came about in 2010. The standards development was led by 48 state governors and the heads of their respective educational departments. They were joined by teacher experts from both content fields of English and mathematics. According to Shanahan (2015), 42% of students graduating from high school in 2012 were required to enroll in remedial reading, writing, mathematics, or all three. The purpose was to have clear and consistent standards for all students regardless of the state they resided. Once again, stakeholders were concerned about students graduating from schools in the U.S. being competitive for jobs here and in other countries. These standards were written for English Language Arts and mathematics. The standards were written for these two core areas because they are the only core classes that are vital to learning in the other subject areas, such as science and social studies. The standards are written for Grades K-12. These standards have been willingly accepted by 43 states as of 2016. The District of Columbia adopted the standards as well. The standards were not written to be a curriculum for all teachers to follow. According to the CCSS, teachers and other school officials will determine instructional strategies for the classroom based on students' needs.

As a result of these standards being developed, a new assessment was also developed. The Partnership for Assessment of Readiness for College and Careers is given to all students in Grades 3-11 in English, Language Arts, and mathematics to assess their progress toward high school readiness and college and career readiness. Although science is not tested, students are expected to be able to apply English Language Arts skills in science content. The standards are divided into three levels: Grade 6-9, Grade 9-10, and Grade 11-12. Some examples of expectations included citing and using evidence from text and analyzing data from science experiments. Although the federal government did not participate in the development of the CCSS, it has invested resources to encourage states to adopt the standards (Porter, McMaken, Hwang, & Yang, 2011).

English Language Learners

Currently, schools and school districts across the U.S. are experiencing an increase in the number of English Language Learners (ELL) students in all grade levels (Wagner & King, 2012). These students are linguistically and culturally diverse. This population growth is not isolated to large metropolitan areas. Rural and suburban areas are also experiencing this growth at unprecedented levels (Hamayan & Freeman, 2012). Hamayan and Freeman (2012) suggested that U.S. schools are at a tipping point with educating ELL students for the following reasons.

1. The U.S. ELL population has increased by 51% in the past 10 years compared to only 7.5% of the general population of schools.
2. Over half of the states' ELL population has increased more than 100%.
3. ELL students are not taught in isolation but are in the regular classes where teachers lack training to teach ELL students.
4. Federal legislation, such as NCLB, required all schools to test all populations of students and hold the schools accountable for their success.

5. States' accountability systems are showing that ELL students are scoring below proficiency levels on state-mandated tests.
6. Budget cuts make meeting the needs of ELL challenging.
7. Lastly, there tends to be confusion at all governmental levels as to what effective instruction looks like for ELL students.

ELL students across the country speak more than 400 different languages (Beltran et al, 2013). According to Beltran et al. (2013) in 2005 ELLs in the U.S. were "70 Hispanic, 13% Asian/Pacific Islander, 12% non-Hispanic white, and 4% non-Hispanic black" (p. 19). In addition, over one-third of ELL students live in poverty (Beltran et al., 2013).

Stephen Krashen's theory on educating ELL students is considered to be the most prominent one to date. Krashen's theory—developed in the 1980s—focuses primarily on the acquisition of a second language. Krashen's (1981) theory for acquiring a second language has five hypotheses:

1. "The Acquisition-Learning hypothesis states how the learner picks up the language" (p. 51).
2. "The Monitor hypothesis states that students acquire (not learn) grammatical structures in a predictable order" (p. 56).
3. "The Natural Order hypothesis states the relationship between acquisition and learning" (p. 57).
4. "The Input hypothesis states we acquire (not learn) language by understanding input that contains structures that are just beyond our current level of competence (1 + 1)" (p. 61).

5. “The Affective Filter hypothesis deals with role of *affect* that is the effect of personality, motivation, and other *affective variables*” (p. 61).

Hamayan and Freeman (2012) stated that in order for ELL students to catch up they must improve by gaining 15 months of knowledge within a typical school year to catch up. The average non-ELL student gains about 10 months during the same timeframe. Hence, the biggest challenge is that ELL students are chasing a moving target which makes catching up and becoming proficient at grade level a challenge. There is *no one size fits all* instructional program to educating ELL students. Hamayan and Freeman (2012) suggested educators should focus on other strategies and not just academics.

CHAPTER III - METHODOLOGY

This chapter describes the research method design used for this study on the 5E learning cycle and lecture teaching strategies. Research and hypotheses will be outlined. Chapter III includes the research questions, participants, research design, instruments, procedure, and analysis. The independent and dependent variables will be explained as well as statistical analysis used for the study. The purpose of this study was to determine if middle-school students' knowledge and attitudes in science can be improved by using the 5E learning cycle as compared to the lecture teaching strategy.

Research Questions

The study investigated the teaching of three chemistry mini-units using the 5E learning cycle and compared it to teaching chemistry using the lecturing teaching strategy. After reviewing the literature, the following action items were proposed:

1. Compare the change in pre- and post-physical and chemical changes knowledge scores of students learning with the 5E learning cycle and students learning with the lecture teaching strategy.
2. Compare the change in pre- and post-phase changes knowledge scores of students learning with the 5E learning cycle and students learning with the lecture teaching strategy.
3. Compare the change in pre- and post-elements, compounds, and mixtures knowledge scores of students learning with the 5E learning cycle and students learning with the lecture-teaching strategy.
4. Determine if there is a difference in students' attitudes about science when using the 5E learning cycle compared to the lecture teaching strategy.

5. Compare the change in whether the students captured the main idea as it was presented during the lesson with the 5E learning cycle and students learning with the lecture teaching strategy.
6. Compare the change in the relationship of the students' question(s) to the lesson with the 5E learning cycle and students learning with the lecture teaching strategy.
7. Compare the change in whether the students could make the class material relevant to their lives about the main idea with the 5E learning cycle and students learning with the lecture teaching strategy.

Participants in the Study

The school in which this research was conducted is a K-8 STEM (science, technology, engineering, and mathematics) school located in a large metropolitan area in the western part of the U.S. The school is a school of choice; however, 50% of the student population is from the surrounding community. The school has approximately 390 elementary students, and approximately 450 are middle-school students. Fifty-four percent of the school's population is male, and 46% of the school's population is female. The eighth-grade class consisted of approximately 152 students. Approximately 83% of students attending the school receive free and reduced lunch. Forty-eight percent of the elementary students and 64% of the middle-school students are identified as ELL students. Within the eighth-grade classes, more than half of the students are classified as ELL. The school's population is 70% Latino, 24% white, and 6% listed as other races.

The school uses the problem-based learning concept throughout all grades. With this model, students are presented with a real-life problem to solve that is actively being researched by industry or some other entity. All middle-school students are required to take science and engineering as a core academic class. The middle-school science classes operate on an alternating A B block schedule. Classes are 90 minutes in length. Due to this model, students are well-versed on presentation and research skills and the use of many teaching practices such as Kagan strategies.

Instrumentation

ESTEEM Instrument

The ESTEEM instrument was developed by Judith A. Burry-Stock and Rebecca Oxford for the Center for Research on Educational Accountability and Teacher Evaluation (CREATE) in 1995 (Burry-Stock, 1995). The instrument consists of several components meant to measure behaviors and student outcomes of a constructivist teacher (see Appendix A). The Student Outcome Assessment Instrument (SOAI) was the only component used for this study. Construct validity for this instrument was found to be significant at .01, and the reliability is reported to be .91 (Burry-Stock & Oxford, 1994).

The assessment consisted of the following questions:

1. What do you think your teacher wanted you to learn today? What was the main idea?
2. List some questions that today's lesson made you want to ask?
3. How is this topic important to you?

Each question was scored using the Student Outcome Assessment Rubric. Questions were scored one at a time in sequence. All questions 1 were scored before moving forward to questions 2 and 3. According to Burry-Stock and Oxford (1994), evaluating each question separately decreases error during the grading process. Question

1 primarily focused on whether students can remember what the main idea was for a science lesson or activity. Question 2 was coded to determine if a student can inquire about the lesson taught and ask questions, such as "what happens if" or "what if." The question(s) goes beyond what was taught during class. Question 3 was to determine if a student can relate the science lesson or activity to real-world experiences. The answers to the questions were scored using a rubric rating from 1 to 5. The rubric has descriptions written for ratings of *5*, *3*, and *1*. However, a score of *2* and *4* may be given if an answer falls between those ratings. Two evaluators were trained on using the Student Outcome Assessment Rubric to determine interrater reliability. Training consisted of meeting with the evaluators and reviewing a sample student document included in the ESTEEM manual and a paper from a student once the study began. During training, evaluators reviewed the rubric and discussed as a group what the expectations were for each score on the rubric. Once a consensus of understanding the rubric was met, the evaluators scored the written responses provided by the researcher. Each evaluator scored the written responses separately. Once complete scores were compared, discussions took place to reach a consensus of whether or not a discrepancy occurred.

Novodvorsky's Science Attitudes Survey

Novodvorsky's Science Attitudes Survey (see Appendix B) uses a 5-point Likert scale. The survey consists of statements in which students answered *Strongly agree*, *Agree*, *Neither agree nor Disagree*, *Disagree*, or *Strongly disagree*. The purpose of the survey was constructed to collect information about student attitudes toward science. The survey has a construct validity of 0.82 and a reliability coefficient of 0.93 (Novodvorsky, 1993). The instrument consists of Form A and Form B. The questions on each survey are equivalent to each other or parallel forms. This is important for the test-retest format. According to Novodvorsky (1993), this decreases "problems arising from respondents remembering items from one administration to the next" (Novodvorsky, 1993, p. 51). The two forms (Form A and Form B) group questions into three categories or factors based on Novodvorsky (1993). They are as follows:

1. Interest in science classes and activities in science class,
2. Confidence in ability to do science, and
3. Interest in science-related activities outside of school. (Novodvorsky, 1993, p. 51)

Some examples from the survey are as follows:

Factor 1- Form A: I do not want to take any more science classes than I have to take.

Form B: I do not want to study any more science.

Factor 2- Form A: I enjoy the challenge of science classes.

Form B: Learning things in biology is easy for me.

Factor 3- Form A: I do not enjoy taking things apart to see how they work.

Form B: I often ask my family how mechanical things work.

Mini-Units Pretest/Posttest

The third instrument used in the study was a pretest and posttest for three different mini-units (see Appendix C). The first mini-unit taught was on physical and chemical changes, the second was on phase changes in matter (e.g., solids, liquids, and gases), and the final mini-unit taught was on elements, compounds, and mixtures. The test questions were retrieved from various textbooks and websites. The three tests were given to a team of science teachers to review for quality of questions and content being tested. Revisions were made to questions as needed based on feedback. For example, one test question choices were edited because it did not reflect proper lab safety.

Research Design

The study was a quasi-experimental design with a control group and an experimental group. The control group was the lecture teaching group, and the experimental group was the 5E learning cycle group. The independent variables were the 5E learning cycle group and the lecture teaching strategy group. The dependent variables measured were student content knowledge, science attitude, capturing the main idea, student inquiry, and student relevance. The last three dependent variables were from the ESTEEM instrument. The study was quantitative by design. Both groups were given the ESTEEM student outcome assessment daily. Both groups were given Form A of the Student Attitude Survey prior to the study beginning and Form B of the Student Attitude Survey upon completion of the study. Each group was given a pretest and posttest for each mini-unit taught. Both tests were the same for each group, and the pretest and posttest were identical each time.

For this study, 61 eighth-grade students received parent permission and signed a minor consent form. Due to the high number of non-English speaking parents, all communication to parents about the study was provided in English and Spanish. All consent forms were kept in a secure location. All records were kept private for the study. The oral presentation of the study was read orally to all students, and a copy was sent home for parents to read and sign at the beginning of the study. Students were required to complete all assignments during the teaching unit as part of their regular schoolwork. Students could withdraw from the study at any time without penalty.

A drawing was held to assign A and B day classes to either the 5E learning cycle group or the traditional lecture group. Intact classes were used for the study. The researcher did not know which students were participants of the study until completion. To ensure anonymity, the consent forms were returned to another teacher for safekeeping. The length of the teaching unit was approximately one month. Most class periods were 90 minutes in length. Students did not know if they were in the experimental group or the control group.

Procedure

Although the lesson plans were written for a 5-day unit; the days varied due to interruptions of the school day, classes being 90 minutes in length, and students varying in the time to complete assignments. For the experimental group, the following 5E lesson plan was followed:

Mini-Unit 1–Physical and Chemical Changes

On Day 1, the *engage*, *explore*, and the *explain* portions of the 5E learning cycle were completed. For the *engagement* portion, students were asked to complete a circle map. This map was completed as a think-pair-share activity in which students completed the circle map as an individual, shared with their table partner, and then shared out loud with the class. For the *explore* portion, students completed an observation activity using boxes. Each box contained the following items: a tennis ball, a golf ball, cotton material, spandex material, two air fresheners with different smells (the push-up type), two different colored paper clips (red and blue), two different sheets of graph paper with different square sizes, and two different shaped erasers (one was the type that fits on top of a standard pencil and the other was a block-shaped eraser). Students were assigned to groups of three or four students. Each group selected a person to be the group observer. The observer was on the opposite side of the room to view the box content. The student had 2 minutes to observe the box content and that student reported to his or her group what was in the box. A member from the group was asked to name one item in the box. The teacher held up the actual item or a different similar item. This activity continued for about 20 minutes. The purpose of this activity was to introduce the students to properties of different objects and to demonstrate the importance of noticing properties. Students shared out loud the properties they discovered, such as texture, color, relative size, and odor. For the *explain* portion of the lesson, students used a note catcher to copy notes for the content to be covered from the teacher presentation.

On Day 2 the *explain* portion was completed. The students continued to copy notes from the first day. Afterwards, the students worked in pairs to complete Frayer models for the following terms: physical change, physical property, chemical change, and chemical property. Students presented their Frayer models to the class. Afterwards, the students began the *elaborate* portion of the 5E learning cycle which included an activity titled Crime Scene Lab. During this lab activity, students identified white powders based on physical and chemical properties and physical and chemical changes. This activity continued until Day 3. Students completed their lab conclusions for homework. On Day 4 students completed their posttest and presented their findings to the class.

Mini-Unit 2–Phase Changes

Mini Unit 1 (see Appendix H) begins with an engagement lesson. On Day 1 students completed the *engage* and *expl*ore portions of the 5E cycle. For the *engagement* portion, students worked in groups to sort various objects, which were in different states of matter. The items included an eraser, a balloon filled with air, a wooden block, a beaker of water with food coloring, and orange juice. Once complete, each group presented to the class their rationale for organizing the groups. The terms *solid*, *liquid*, and *gas* were introduced. Afterward for the *explore* portion, students made silly putty to answer the question: Is it a solid or liquid? For Day 2, students completed notes using a note catcher and the teacher presentation. For Day 3, the students completed a lab activity titled *Boiling Water Lab* in groups and completed lab post questions and wrote a lab conclusion. On Day 4, students completed a missing poster activity and the posttest for the *evaluation* section.

Mini-Unit 3–Elements, Compounds, and Mixtures

On Day 1, students watched a video from *NBC News* about male fish turning into female fish (see Appendix I). This activity was their *engagement* phase of the 5E learning cycle. Afterward, students completed an explore activity to investigate the properties of mixtures. The students had three items: sugar water with food coloring, oil and water, and milk. Also, for the *explore* portion, students read an article out loud as a class. Upon completion, students worked in pairs to complete the graphic organizer for the article. The article was a follow-up about male fish becoming female fish in a Colorado water system.

On Day 2, on the third teaching unit students completed the *explain* portion of the 5E learning cycle to include completing notes using a note catcher and teacher presentation. Afterward students worked in pairs and completed a cut-and-paste activity. The activity involved the students cutting out the words introduced in the notes and gluing them next to the correct definition on a separate handout.

Day 3 began the *elaborate* portion of the 5E model. Students worked in groups and analyzed a water sample to simulate a sample of water they read about in the article from the *explore* section and the *NBC News* video from the *engagement* portion. The sample was teacher-made to include small pieces of paper clips, potting soil, water from the class, and a thin layer of cooking oil. The students identified their variables, wrote an hypothesis, created a material list, identified safety procedures, and a step-by-step procedure detailing how to separate the mixture of simulated polluted water. Afterward, students planned, designed, and built a separating apparatus. This activity continued until Day 6. On Day 6, students completed their posttest on elements, compounds, and mixtures. Students shared their findings with the class and wrote a lab conclusion.

For the control group, a traditional lecture-style lesson plan was followed (see Appendix J). For the properties of *matter*, mini-unit students completed the following in order:

1. Students copied notes from the same presentation as the experimental group using an identical note catcher.
2. Students completed a worksheet describing matter.
3. Students completed a mystery powder lab crime scene.
4. Students completed their posttest.

For the phases of *matter*, mini-unit students completed the following:

1. Students copied notes from the teacher presentation using the same presentation and note catcher as the experimental group.
2. Students watched a Bill Nye video on phases of matter and completed questions.
3. Students completed the boiling water lab in groups.
4. Students completed a review handout.
5. Students completed the posttest for phases of matter.

For the elements, compounds, and mixtures, mini-unit students completed the following:

1. Students copied notes from the teacher presentation using the same note catcher as the experimental group. The presentation was also the same.
2. Students completed a practice worksheet.
3. Students worked in lab groups to separate a mixture given by the teacher. Each group received a mixture of potting soil, salt crystals, and small paper clip pieces in a cup. Students wrote a procedure to separate the mixture before doing so.
4. Students completed lab conclusions
5. Students completed posttests for the final teaching mini-unit.

Data Analysis

The quantitative study was analyzed using descriptive statistics. The tests were used to analyze students' grades on the pretest and posttest for each mini-unit Data were also analyzed using a repeated measures mixed-effects Analysis of Variance (ANOVA).

This type of ANOVA was used because the study (a) examined the differences across time within the experimental and control group, (b) compared the two groups, and (c) examined if the interaction between the groups. The Student Science Attitudes Survey was analyzed using the same method. The ESTEEM instrument was analyzed comparing growth over time.

CHAPTER IV – RESULTS

This chapter will explore the results of this study. The purpose of the study was to determine if middle-school students' chemistry knowledge and interest can be increased by using the 5E learning cycle. The results are organized into sections based on the research questions described in Chapter III. The first section will review the participants of the study. The second section will present the results from the research questions—addressing the content knowledge from the teaching units. The third section will present the results from the Student Science Attitudes Survey. The final section will present the results from the ESTEEM instrument.

Participants

Data were collected from all eighth-grade science students. At the time of the study, there were 150 eighth-grade students. All students in the study were students at a K-8 STEM school located in a large metropolitan area in the western part of the U.S. After implantation of the study, the overall sample size was determined to be 61 students based on signed parent permission forms and minor consent forms. The study was divided into two groups: the control group and the experimental group. The control group was the lecture teaching strategy group, and the experimental group was the 5E learning cycle group.

After a drawing to determine which group would receive the treatment; the groups were coded as A or B based on the alternating class schedule determined by the school master schedule. A classes were coded as the experimental group, and B classes were coded as the control group. The control group consisted of 32 students (15 girls and 17 boys). The experimental group sample size was 29 students (14 girls and 15 boys). The sample size for data collected varied for each statistical test or research question due to student absences or unscheduled school events on the day data were collected.

Content Knowledge Research Questions

Research Question 1

Research Question 1: Compare the change in pre- and post-chemistry knowledge scores of students learning with the 5E learning cycle and students learning with the lecture teaching strategy. All analyses were conducted using SPSS Version 2, and statistical significance was assumed at an alpha value of .05 (p = .05). Mixed-effects repeated measures ANOVAs were used to test for significant interactions between independent groups and change in outcome across time. A repeated measures ANOVA is used when taking measurements over time with the same subjects. To compare the two groups the chemistry content was taught in three sections called *mini-units*. The units were taught in the following order: Mini-Unit 1: Chemical and physical changes; Mini-Unit 2: Phases of Matter; and Mini-Unit 3: Elements, Compounds, and Mixtures. Statistical analysis was conducted for each teaching mini-unit. Participants were coded into either group 0 (control group, lecture) or group 1 (experimental group) 5E learning cycle. The questions were titled preq1, preq2, etc. for the pretest and postq1, postq2, etc. for the posttest. Each student's percentage grade was entered for each pretest and posttest. There were 61 students who consented to participate in the study. Due to student absences, all students did not complete all portions of the study. The following table shows the number of participants for each unit and the student attitude survey.

Table 1

Number of Participants for each Unit and the Student Attitude Survey

	Participants A	Participants B	
Unit	*n*	*n*	Total *n* value
1	21	13	34
2	28	22	50
3	29	23	52
Survey	28	19	47

For Mini-Unit 1, physical and chemical changes, data suggested that there was a statistical significant difference across time within the groups, F(1, 32) = 22.5, $p < 0.001$. When comparing the two groups, the data suggested no statistical significant difference between the subjects, F(1, 32) = 2.1, $p = .16$. Finally, the data suggested nonsignificant interaction between the groups on how they change, F(1, 32) = 0.04, $p = 0.84$.

Examination of means suggested that there was a difference between the groups at the onset of the unit based on pretests of the control group ($M = 47.69$) and experimental group ($M = 58.24$). Overall, the control group showed a gain in content knowledge for physical and chemical. Changes from time one to time two and the experimental group also demonstrated a gain from time one to time two. Hence, both groups demonstrated growth. The results are listed in Figure 1 below.

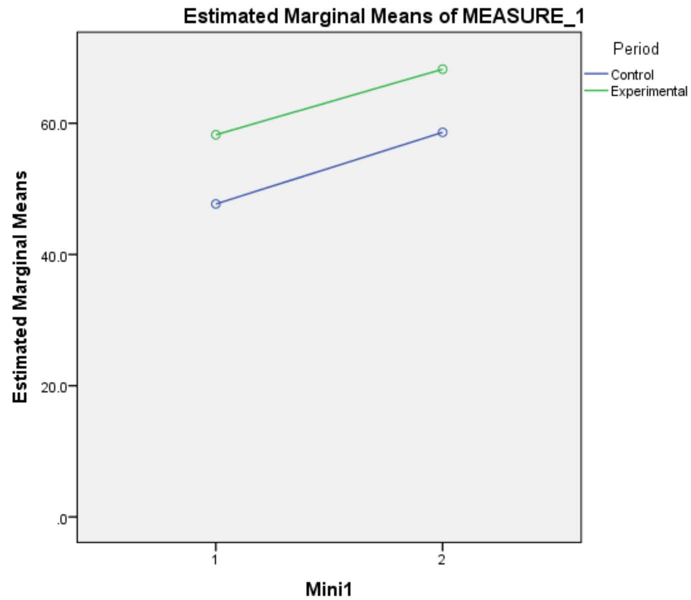


Figure 1. Comparison of the control group pretest and posttest mean scores to the experimental group's pretest and posttest mean scores.

The x axis reflects the pretest (1) and the posttest (2). The y axis reflects the mean scores.

For Mini-Unit 2, phases of matter, the data suggested that there was a statistical significant difference across time within the groups, F(1, 48) = 105.92, *p* = 0.001. When comparing the two groups, the data suggested no statistical significant difference between the subjects, F(1, 48) = 0.29, *p* = 0.60. Finally, the data suggested nonsignificant interaction between the groups on how they change, F(1, 48) = 0.17, *p* = 0.68.

When examining the mean scores for both groups, the treatment group (5E learning cycle) and the control group (lecture teaching) did not show a statistical significant difference. Both groups' (experimental, *M* = 43.46; control *M* =4 5.14) mean pretest scores suggested that both groups were similar at the beginning of the experiment. However, both groups demonstrated growth over time. The results are listed in Figure 2 below.

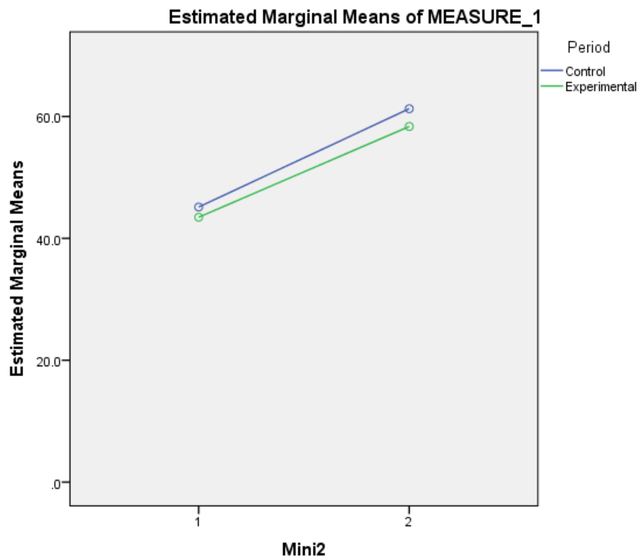


Figure 2. Comparison of the control group pretest and posttest mean scores to the experimental groups pretest and posttest mean scores.

The x axis reflects the pretest (1) and the posttest (2). The y axis reflects the mean scores.

For Mini Unit 3, elements, compounds, and mixtures, the data suggested that there was a statistical significant difference across time within the groups, $F(1, 50) = 149.04$, $p < 0.001$. When comparing the two groups, the data suggested no statistical significant difference between the subjects, $F(1, 50) = 0.08$, $p < 0.78$. Finally, the data suggested nonsignificant interaction between the groups on how they change, $F(1, 50) = 0.01$, $p < 0.92$.

When examining the mean pretest scores for both groups (experimental, *M* = 33.10; control, *M* = 34.35), the data suggested that there was not a difference between the two groups from the onset. Upon completion of the study, the data again demonstrated that there was no difference between the two groups based on mean posttest scores (experimental, *M* = 55.00; control, *M* = 55.87. See Figure 3 below.

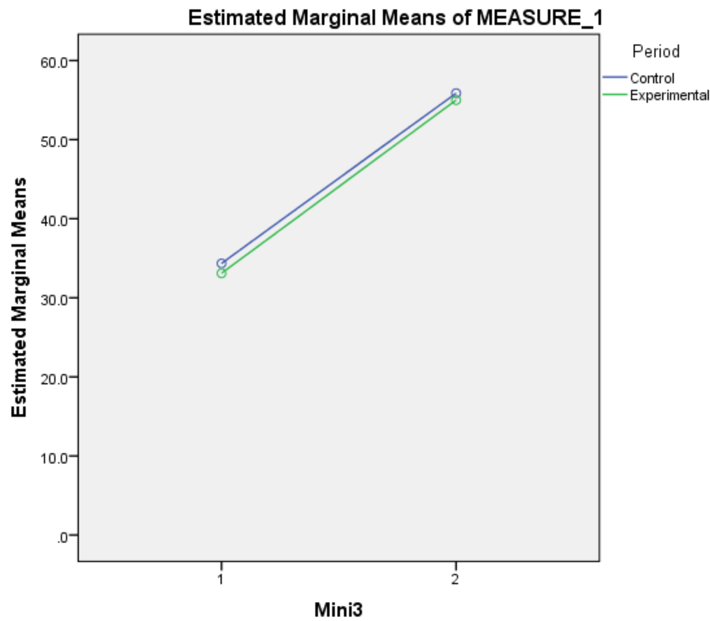


Figure 3. Comparison of the control group pretest and posttest mean scores to the experimental groups pretest and post-test mean scores.

The x axis reflects the pretest (1) and the posttest (2). The y axis reflects the mean scores.

Skewness and kurtosis statistics were used to assess normality of continuous outcomes. Box's Test of Equality of Covariance Matrices and Mauchly's Test were used to assess equal covariance and sphericity assumptions. Greenhouse-Geisser corrections were used when sphericity was violated. Marginal means with 95% confidence intervals were interpreted.

Attitude Survey Research Question

Research Question 4

Research question 4. *To determine if there is a difference in student attitudes about science when using the 5E learning cycle compared to the lecture teaching strategy*. A mixed-effects repeated measures ANOVA was used to answer the research question for the student attitude survey. When comparing the scores for all students taking the survey, data suggested that there was a significant difference across time within-subjects for all participants, $F(1, 47) = 5.72$, $p = 0.02$. When comparing the two groups, there was a nonsignificant difference between the groups, $F(1, 47) = 1.89$, $p = 0.18$. Finally, data suggested that there was a significant interaction between the groups in terms of how they changed across time, $F(1, 47) = 6.19$, $p = 0.016$. When examining the means, there was a slight decrease in the mean for the control group (pretest, $M = 3.04$; posttest, $M = 2.59$). The experimental group experienced a slight gain in mean (pretest, $M = 2.95$; posttest, $M = 2.96$) (see Appendix K). Figure 4 below shows that the groups were almost equal at pre-survey administration.

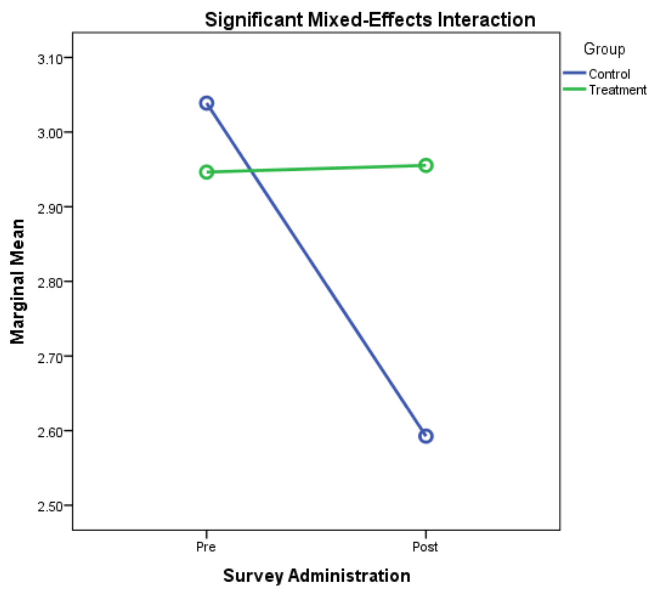


Figure 4. Comparison of mean pre- and post-survey scores.

The questions from the science attitudes survey were also grouped into three factors:

Factor 1: Interest in science classes and activities in science class.

Factor 2: Confidence in ability to do science.

Factor 3: Interest in science-related activities outside of school (see Table 2).

Table 2

Survey Form for Factor A and Factor B Questions

Form	Factor	Questions	Score
A	1	Q2, Q6, Q9, Q11, Q21, Q26, Q37, Q30	8
	2	Q3, A7, A12, A17, A20, A22, A28	7
	3	Q8, Q10, Q13, Q14, Q16, Q23, Q24, Q25, Q29	9
B	1	Q1, Q6, Q9, Q13, Q21, Q22, Q25, Q27, Q30	9
	2	Q5, Q11, Q12, Q14, Q15, Q17, Q18, Q23, Q26	10
	3	Q2, Q3, Q4, Q7, Q10, Q19, Q20, Q28	9

Factor 1 of the attitude survey data suggested that there is a statistical significant difference within each group, $F(1, 39) = 25.48$, $p < 0.001$. When comparing the two groups, data suggested that there is not a significant difference between the experimental group and control group, $F(1, 39) = 0.89$, $p = 0.35$. Finally, data suggested a significant interaction with how the groups changed over time, $F(1, 39) = 4.78$, $p = 0.04$.

When examining the mean pre-survey scores for both groups (experimental, $M = 3.01$; control, $M = 3.09$), data suggested that there was not a difference between the two groups from the onset. Upon completion of the study, the data showed a slight decline in mean post-survey scores for student attitudes (experimental, $M = 2.83$; control, $M = 2.64$). See Figure 5 below and Appendix K for SPSS output.

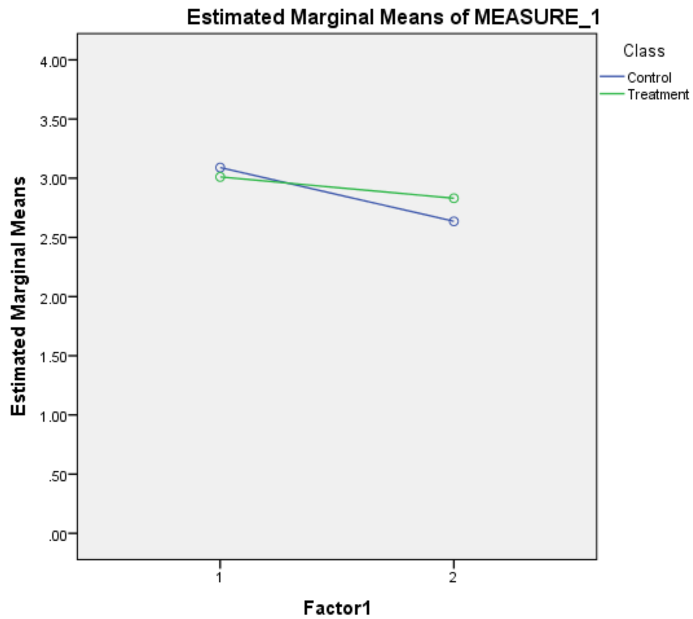


Figure 5. Comparison of mean pre- and post-survey scores for Factor 1.

Factor 2 of the attitude survey data suggested that there is no significant difference within the subjects, $F(1, 42) = 2.49$, $p = 0.12$. When comparing the two groups, data suggested a nonsignificant difference between the two groups, $F(1, 42) = 0.21$, $p = 0.65$. Finally, data suggested a nonsignificant interaction between the means in how the groups changed over time, $F(1, 42) = 0.01$, $p = 0.94$.

When comparing the mean scores for both groups (control pretest, $M = 2.91$; experimental pretest, $M = 2.95$; and control posttest, $M = 3.03$; experimental posttest $M = 3.08$), data demonstrated that both groups were similar at the beginning and end of the experiment. The mean scores suggested that the two groups did not change over time. See Figure 6 below and Appendix K for SPSS output.

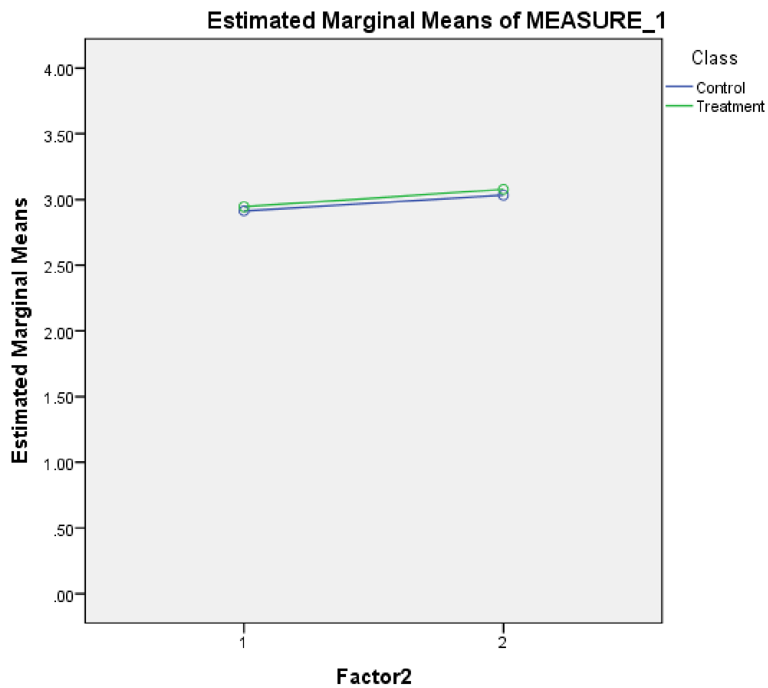


Figure 6. Comparison of mean pre- and post-survey scores for Factor 2.

Factor 3 of the attitude survey data suggested that there is not a statistical significant difference within each group, $F(1, 42) = 0.10$, $p = 0.76$. When comparing the two groups, data suggested no statistical significant difference between the subjects, $F(1, 42) = 0.01$, $p = 0.93$. Finally, data suggested nonsignificant interaction between the groups on how they change across time, $F(1, 42) = 1.0$, $p = 0.32$.

When comparing the mean scores for both groups (control pretest, $M = 2.92$, experimental pretest, M = 2.984; and control posttest, $M = 2.83$, experimental posttest, $M = 2.89$), data demonstrated that both groups were similar at the beginning and end of the experiment. Although there was a slight decrease from time one to time two for the control group; the mean scores suggested that the two groups did not change over time. See Figure 7 below and Appendix K for SPSS output.

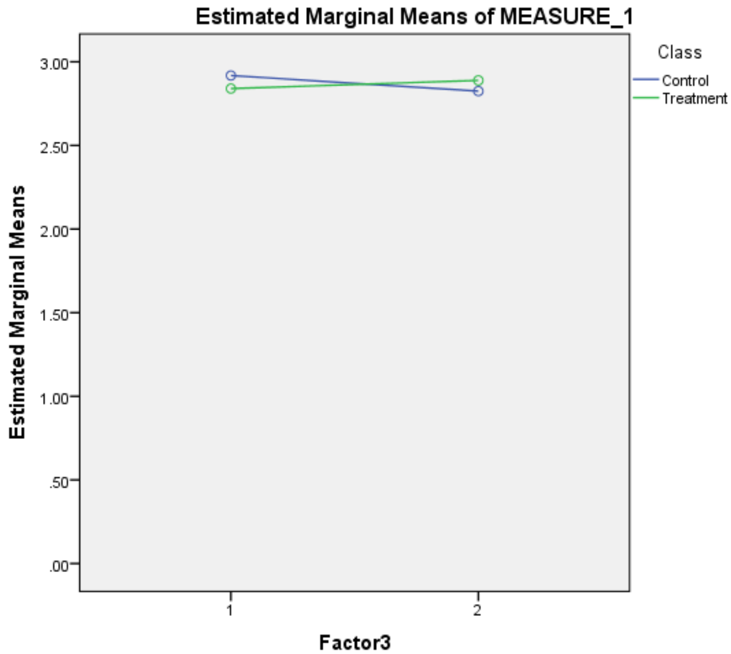


Figure 7. Comparison of mean pre- and post-survey scores for Factor 3.

Research Question 5

Research Question 5: To compare the change in whether the students captured the main idea as it was presented during the lesson with the 5E learning cycle and students learning with the lecture teaching strategy. Results showed that students demonstrated an increase in their ability to capture the main idea as it was presented during the lesson using the 5E learning cycle compared to students learning with the lecture teaching strategy. See Appendix L for figures.

The question from the ESTEEM instrument for this research question is "What do you think your teacher wanted you to learn today (what was the main idea)?" The objective for the day was to identify types of mixtures and explain how to separate a mixture. An example of a student score of two was "To understand the problem and the aspects of it." A student score of three was "How to separate parts of a mixture."

Research Question 6

Research Question 6: To compare the change in the relationship of the student's question(s) to the lesson with the 5E learning cycle and students learning with the lecture teaching strategy. The results showed that students demonstrated an increase to compare the change in the relationship of the students' question(s) to the lesson with the 5E learning cycle compared to students learning with the lecture teaching strategy. See Appendix L for data.

The question from the ESTEEM instrument for this research question is "List some questions that today's lesson made you want to ask?" An example of a score of one written by a student was "N/A." An example of a score of two for this question was "Why does this have to be so complicated." These examples were written by students for mini unit three. The learning objectives for the day was to identify types of mixtures and explain how to separate a mixture. An example for a score of five for the same question but for mini unit one was "What's the difference between physical and chemical reaction? Can one thing have both reactions? What's the deadlist reaction?" The objective for the day was to distinguish between physical and chemical changes.

Research Question 7

Research Question 7: To compare the change in whether the students could make the class material relevant to his/her life about the main idea with the 5E learning cycle and students learning with the lecture teaching strategy. The results showed no difference between 5E learning cycle and lecture teaching strategy for students to be able to make the class material relevant to his or her life about the main idea. See Appendix L for data.

The question from the ESTEEM instrument for this research question is “How is this topic important to you? An example of a score of two written by a student was “I can use it in the future to understand topics” This response was from mini unit three-elements, compounds, and mixtures. Another student response was “This is important because if this is affecting our fish, we don’t know how it’s going to affect humans and our food supply.” This response was given a score of four. The objective for the day was to identify types of mixtures and explain how to separate a mixture.

Summary

The purpose of this research was to determine if middle-school students’ chemistry knowledge and interest can be increased by using the 5E learning cycle. Overall, data did not show a statistical significance with students in the 5E learning cycle group compared to the lecture teaching strategy group. The results suggested that students’ attitudes toward science in the 5E learning cycle group did not make an overall difference in the students. In addition, when using the ESTEEM instrument to compare change in students’ statement of the main idea, ability to ask inquiry questions, and make the content relevant to their lives; there was a noticeable pattern of growth over time in the main idea and ability to ask inquiry questions. However, students were not able to make any noticeable growth over time when making the content relevant to their daily lives. Therefore, it can be concluded that the students in the study showed overall gain in learning and interest in science but no statistical significant differences were supported by the data.

CHAPTER V – DISCUSSION

It seems for decades dating back to the 1800s the teaching of science changes back and forth from being thought of as a verb and then as a noun. Per Bybee (2010), science educators and our country have been trying to achieve scientific literacy for many decades with our students. We continue to struggle as a nation with what our students should be able to know and do in science (Bybee, 2010). Organizations, such as the Biological Sciences Curriculum Study, have supported the research of the constructivist learning theory beginning with the 5E learning cycle in the 1980s. The overall purpose of this study was to determine if middle-school students' chemistry knowledge and interest can be increased by using the 5E learning cycle. The research explored the following research questions:

1. Compare the change in pre- and post-physical and chemical changes knowledge scores of students learning with the 5E learning cycle and students learning with the lecture teaching strategy.
2. Compare the change in pre- and post-phase changes knowledge scores of students learning with the 5E learning cycle and students learning with the lecture teaching strategy.
3. Compare the change in pre- and post elements, compounds, and mixtures knowledge scores of students learning with the 5E learning cycle and students learning with the lecture teaching strategy.
4. Determine if there is a difference in students' attitudes about science when using the 5E learning cycle compared to the lecture teaching strategy.

5. Compare the change in whether the students captured the main idea as it was presented during the lesson with the 5E learning cycle and students learning with the lecture teaching strategy.
6. Compare the change in the relationship of the student's question(s) to the lesson with the 5E learning cycle and students learning with the lecture teaching strategy.
7. Compare the change in whether the students could make the class material relevant to his or her life about the main idea with the 5E learning cycle and students learning with the lecture teaching strategy.

To address these research questions, students were taught three mini-units in chemistry. The topics were mini-unit one, physical and chemical changes; mini-unit two, phases of matter; and mini-unit three, elements, compounds, and mixtures. Students were given a pretest and posttest for each of these mini-units to compare gain in content knowledge. Students were surveyed at the beginning and end of the study to measure students' attitudes about science. The third instrument used in the study was the ESTEEM. Its main purpose was to compare the change in students' ability to write the main idea of a daily lesson, students' ability to ask inquiry-style questions, and students' ability to make the content being taught relevant to their respective lives.

The students participating in the study were eighth-graders from a large metropolitan area in the western United States. There were 61 participants in the study. Over half of the student participants were Latino.

Based on the data collected, there was no statistically significant difference between the two teaching methods. However, each research question yielded varied results that either supported or negated the 5E learning cycle method. These factors demonstrated that 5E learning within this study showed benefits that enhanced learning but also deficits that could hinder student growth.

Research Questions

Possible explanation for the findings could include students' affinity for chemistry topics. The majority of the students' favorite science topic was chemistry. Consequently, the students still struggled learning the concepts. However, the students were interested in the lab activities. The crime scene lab seemed to be their favorite activity because students wanted to see chemical reactions or something exploding. It is likely that their high interest for the topic had an impact on students learning. Evidence of this was also noticed during the elements, compounds, and mixtures unit. Students were highly engaged in trying to separate their mixtures even when they were not successful.

Another factor that could have influenced the outcome was the class scheduling. The school has an alternating A B day block schedule. There were some weeks the students were seen twice or three times for consecutive days. Although over time students' time in class was basically the same, there could have been some gaps in learning and understanding due to the design of the schedule. For example, the experimental group could have attended science class on a Monday and not attended science class again until Thursday and then the following Monday. An example of interrupted learning would have been if a lab began on a Monday and the students did not complete the lab activity, then conclusion of the lab would have been on that Thursday. However, there were some proactive interventions to keep the meeting times more consistent. This type of schedule may not be the best for students who struggle in science and language acquisition.

Although the schedule could have had some impact on student learning; there was a significant difference within groups across time in student attitudes toward science in the overall survey and Factor 1 which pertains to students' interest in science classes and the activities. Unfortunately, the significance came from a slight decline in mean scores which could be attributed to the schedule or other factors.

Another factor that could have influenced the research was the time of year the research was conducted. The spring semester is when standardized testing is conducted. Students complained about taking too many tests throughout the duration of the study. During the course of this research, ELL students were pulled from class to take the World Class Instructional Design and Assessment (WIDA) Assessing Comprehension and Communication in English State (ACCESS) testing. The WIDA ACCESS test is a mandated state test to determine language proficiency in ELL students. Per NCLB, all schools and districts are held accountable for testing all student populations. Although NCLB has been updated, the requirement remains in place.

At the onset of the study, students had completed their MAPS (Measure of Academic Progress) testing, which is required by the district to be given three times a year. Consequently, this study is reflective on this school because state standardized testing shows the same trend. Students tend to demonstrate growth in content throughout the year but by yearend, they are still not proficient or where they should be academically for their grade level. This could be based on Hamayan and Freeman's (2012) thinking that ELL students grow, but they are chasing a moving target because the system is moving forward at the same time.

For this study, students were taught three mini-units on chemistry topics. After each mini-unit, the students were given the posttest. Prior to the mini-unit being taught all students took the pretest. This could have compounded the problem with students feeling test fatigue. Testing is also a reason many teachers do not conduct their class with a constructivist model like the 5E learning cycle. This supports the claim made by Wong and Day's (2009) study about high-stakes testing deterring some teachers and administrators from the constructivist approach to teaching. Hence, teachers do not use the model based on numerous testing requirements. The 5E learning cycle—like most constructivist learning models—can be time-consuming to implement, and many classrooms across the nation are in test preparation mode for most of the year. Therefore, the constructivist model of learning is foreign to students and sometimes students do not like the drastic change from a teacher-centered learning environment to a student-centered learning environment.

This leads to another important factor possibly affecting the outcome—the constructivist theory itself. The constructivist model is not something most students are familiar with in many science classes. The population for this study was not only heavily tested, but they were also from a low-socioeconomic background and mostly ELL students. For these reasons, there was some opposition to the use of the constructivist way of learning. Students in the study seemed resistant to exploring the answers to questions they did not know or understand. For many students, this caused them to disengage from the learning process. Students wanted more assistance from the teacher. According to Vygotsky's ZPD, once you place a kid above this zone, learning does not take place for most people. Some evidence of this occurring was visible during this study. For example, when students were attempting to separate their mixtures of contaminated river water, scaffolds would have been a great addition to help students identify the necessary steps to help them separate the mixture. As a result, not one group was successful with separating the contaminate (fish hormones) from the water. Based on Krashen's theory of language acquisition, ELL students need comprehensible input or scaffolds to learn content due to the lack of language development.

These frustrations could also play a role in students lacking confidence in their ability to do science. This was supported based on the evidence for the student attitude survey Factor 2 data. There was not a statistical significant difference within groups, between the groups, or between the groups in terms of how they changed over time. This supports the work of Mayer (2004) who opposed the idea of constructivist learning being more effective because students want and need guidance to learn. This also supports the ELL concept of guiding students through the learning process with many scaffolds to make sure the intended content was learned.

In addition, constructivist teaching is limited in chemistry because some topics are more difficult to learn. An example would be atomic structure. Students simply do not have the background knowledge to ascertain abstract topics. Lack of background knowledge is another reason Chall (2000) believed that students from low-socioeconomic backgrounds do not benefit from constructivist learning like the 5E learning cycle. A possible reason for this could be the lack of background knowledge. Children from poor backgrounds are usually deficient in background knowledge because they lack many worldly experiences that students who are not in this category are able to explore. Thus, these students bring less experiences and information to relate to new concepts. This rationale could have been a factor with this study since 83% of the study population was classified as free- and reduced-lunch recipients. This is not giving students an excuse for not learning but should be informative for educators on how best to serve this population of students. Training teachers how to best serve this population is vital to the success of the students.

Consequently, training was not conducted for this study. That could be a possible explanation for the outcome of this study. This supports Patrick's (2013) research findings in which no significant difference was found between his groups. Patrick (2013) also stressed the need for training the teachers as well as the students on how to use the 5E learning cycle teaching strategy and other constructivist learning models. The students in this study did not receive any information on the 5E learning cycle nor did they know the group in which they were participating. The lack of Krashen's (1981) Affective Filter hypothesis could have influenced the outcome of this study. If students do not feel comfortable in their learning environment, they may lack the motivation to learn the concepts being taught. It does appear that the students who participated in this study had no previous experience with the 5E learning cycle or any other classroom that is taught primarily through the constructivist setting. Therefore, training students about the expectations of a student-centered learning environment could have been helpful and would lower students' affective filter. It is essential for ELL students not to feel stressed about learning to learn. Cam and Geban's (2011) research study concluded that lack of teacher training could be the reason more teachers are not incorporating the 5E learning cycle and other constructivist teaching strategies into their classrooms.

The teacher in the current study did not receive any formal training on the 5E learning cycle nor the ESTEEM instrument. The ESTEEM instrument, which is addressed in research questions 5 through 7, was designed to measure the effectiveness of a teacher using the constructivist model. This study only used the student outcome assessment rubric and did not link those scores back to the effectiveness of the teachers' ability to teach using the constructivist framework.

Research questions 5 through 7 pertained to students' ability to understand the main idea of a lesson, asking inquiry-style questions about the lesson, being able to make the content relevant to their respective daily lives. The data showed growth over time for the main idea and asking inquiry-style questions. Students did not show any growth in their ability to demonstrate relevance to their individual lives. The experimental group demonstrated more growth than the control group. As time passed during the study, students scored higher on the student outcome assessment rubric. In the beginning of the study none of the students scored a 5, but by the end of the study, students could obtain a score of 5 on the rubric which meant students had the ability to expand on their thoughts about the main idea of the lesson. Students could ask questions about the big picture of the lesson without the answers being provided during the lesson. Finally, toward the end, a small percentage could make the connection between the lesson and society. One interesting point to note from the data pertaining to the experimental group is that student interest was at its highest on day one and tended to decrease after day one. This could be due to the structure of the 5E learning cycle. The first E focused on engaging the students and capturing their attention about the topic of study. This is also supported by Duran et al. (2011) that students benefit more during the earlier stages of the learning cycle.

In addition to the above findings, other factors could have contributed to the outcome of this study but were not measured. For example, the wording on the instruments and the depth of knowledge of the test questions on the content pretest and posttest. ELL students can be at various steps on acquiring English based on their ACCESS test scores. There were many terms or phrases on the tests that students did not understand or have the language skills to decipher. One example would be the word *component* from the mini-unit three test. Several students had questions about what the word meant and could not focus on the content the question was referring to. Another example was the words h*omogeneous* and *heterogenous*. Although these two terms have cognates that Spanish-speaking ELL students should understand, there were still difficulties answering questions using these words.

Research question 5 addressed the difference in student attitudes toward science. Based on the data collected there was no difference between the two groups. However, when subdivided into the three main factors, two areas revealed a statistically significant difference in Factor 1. Factor 1 questions pertained to the students' interest in science class and activities in the science class, Factor 2 pertained to how confident the students felt in their ability to do science, and Factor 3 referred to the students' interest in science-related activities outside of school. Factor 2 of the survey revealed that students' confidence in their ability to do science is low. The survey data showed students have interest in science inside the classroom but not with science activities outside of school—

but low confidence. Part of the results could be explained by the wording of the questions on the survey. As students answered the survey, they were conflicted by meaning of the statements being asked of them. Some students were confused with the statements which could have had an impact on the study outcome. One example was that students did not know what *earth science*, *physical science*, and *chemistry* were. It would be difficult for a student to respond how much they agree or strongly agree to liking something when they are not sure of its meaning. The current researcher believes this to be relevant due to the high ELL population of the participants. Perhaps, students would have responded differently to some questions if the entire survey was read aloud to students with explanation along the way.

Implications for Teaching

This study was designed to determine if middle-school students' chemistry knowledge and interest can be increased by using the 5E learning cycle. The findings from this study indicated that there was no statistical difference between the control group and the experimental group. However, based upon the data, there needs to be explicit instruction on the relevancy of what is being taught in a science lesson. When teaching a large group of ELL students, the primary focus may not always need to be the instructional piece. Other measures might be needed to help increase the confidence levels of students' ability to do science. To increase the impact of the 5E learning cycle, teachers might need training on what this should look like and sound like in a science classroom. This would include quality professional development training for science educators on how to incorporate the 5E learning cycle into their classrooms. Administrators would need training as well. The administrators need to know what qualities to look for in an effective constructivist learning classroom when performing teacher evaluations. All chemistry topics do not easily lean toward the 5E learning cycle strategy. Finally, the most important implication from this study is that students need to be trained on the constructivist model so learning is not impeded by the drastic change of instruction. This may eliminate or minimize the confusion students may have between a teacher-centered classroom and a student-centered classroom.

Future Studies

The concept of teaching in a constructivist nature is not a new idea. Research should continue with the 5E learning cycle, especially as it pertains to ELL students. This study could be expanded in several ways. The following options are important for future studies. Educators years from now would have tangible data to use and studies that reflect the growing population of many classrooms across the nation.

1. Use a larger sample size.
2. Segregate data based on gender and ELL level according to ACCESS test scores.
3. Use multiple teachers for the study.
4. Allow for each group to receive the treatment.
5. Repeat the study during a time of low mandated testing period.
6. Conduct additional studies that incorporate training for teachers before implementation of the model to allow for some sort of standardization.
7. Extend the length of the study.

8. Replicate this study using the ESTEEM instrument and incorporate the teacher component of the instrument to give more context for the student portion.

APPENDIX A – ESTEEM

EAGLE APPS

Cynthia McWright <cynthia.mcwright@eagles.usm.edu>

attitudes toward science survey instrument
5 messages

Cynthia McWright <cynthia.mcwright@eagles.usm.edu> Sun, Apr 17, 2016 at 10:25 PM
To: novod@email.arizona.edu

Dr. Novodvorsky,

I am a doctoral student at the University of Southern Mississippi studying chemistry education. During my literature review I came across a modified version of the science attitude survey instrument you developed in 1993. I would like permission to use the instrument and/or modify the instrument. If you have a Word version of the document you can share that would be helpful and much appreciated. I am researching the science attitudes of eighth graders after being taught changes in matter using the 5 E learning cycle and traditional lecture style.

Sincerely,
Nicole McWright

Novodvorsky, Ingrid - (novod) <novod@email.arizona.edu> Mon, Apr 18, 2016 at 10:37 AM
To: Cynthia McWright <cynthia.mcwright@eagles.usm.edu>

Nicole,

Thanks for contacting me…yes, you have my permission use and/or modify the science attitude survey that I developed for my dissertation.

And, surprisingly to me, I actually still had a copy of my dissertation on my computer! I've extracted the survey, with student instructions, from that document and attached it.

Good luck with your research!

Ingrid

Re: Form submission from: Contact Us

WMU Evaluation Center

Tue 2/21/2017 2:31 PM

To:Cynthia McWright <Cynthia.Mcwright@usm.edu>;

Dear Ms. McWright:

This ESTEEM document was one of the deliverables from the CREATE project. CREATE's objective was to get good materials developed and out into the field where it could do some good. With that in mind and the fact that it was being used for educational purposes, the CREATE principal investigator, Dr. Daniel Stufflebeam grants permission. Please make sure you cite the document in your work.

Good luck in your writing,
Mary Ramlow
Office Manager

The Evaluation Center
Western Michigan University
1903 W. Michigan Avenue MS 5237
Kalamazoo, MI 49008-5237
269-387-5895
269-387-5923 (fax)
www.wmich.edu/evaluation

From: CMS Requests, UR on behalf of WMU Webmaster
Sent: Monday, February 20, 2017 6:16 PM
To: WMU Evaluation Center
Subject: Form submission from: Contact Us

Submitted values are:

Name: Cynthia McWright
Email: cynthia.mcwright@usm.edu
Affiliation: Current graduate student
Subject: ESTEEM instrument (Expert Science Teaching Educational Evaluation Model)
Message: I would like to have permission to use the Student outcome assessment rubric with my dissertation.

Re: permisison to use ESTEEM

Rebecca Oxford

Tue 2/21/2017 2:27 PM

To:Cynthia McWright <Cynthia.Mcwright@usm.edu>;

Yes, you have permission to use it! Best wishes,
Dr. Oxford

On Feb 21, 2017 1:56 PM, "Cynthia McWright" <Cynthia.Mcwright@usm.edu> wrote:

Hello Dr. Oxford,

I am currently working on my dissertation at the University of Southern Mississippi. I would like to have permission to use the Student Outcome Assessment Rubric tool as part of my studies. I am comparing the 5E learning cycle with a traditional lecture style of teaching with a middle school group of students. Looking forward to hearing from you.

Sincerely,

Nicole McWright

ESTEEM

STUDENT OUTCOME ASSESSMENT RUBRIC

Directions:

A Preobservation form should be completed before the lesson plan from which the *Student Questions* are administered. *Student Questions* are to be administered when a classroom observation using the *Classroom Observation Rubric* is done. These two instruments should be viewed as companion pieces. The *Student Outcome Assessment Rubric* may be administered alone, but the classroom observation should always be accompanied with the *Student Outcome Assessment Rubric*. The completed Preobservation form provides the necessary information (lesson purpose, procedures, and intended outcomes) necessary for scoring the *Student Outcome Assessment Rubric*.

Student Questions are to be scored on the *Student Questions* sheet using the criteria detailed in the *Student Outcome Assessment Rubric*. A rubric is a scoring guide. Student responses should be scored one question at a time. All of the "Main Idea" questions should be scored at one time. On a second pass through, the "Inquiry" question should be scored. A third pass through is required to score the "Relevance" questions.

Evaluators should become familiar with the scoring guide before using it.

The ratings for all three questions are anchored at levels "5," "3," and "1" with descriptors that are the criteria for scoring student responses. If a student's response is described by a "1" level description, the student receives a "5." If the response is best described by a "3" level description, the student receives a "3." However, if the student response would be better described somewhere between a "5" and a "3," the student score should be a "4." A "2" rating would fall between a "3" and a "1." Ratings of "4" and "2" should be used when the student response is best described by a criteria between "5" and "3" and "3" and "1" respectively.

ESTEEM

STUDENT OUTCOME ASSESSMENT RUBRIC
(Student)

Directions:

The *Student Questions* and the accompanying rubric *Student Outcome Assessment Rubric* are companions to the *Classroom Observation Rubric*. *Student Questions* should be administered with every classroom observation that is to be evaluated using the *Classroom Observation Rubric* to provide student data for one lesson. These questions may also be used alone to obtain student feedback.

Student Questions should be administered at the end of a daily lesson. The following directions are to be read by the evaluating teacher who may be the teacher, a peer, or an external evaluator.

"I would like very much if you would give us some information about today's class. There are three questions for you to answer on this sheet of paper."

Pass out a set of *Student Questions* to every student.

"What you say is important, please take a minute to think through your answers."

"Thank you."

Pick up the papers.

ESTEEM

STUDENT QUESTIONS

Name: ______________________ Date: ______________

Teacher: ______________________ Grade: ______________

1. What do you think your teacher wanted you to learn today (what was the **main** idea)?*

2. List some questions that today's lesson made you want to ask?

3. How is this topic important to you?

**This question is an adaptation of a "Main Idea" question written by Angelo and Cross (1993).*

ESTEEM

Student Outcome Assessment Rubric

1. Capturing the Main Idea

Coding addresses whether or not the student captured the main idea as it was presented during the lesson.

5 = The response states the main idea **and** provides details, descriptions, or explanations that indicate the student did not just copy or regurgitate the main idea. The response indicates the student understood the big picture surrounding the main idea. Response may go beyond the idea as discussed in class.

3 = The response states the main idea, with no elaboration. The statement may appear to be book-related.

1 = The student's response has little or no relationship to the main point of the lesson. The response is about a different topic or an aspect of the broader topic. For example, humans have two arms should be rated 1 if the lesson was about the endocrine system.

2. Student Inquiry

Coding addresses the relationship of the student's question(s) to the lesson. Was the question one that was addressed during the lesson but the student did not understand, or was it a question that arose out of the lesson but could not be answered from material addressed? Was it a fairly straightforward question or was it an imaginative question?

5 = The student asks an **abstract** question that relates to **a part** of the lesson, but the answer was **not** provided during the lesson. The question may be complex, multifaceted. The question might be a "what if" or a "how do we know" kind of a question, for example. The question relates to **the big picture** of the lesson, but the answer was **not** provided during class.

3 = The student asks a **concrete** question that relates to the lesson, but the answer was **not** provided during the lesson. The question could be answered with a yes/no, a fairly simple fact, or set of facts. The question calls for an explicit answer. Example: How many bones does a bird have? The question may appear to be book-related.

1 = The student indicates he/she did not understand, has no questions, or the question does not relate at all to the lesson or even to science. For example: When's lunch? The question is not related to the lesson at all--to any part of the lesson--it addresses a totally different topic, but it is related to science. For example, a question about dogs when the topic was planets.

3. Student-Relevance

Coding addresses whether or not the student was able to make the class material relevant to his/her life.

5 = The student states in detail that content from the lesson is important to some aspect of society.

3 = The student in some way states that the content is tied to something relevant in his/her life.

1 = The student comments about the lesson, but does not make it relevant to his or her life or to society.

ESTEEM
STUDENT OUTCOME ASSESSMENT RUBRIC CLASS TALLY PAGE

Teacher's Name: ______________________________ Date: _______________

	MAIN IDEA					INQUIRY					RELEVANCE					TOTAL
STUDENT	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	POINTS
1																
2																
3																
4																
5																
6																
7																
8																
9																
10																
11																
12																
13																
14																
15																
16																
17																
18																
19																
20																
21																
22																
23																
24																
TOTAL N																
PERCENTAGE																

ESTEEM

STUDENT OUTCOME ASSESSMENT RUBRIC CLASS PROFILE

Teacher's Name: ______________________________ **Date:** ________________

	100	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	90	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	80	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	70	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	60	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Percentage	50	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	40	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	30	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	20	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	10	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	______/15
		Main Idea					**Inquiry**					**Relevance**					**Total**

APPENDIX B – Student Survey

This survey is designed to gather information about your attitude toward science. Before you begin the survey, circle the corresponding answer to your sex and write in your grade level on the survey. Write a 4-digit number you can remember in the "Special Code" boxes, and check the corresponding box to your answers. **Do not put your name on the answer sheet. The researchers need your student number only to keep track of the responses. They will not be able to find out your name from your student number.**

Some of the statements in the survey refer to "science." You should think about any science classes you have taken when you respond to those statements. Some statements refer to "biology." You should think about any biology classes you have taken or any parts of science classes in which you learned about living things. Some statements refer to "physical science." You should think about classes such as chemistry, physics, geology, or earth science, or any parts of science classes in which you learned about chemicals, the earth, machines, or similar topics. If you have not yet had a class in biology or in any physical science, respond to the statements on the basis of what you know or have heard about those classes.

Please read the statements and decide how much you agree with each. Using the following list, check the box that matches how you feel about each statement.

Strongly agree
Agree
Neither agree nor disagree
Disagree
Strongly disagree.

Example: *I enjoy reading scary stories.*

If you really don't like scary stories, you would probably "strongly disagree" with this statement, and would check the box labeled "Strongly Disagree" on the survey. If you like scary stories somewhat, you would probably "agree" with this statement, and would check labeled "Agree" on the answer sheet.

Special Code

Please circle
Male Female
Grade level _________

Form A

Please read the statements and decide how much you agree with each. Check the box that corresponds with your answer.

		Strongly agree	Agree	Neither agree or disagree	Disagree	Strongly Disagree
1	I wonder about stars and constellations.					
2	I do not want to take any more science classes than I have to take.					
3	I enjoy the challenge of science classes.					
4	I do not enjoy identifying shells.					
5	I have a talent for biology					
6	I would not recommend science classes to anyone					
7	I am confident about answering questions in science classes.					
8	I do not enjoy taking things apart to see how they work.					
9	Studying physical science is boring					
10	I like to share what I've learned in science class with my friends or family					
11	I am interested in learning more about topics in biology.					
12	I doubt I will ever grasp biology					
13	I am not confident about my ability to understand science					
14	I do not think about the things I learn in science class outside of school					
15	I enjoy participating in hands-on activities in physical science classes.					
16	I enjoy reading books about science.					
17	I have a talent for physical science					
18	I do not enjoy doing labs in biology classes					

19	Physical science makes sense to me.					
20	Science classes are too difficult for me.					
21	I am interested in learning more about topics in physical science.					
22	Biology makes no sense to me.					
23	I enjoy taking care of animals					
24	I do not enjoy watching TV shows that deal with science.					
25	I like learning about rocks and minerals.					
26	Studying biology is boring					
27	Science classes are interesting					
28	I doubt I will ever grasp physical science.					
29	I do not like to read about different kinds of animals					
30	I am fascinated by what I learn in science classes					
31	Science is fun.					
32	I do not like science and it bothers me to have to study it.					
33	During science class, I usually am interested					
34	I would like to learn more about science.					
35	If I knew I would never go to science class again, I would feel sad.					
36	Science is interesting to me and I enjoy it.					
37	Science makes me feel uncomfortable, restless, irritable, and impatient					
38	Science is fascinating and fun.					

Thank you for completing this survey.

Special Code

Please circle

Male Female

Grade level __________

Form B

Please read the statements and decide how much you agree with each. Check the box that corresponds with your answer.

		Strongly agree	Agree	Neither agree or disagree	Disagree	Strongly Disagree
1	I do not want to study any more science.					
2	I often ask my family how mechanical things work.					
3	I do not enjoy watching and learning about birds.					
4	I like to repair things such as bicycles or cars.					
5	Learning things in biology is easy for me.					
6	Paying attention in physical science classes is hard for me.					
7	I would or do belong to a science-related club.					
8	I am not able to easily understand topics in physical science.					
9	I like going to biology classes because I learn interesting things.					
10	I would not try to learn about science on my own.					
11	I have the ability to be successful in science classes.					
12	Biology seems to be "over my head."					
13	I do not enjoy doing labs in physical science classes					
14	Although sometimes science is difficult, I enjoy trying to understand it.					
15	I am afraid to ask questions in science classes.					
16	I feel overwhelmed in science class.					
17	Learning things in physical science is easy for me					
18	I am able to easily understand topics in biology.					
19	I enjoy reading about science in the newspaper or magazines.					
20	I do not enjoy talking about science with my friends.					

21	Paying attention in biology classes is easy for me.					
22	I enjoy science classes					
23	I would not like to learn more about the weather					
24	I do not enjoy reading about animals that live in the ocean.					
25	I like going to physical science classes because I learn interesting things.					
26	Physical science seems to be "over my head."					
27	Science classes should be required only for students who plan on being scientists.					
28	I have or would like to have a job dealing with animals.					
29	Things that I learn in science classes interest me.					
30	I do not enjoy participating in hands-on activities in biology classes.					
31	The feeling that I have towards science is a good feeling.					
32	When I hear the word science, I have a feeling of dislike					
33	Science is a topic which I enjoy studying					
34	I feel at ease with science and I like it very much					
35	I feel a definite positive reaction to science					
36	Science is boring.					

Thank you for completing this survey.

APPENDIX C– Pretests and Posttests

Mini Unit 1 Physical and Chemical Changes Pre Post Test

Name ________________________ Period ___________

Choose the best answer for each below:

1. _____ A different chemical substance is formed when
   a. A cloth is cut c. a candle burns
   b. A cup breaks d. a piece of chalk falls apart
2. _____ David added a little baking soda to a beaker that contained vinegar. Bubbles started coming from the mixture as a gas was released. The gas was evidence that
   a. The mixture was starting to boil
   b. The air in the flask contracted
   c. A chemical reaction took place
   d. The vinegar and baking soda expanded
3. Use the table below to answer this question.

Mineral	**Vinegar Drops Produce Bubble's**
Limestone	Yes
Sandstone	Probably not
Granite	No
Gneiss	no

   Vinegar is an acid that bubbles when it interacts with calcite. Which mineral contains calcite? _____
   a. Limestone c. sandstone
   b. Granite d. gneisis
4. _____ Mark is observing a burning candle. He notices that the candle wax makes a pool and dribbles down the side of the candle, where it hardens again. The candle wax hardening has undergone
   a. A physical change c. a physical and a chemical change
   b. A chemical change d. the formation of a new substance
5. _____ Which of the following is an example of a chemical property of water? It
   a. Boils at 100 C c. has no odor
   b. Is transparent d. reacts with calcium
6. _____ Which of the following is an example of a physical property of hydrogen? It
   a. Is less dense than air c. is highly flammable
   b. Reacts with oxygen d. forms hydrochloric acid
7. _____Which of the following is true of chemical properties? They
   a. Describe the phase the substance is in
   b. Are measurements of the size or mass of the substance
   c. Explain how the substance reacts with other substances
   d. Predict how much of the substance is found in the universe

8. _____ Two students mix vinegar and baking soda. They observe bubbles forming, baking soda dissolving, and vinegar turning cloudy. They infer that a chemical change has occurred. Which data support this inference?
   a. Bubbles formed c. vinegar evaporated
   b. Baking soda dissolved d. color of vinegar changed

Use the information in this table to answer the next two questions (9 and 10).

Properties of 4 Substances

Substance	Density	Phase at room temperature	Reaction with water	Reaction to flame
Hydrogen gas	.00009g/ml	Gas	None	Burns explosively
Sodium	0.97g/ml	Solid	Violent bubbling reaction	Burns explosively
Carbon	2.2 g/ml	Solid	None	Burns slowly
argon	0.002 g/ml	gas	none	none

9. _____ Which substance showed no chemical change?
   a. Hydrogen c. carbon
   b. Sodium d. argon
10. _____ Which of the properties measured physical properties?
    a. Density & reaction to flame c. reaction to flame and water
    b. Density & phase d. phase & reaction to water
11. _____ Marie Curie was the first scientist to purify and name the element Radon. What must she have done to describe Radon to other scientists?
    a. Discovered its chemical and physical characteristics
    b. Tell them how much she enjoyed finding it in the ore.
    c. Found pictures in a book to share with them
    d. Looked all over the world for other samples of pure Radon

Mini Unit 1 Physical and Chemical Changes Pre Post Test

Read the following information on "gold". Use it to answer the next three questions (12-13):

Gold
Gold is the most malleable metal. A single gram can be beaten into a sheet of one square meter. Gold leaf can be beaten thin enough to allow light to shine through it.
Gold is a good conductor of heat and electricity, and is not affected by air and other chemicals. Heat, moisture, oxygen, and most corrosive agents have very little chemical effect on gold, making it useful for use in coins and jewelry. Because of its low reactivity, pure, metallic gold is tasteless.
In addition, gold is very dense, a cubic centimeter weighing 19.3g. By comparison, the density of lead is 11.3g/cm^3 .

12. _____ Which of the following is a chemical property of gold?
    a. Does not react with most other chemicals.
    b. Is very malleable, can form thin sheets
    c. Is very dense
    d. It forms beautiful and valuable jewelry.
13. _____ Thin sheets of gold of gold are often used to cover clay statues to create the appearance of the stature being made of solid gold. Which property of gold allows it to be used this way?
    a. Taste c. reactivity
    b. Density d. malleability
14. ____ Which properties of gold make it valuable for use in computers and satellites?
    a. It is yellow in color and has no taste.
    b. It conducts electricity and not affected by other chemicals
    c. It forms thin sheets and has a high density
    d. It can be reused to make jewelry and other valuable objects.
15. _____The physical properties of a substance can be observed or measured without ___ the substance.
    a. Chemically changing b. physically changing c. paying for
16. ___ Color, shine, odor, taste, hardness, boiling point, and heat conductivity are all examples of ___ properties.
    a. Physical b. chemical c. none
17. ___ _____ are those characteristics of a substance that can only be observed during a chemical change.
    a. Chemical properties b. physical properties c. states of matter
18. ___ A chemical property is only observed during a chemical change. Chemical changes result in the ___.
    a. Production of new colors
    b. Production of a new substance
    c. Change from liquid to solid

19. Pick one of the following substances (gold, baking soda, or vinegar) and describe a physical property and a chemical property of that substance.

20. An observant chemistry student is enjoying a glass of iced tea during lunch (not in the lab!), and she notices that the color of her drink changes as the ice in the glass melts. Is a chemical reaction occurring? Why or why not?

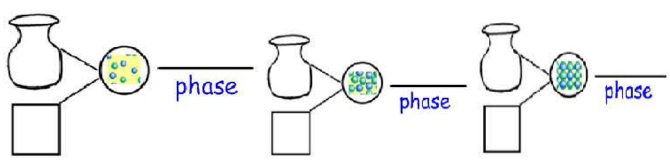
Mini Unit 2 Phase changes

Name ______________________________ Period _______

Choose the best answer for each below:

1. _____ When water in an open pan is heated for a long time, it becomes
   a. solid c. a gas
   b. vacuum d. dew
2. _____ Which of the following is an example of MELTING?
   a. A stirring some sugar in water until you cannot see the sugar
   b. Heating a pan of water until the water is all gone
   c. Heating a block of ice until the ice turns to water
   d. Cooling water in the freezer until the water becomes solid
3. ___An example of a liquid turning into a gas is
   a. A chocolate bar melting
   b. An ice cream cone dripping.
   c. A stick of butter getting warm
   d. Steam escaping from a cup of hot chocolate
4. ____ The state that matter is in depends on how ___ the molecules are moving and how much attraction the molecules have for one another.
   a. Curvy c. straight
   b. Fast d. dense
5. _____ The force of attraction between a ____ molecule is strong enough to keep the volume constant, but not strong enough to give the matter a definite shape.
   a. Solid b. Liquid c. gas
6. _____ The molecules in a ___ do not move around freely, but they do vibrate.
   a. Solid b. Liquid c . Gas d. plasma
7. _____The molecules in a ___ are very far apart and are also moving very quickly.
   a. Solid b. Liquid c. Gas d. plasma
8. _____A ___ has a definite shape and volume.
   a. Solid b. Liquid c. Gas d. plasma
9. _____ The state of matter that expands to fill and take the shape of whatever container they are in.
   a. Solid b. Liquid c. Gases d. plasma
10. _____ State of matter that has a definite volume, but not a definite shape.
    a. Solid b. Liquid c. Gas d. plasma
11. _____In order for matter to change from one state to another, ___ must be added or removed.
    a. Energy b. Layers c. Mass d. gravity
12. _____ What occurs when we add enough energy that a solid changes directly into a gas without first becoming a liquid.
    a. Melting c. condensation
    b. Sublimation d. evaporation

13. _____ Evaporation occurs when a ___
    a. Liquid changes into a gas
    b. Gas turns into a liquid
    c. Solid becomes harder
14. _____ If we add enough energy (in the form of heat) to a solid, it will ___ and become a liquid
    a. Melt b. change color c. Freeze d. over heat
15. _____If we take away enough energy from a gas, it will ___ into a liquid.
    a. Freeze b. Condense c . Melt d. solidify
16. _____If we take away enough energy from a liquid, it will ___ into a solid
    a. Freeze b. Condense c. Melt d. evaporate
17. _____ Which of the following is NOT a way that matter changes phase?
    a. Melting c. evaporation
    b. Freezing d. mixing
18. _____ Something that has volume and mass, is made up of particles called molecules, and can be a solid, liquid, gas, or plasma.
    a. Seawater c. mixture
    b. Matter d. chemical properties
19. _____ What would happen if you tried to squeeze a gas into a smaller container?
    a. The attractive forces between the particles would increase.
    b. The force of the particles would prevent you from doing it.
    c. The particles would have fewer collisions with the container.
    d. The repulsive forces of the particles would pull on the container.
20. Identify and describe the particles in each phase of matter and how they are different in each phase of matter.



A. ________ B. ______________ C. ____________

McWright Mini Unit 3 Elements, Compounds, and Mixtures

Name ______________________________ Period __________

Choose the best answer for each below:

Complete the chart below by marking the true statements with an X.

	ELEMENT	COMPOUND	MIXTURE
1.Consists of elements from the periodic table			
2.Is a pure substance			
3. Are combined physically			
4.Looks the same throughout			
5.Components can change in concentration or proportions			
6.Components are chemically combined			

7. _____ An element is a pure substance in which there are how many kinds of atoms?
   a. two kinds of atoms c. three kinds of atoms
   b. four kinds of atoms d. one kind of atom
8. _____ When two or more elements join together chemically,
   a. compound is formed
   b. a mixture is formed
   c. a substance that is the same as the elements is formed
   d. the physical properties of the substances remain the same
9. _____ Which of the following will NOT break down compounds?
   a. heat c. chemical change
   b. electric current d. filtering
10. _____ How do elements join to form compounds?
   a. randomly c. in a ratio of 1 to 8
   b. in a specific mass ratio d. as the scientist plans it
11. _____ How do properties of a compound compare with the properties of the elements that make up the compound?
   a. only the physical properties are the same
   b. only the chemical properties are the same
   c. all the properties are identical
   d. the properties are different
12. _____By what processes can compounds be broken down?
   a. physical changes c. compound changes
   b. chemical changes d. either physical or chemical changes

13. _____ Which of the following is true about elements?
    a. they are impure substances
    b. they cannot be classified by their properties alone
    c. they cannot be broken down into simpler substances
    d. they have more than one kind of particle

14. _____ If a spoonful of salt is mixed in a glass of water, and the salt disappears what is the role of the water called?
    a. solute c. a solvent
    b. a solution d. an element

15._____In which of the following are particles of two or more substances evenly mixed so they appear to be a single substance?
    a. a compound c. a solution
    b. a mixture d. an element

16. _____ When materials combine to form a mixture, they
    a. keep their original properties
    b. react to form a new substance with new properties
    c. combine in a specific ratio
    d. always change their physical state

17. _____Which is the best way to get salt from salty water?
    a. evaporation c. filtration
    b. distillation d. use a spoon

18. _____ Which of the following is a homogeneous mixture?
    a. tossed salad c. lemonade without pulp
    b. soil d. vegetable soup

19. Why doesn't water appear in the periodic table?

20. Describe two tests that you can run to determine if something is a pure substance or a mixture.

APPENDIX C – IRB Approval Letter

THE UNIVERSITY OF
SOUTHERN MISSISSIPPI.

INSTITUTIONAL REVIEW BOARD
118 College Drive #5147 | Hattiesburg, MS 39406-0001
Phone: 601.266.5997 | Fax: 601.266.4377 | www.usm.edu/research/institutional.review.board

NOTICE OF COMMITTEE ACTION

The project has been reviewed by The University of Southern Mississippi Institutional Review Board in accordance with Federal Drug Administration regulations (21 CFR 26, 111), Department of Health and Human Services (45 CFR Part 46), and university guidelines to ensure adherence to the following criteria:

- The risks to subjects are minimized.
- The risks to subjects are reasonable in relation to the anticipated benefits.
- The selection of subjects is equitable.
- Informed consent is adequate and appropriately documented.
- Where appropriate, the research plan makes adequate provisions for monitoring the data collected to ensure the safety of the subjects.
- Where appropriate, there are adequate provisions to protect the privacy of subjects and to maintain the confidentiality of all data.
- Appropriate additional safeguards have been included to protect vulnerable subjects.
- Any unanticipated, serious, or continuing problems encountered regarding risks to subjects must be reported immediately, but not later than 10 days following the event. This should be reported to the IRB Office via the "Adverse Effect Report Form".
- If approved, the maximum period of approval is limited to twelve months. Projects that exceed this period must submit an application for renewal or continuation.

PROTOCOL NUMBER: 16120705
PROJECT TITLE: A Comparative Study Teaching Chemistry Using the 5 E Learning Cycle & Traditional Teaching with a Large English Language Population in a Middle School Setting
PROJECT TYPE: New Project
RESEARCHER(S): Cynthia Nicole McWright
COLLEGE/DIVISION: College of Science and Technology
DEPARTMENT: Center for Mathematics and Science
FUNDING AGENCY/SPONSOR: N/A
IRB COMMITTEE ACTION: Expedited Review Approval
PERIOD OF APPROVAL: 01/09/2017 to 01/08/2018
Lawrence A. Hosman, Ph.D.
Institutional Review Board

APPENDIX D – District Consent Forms

[redacted]

[redacted] *School Effectiveness & Accountability*

[redacted]

Dav[redacted]
Director of Assessment & Accountability

November 10, 2016

Nicole McWright
[redacted]e
Aurora, CO 80016

Dear Nicole,

Congratulations, your request to conduct research has been approved.

As a guideline, please note the following requirements for your project: Comparative Study Teaching chemistry using the 5E Learning Cycle

<u>**You must receive the permission of the principal to conduct the study.**</u>

- No research can be conducted before **<u>October 1, 2016 or after May 1, 2017.</u>**
- You must obtain signed <u>parent permission</u> from each student included in your study. Maintain a file of these permission slips throughout the course of your study. No surveys or research can be conducted with students without parent permission.
- [redacted]ipants, including the school district must be assured.
- [redacted]chools must receive a copy of your results at the completion of your study.

The school district appreciates your interest and cooperation. If you have any questions, please call me at 720-972-6949.

Sincerely,

David [redacted]

David[redacted]
Director of Assessment & Accountability
School Effectiveness & Accountability
[redacted]

Broomfield Federal Heights Northglenn Thornton Westminster

[redacted]

STEM Launch K-8

Off[redacted]

Kelli[redacted]th
Principal

December 9, 2016

Dear Review Board:

I give permission for Nicole McWright to use her 8th grade science classes to collect data for her dissertation at the University of Southern Mississippi. I understand that the Institutional Review Board (IRB) has to approve of the research to make sure it is valid and will not harm human subjects. If you have any questions or concerns, please feel free to contact me at 720-972-5120.

Sincerely,

Martin[redacted]y
Assistant Principal

Broomfield Federal Heights Northglenn Thornton Westminster

APPENDIX E – IRB Consent Forms

ORI | Office *of* Research Integrity

INSTITUTIONAL REVIEW BOARD

PARENTAL CONSENT FORM

PARENTAL CONSENT PROCEDURES

This document must be completed by the Principal Investigator and signed by the parent or guardian of each potential research participant.

- The Project Information and Research Description sections of this form should be completed by the Principal Investigator before submitting this form for IRB approval.
- Signed copies of the long form consent should be provided to a parent or guardian of every participant.

Last Edited May 22nd, 2014

Today's date:		
PROJECT INFORMATION		
Project Title: Comparative Study Teaching chemistry Using the 5E Learning Cycle and Traditional Teaching with a Large ELL Population in a Middle School Setting		
Principal Investigator: Nicole McWright	Phone: 720-287-3808	Email: cynthia.mcwright@usm.edu
College: Science and Technology	Department: Center for Science and Mathematics Education	
RESEARCH DESCRIPTION		

1. **Purpose**:

The study will compare the 5E learning cycle teaching strategy with the traditional style of teaching and students attitudes toward science.

2. **Description of Study:**

All students are required to complete the chemistry unit as part of their regular schoolwork but your child is not required to participate in this study. If you agree to allow your child to take part in this study, your child will be asked to fill out an initial science attitudes survey during his/her science class. Your child will be asked to rate how much he or she agrees with statements about science. The same form will be completed at the end of the teaching unit. Your child will then participate in the teaching of a chemistry science unit over the course of four weeks. This will take place during normal class time. Students will be asked to answer questions about what they have learned on a daily basis.

3. **Benefits:**

There are not direct benefits for those students choosing to participate is this study, however, their participation might improve the quality of teaching chemistry concepts to secondary students.

4. **Risks:**

The risks to you and your child are minimal. The information that is obtained during this research project will be kept strictly confidential and will not become a part of your child's school record. Any sharing or publication of the research results will not identify any of the participants by name.

5. **Confidentiality:**

All information about you and your child will be kept confidential and will not be released. Questionnaires will be identified by subject number only, rather than names on them. All information will be kept in a secure place that is open only to the research. This information will be saved as long as it is scientifically useful: typically, such information is kept for five years after publication of the results. Results from this study may be presented at professional meetings or in publications. You and your child will not be identified individually; I will be looking at the group as a whole.

6. **Alternative Procedures:**

NA

7. **Participant's Assurance:**

This project has been reviewed by the Institutional Review Board, which ensures that research projects involving human subjects follow federal regulations.

Any questions or concerns about rights as a research participant should be directed to the Manager of the IRB at 601-266-5997.Participation in this project is completely voluntary, and participants may withdraw from this study at any time without penalty, prejudice, or loss of benefits.

Any questions about the research should be directed to the Principal Investigator using the contact information provided in Project Information Section above.

PARENTAL CONSENT INFORMATION	
Participant's Name:	Participant's Age:
Parent or Guardian's Name:	
Person Soliciting Parental Consent:	

AGREEMENT TO ALLOW PARTICIPATION IN RESEARCH

Consent is hereby given to participate in this research project. All procedures and/or investigations to be followed and their purpose, including any experimental procedures, were explained. Information was given about all benefits, risks, inconveniences, or discomforts that might be expected.

The opportunity to ask questions regarding the research and procedures was given. Participation in the project is completely voluntary, and participants may withdraw at any time without penalty, prejudice, or loss of benefits. All personal information is strictly confidential, and no names will be disclosed. Any new information that develops during the project will be provided if that information may affect the willingness to continue participation in the project.

Questions concerning the research, at any time during or after the project, should be directed to the Principal Investigator with the contact information provided above. This project and this consent form have been reviewed by the Institutional Review Board, which ensures that research projects involving human subjects follow federal regulations. Any questions or concerns about rights as a research participant should be directed to the Chair of the Institutional Review Board, The University of Southern Mississippi, 118 College Drive #5147, Hattiesburg, MS 39406-0001, (601) 266-5997.

	Nicole McWright
____________________	____________________
Parent or Guardian of Research Participant	**Person Explaining the Study**
____________________	____________________
Date	**Date**

straker TRANSLATIONS

1330 Avenue of the Americas, Suite 23
New York City, NY, 10019
+1 646 457 4093
info@strakertranslations.com | www.strakertranslations.com

[logo] Office of Research Integrity (Oficina de Integridad en la Investigación de los Estados Unidos)

INSTITUTIONAL REVIEW BOARD
(COMITÉ DE REVISIÓN INSTITUCIONAL)

FORMULARIO DE CONSENTIMIENTO PARENTAL

PROCEDIMIENTOS PARA EL CONSENTIMIENTO PARENTAL

Este documento lo debe completar el Investigador Principal y lo debe firmar el padre o tutor de cada posible participante de la investigación.

- Las secciones "Información sobre el proyecto" y "Descripción de la investigación" de este formulario las debe completar el Investigador Principal antes de enviar este formulario para que lo apruebe el IRB (Comité de Revisión Institucional).
- Se deben proporcionar copias del consentimiento del formulario largo al padre o tutor de cada participante.

Última edición: 22 de mayo de 2014

Fecha actual: 11 de octubre de 2016		
INFORMACIÓN SOBRE EL PROYECTO		
Título del proyecto: Estudio comparativo entre la enseñanza de química utilizando el ciclo de aprendizaje de las 5 E y la enseñanza tradicional a una gran población de alumnos hablantes de inglés en un entorno de enseñanza secundaria.		
Investigador Principal: Nicole McWright	Teléfono: 720-287-3808	E-mail: cynthia.mcwright@usm.edu
Facultad: Ciencia y Tecnología	Departamento: Centro para la educación en ciencia y matemática	
DESCRIPCIÓN DE LA INVESTIGACIÓN		

1. **Objetivo:**

El estudio comparará la estrategia de enseñanza del ciclo de aprendizaje de las 5 E con el estilo de enseñanza tradicional, así como la actitud de los estudiantes con respecto a la ciencia.

2. **Descripción del estudio:**

Todos los estudiantes están obligados a completar la unidad de química como parte de sus tareas escolares habituales pero su hijo/a no está obligado/a a participar de este estudio. Si usted permite que su hijo/a participe de este estudio, se le solicitará a su hijo/a que complete una encuesta inicial acerca de las actitudes durante su clase de ciencias. También se le solicitará que califique cuánto coincide con ciertas afirmaciones vinculadas con la ciencia. Completará el mismo formulario al final

straker TRANSLATIONS

1330 Avenue of the Americas, Suite 23
New York City, NY, 10019
+1 646 457 4093
info@strakertranslations.com I www.strakertranslations.com

de la unidad de aprendizaje. Entonces, su hijo/a participará de la enseñanza de una unidad de ciencias químicas durante cuatro semanas. Esto se llevará a cabo durante el tiempo habitual de clases. Se les pedirá a los estudiantes que respondan preguntas sobre lo que aprendieron en forma diaria. Cada estudiante participará en una prueba previa y posterior a cada miniunidad de aprendizaje.

3. **Beneficios:**

No existen beneficios directos para los estudiantes que decidan participar en este estudio; sin embargo, es posible que su participación mejore la calidad de la enseñanza de los conceptos de química a alumnos de la escuela secundaria.

4. **Riesgos:**

Los riesgos para usted y su hijo/a son mínimos. La información que se obtenga durante este proyecto de investigación será estrictamente confidencial y no será parte del registro escolar de su hijo/a. Ninguna divulgación o publicación de los resultados de la investigación identificará a ningún participante por su nombre.

5. **Confidencialidad:**

Toda la información acerca de usted y su hijo/a será confidencial y no se divulgará. Los cuestionarios solo se identificarán con el número del sujeto, no por los nombres. Toda la información se guardará en un lugar seguro que solo se abrirá para la investigación. Esta información se guardará durante todo el tiempo que sea útil desde el punto de vista científico; en general, la información se guarda durante cinco años después de la publicación de los resultados. Es posible que los resultados de este estudio se presenten en reuniones profesionales o en publicaciones. No se lo identificará a usted ni a su hijo/a individualmente; analizaré el grupo en conjunto.

6. **Procedimientos alternativos:**

ND

7. **Seguridad del participante:**

Este proyecto fue revisado por el Institutional Review Board, que asegura que los proyectos de investigación en los que participan sujetos humanos cumplen con las normas federales.

Si tiene alguna pregunta o inquietud acerca de sus derechos como sujeto de investigación debe dirigirlas al Gerente del IRB al 601-266-5997. La participación en este proyecto es completamente voluntaria, y los participantes pueden renunciar a este estudio en cualquier momento sin estar sujetos a ninguna penalidad, perjuicio o pérdida de beneficios.

Si tiene alguna pregunta acerca de la investigación debe dirigirla al Investigador Principal utilizando la información de contacto que se indica en la sección "Información sobre el proyecto" que se encuentra más arriba.

INFORMACIÓN SOBRE EL CONSENTIMIENTO PARENTAL

Job ID No. TJ360013

straker TRANSLATIONS

1330 Avenue of the Americas, Suite 23
New York City, NY, 10019
+1 646 457 4093
info@strakertranslations.com I www.strakertranslations.com

Nombre del participante:	Edad del participante:
Nombre del padre o tutor:	
Persona que solicita el consentimiento parental:	

ACEPTACIÓN PARA PERMITIR LA PARTICIPACIÓN EN LA INVESTIGACIÓN

Por este medio presto el consentimiento para participar en este proyecto de investigación. Se explicaron todos los procedimientos e investigaciones que se realizarán y su objetivo, incluidos todos los procedimientos experimentales, de corresponder. Se brindó información acerca de todos los beneficios, riesgos, inconvenientes o incomodidades que pueden esperarse.

Se brindó la oportunidad de formular preguntas en cuanto a la investigación y a los procedimientos. La participación en el proyecto es completamente voluntaria, y los participantes pueden renunciar en cualquier momento sin estar sujetos a ninguna penalidad, perjuicio o pérdida de beneficios. Toda la información personal es estrictamente confidencial y no se revelará ningún nombre. Toda la información nueva que surja durante el proyecto se brindará siempre que dicha información afecte la voluntad de continuar la participación en el proyecto.

Las preguntas acerca de la investigación, en cualquier momento durante el proyecto o con posterioridad, deben dirigirse al Investigador Principal utilizando la información de contacto que se brinda más arriba. El proyecto y el formulario de consentimiento fueron revisados por el Institutional Review Board, que asegura que los proyectos de investigación en los que participan sujetos humanos cumplen con las normas federales. Si tiene alguna pregunta o inquietud acerca de los derechos como participante de una investigación que involucra a sujetos humanos, debe dirigirla al Presidente del Institutional Review Board, The University of Southern Mississippi, 118 College Drive #5147, Hattiesburg, MS, 39406-0001, (601) 266-5997.

Nicole McWright

_______________________ ---

Padre o tutor del participante de la investigación — Persona que explica el estudio

_______________________ _______________________

Fecha — Fecha

CERTIFIED TRANSLATION ★ STRAKER TRANSLATIONS ★ www.strakertranslations.com info@strakertranslations.com EUROPEAN STANDARD EN: 15038 & ISO 9001 CERTIFIED

ORI | Office of Research Integrity

INSTITUTIONAL REVIEW BOARD

MINOR ASSENT FORM

MINOR ASSENT PROCEDURES
This document must be completed by the Principle Investigator and signed by each assenting minor. • The Project Information and Research Description sections of this form should be completed by the Principal Investigator before submitting this form for IRB approval. • Parental consent must be obtained before soliciting the assent of any minor participating in the study. • Signed copies of the IRB approved assent form should be provided to a parent or guardian of every assenting minor. Last Edited May 22nd, 2014

Today's date:

PROJECT INFORMATION

Project Title: A Comparative Study Teaching Chemistry Using the 5 E Learning Cycle and Traditional Teaching with a Large English Language Population in a Middle School Setting"

Principal Investigator: Cynthia N. McWright	Phone: 720-287-3808	Email: cynthia.mcwright@usm.edu
College: Science and Technology	Department: Center for Mathematics and Science	

RESEARCH DESCRIPTION

1. **Why am I being asked to participate?**

The purpose of this investigation is to fulfill a partial requirement of my graduate studies.It is being performed to determine if the 5 E learning cycle increases students learning when compared to the traditional style of teaching. The results of this investigation could be used to help future students retain their learning of science and increase students interest in science.

2. **What will I have to do?**

All students are required to complete all assignments related to topic taught as part of their regular schoolwork but you are not required to participate in this study. Students will be asked to take a pre and post test on content, a pre and post survey on student interest/attitude in science, complete a three question reflection sheet at the end of each day as an exit ticket, and participate in a classroom setting that is either using the 5 E method or traditional method. The investigation will last for approximately one month and will involved approximately 160 8th grade students. The time required for each participate will be normal class time as their normal science class.

3. **What do I get if I agree to participate?**

There are no direct benefits for participating in this study. Your participation in the study could benefit others in the future by making learning science more interesting, relevant and improve the quality of teaching science.

4. **Can anything bad happen if I participate?**

There are minimal to no risk for participating in this study.

5. **Who will get to see information about me?**

The information that is obtained during this project will be kept strictly confidential and will not become a part of your school record. Any sharing or publication of the research results will not identify you by name. All information about the student will be kept confidential and will not be released. All information will be kept iin a secure place that is open only to the researcher. This information will be saved as long as it is scientifically useful. Results from this study may be presented at professional meetings or in publications.It is possible that the consent process and data collection will be observed by research oversight staff responsible for safeguarding people who participate in the study.

6. **What if I do not want to participate?**

If you do not want to participate in this study you do not have to and your grade will not be affected. Your participation is completely voluntary. You are free to to withdraw from the study at any time and for any reason without penalty. These decisions will have no affect on you. However all students will be required to complete required assignments for this class based on school curriculum.

7. **Who may I contact if I have other questions or concerns about my participation?**

This project has been approved by the Institutional Review Board. Its job is to protect research participants. Questions or concerns about your participation should be directed to the Manager of the IRB at 601-266-5997.

ASSENT TO PARTICIPATE IN RESEARCH

Participant's Name:	Participant's Age:
Person Soliciting Assent: Cynthia N. McWright	

Check one of the following (to be completed by the person soliciting assent):

☒ In my opinion this minor is able to provide informed assent (proceed to Agreement to Participate).
☐ In my opinion this minor is unable to provide informed assent for the following reason(s) (do not proceed):

AGREEMENT TO PARTICIPATE

I agree to participate in this research project. The project has been fully explained to me and I was given the chance to ask any questions I have about it. I understand that I can stop participating at any time.

	Cynthia N. McWright
Research Participant	**Person Soliciting Assent**
Date	**Date**

APPENDIX F –Mini-Unit 1

Introduction to Matter: Ch. 1
Properties of Matter

An 8th Grade Science Presentation

What is Matter?

- Anything that has mass and takes up space.
- "Everything is made of matter."

Physical Properties of Matter

- Physical properties can be observed or measured WITHOUT changing the matter.

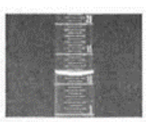
- Volume
- Mass
- Weight
- Inertia
- Density

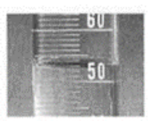
What is Volume?

- Volume is the amount of space that is taken up by a form of matter.
- Liquid is measured using a graduated cylinder- Units are in milliliters
- Solid is measured by using the formula: length x width x height
  - Units are in cubic units

Reading a Graduated Cylinder

- Pour in an amount of water.
- Get down to eye level.
- Looking at the bottom of the meniscus, or dip, read the measurement in mL.



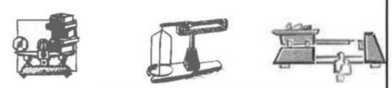


Volume for an Irregular Object: Displacement Method

- Pour in an amount of water.
- Looking at the bottom of the meniscus, or dip, read the measurement in mL.
- Add your object.
- Once again, look at the meniscus and get the measurement.
- Find the difference.

What is mass?

- The amount of matter in an object.
- The mass of an object WILL NOT change throughout the universe.
- Usually measured in grams (g), kilograms (kg), or milligrams (mg) with a Balance Scale.



What is weight?

- The amount of gravitational force exerted on an object.
- Usually measured in Newtons (N) using a spring scale. 1 N= 100g

What is inertia?

- The tendency of an object to resist change in motion.
- Newton's 1st Law of Motion- An object in motion will remain in motion and an object at rest will remain at rest unless acted upon by a force.
- Mass is a measure of inertia. The larger the mass, the harder it is to move.

What is density?

- The amount of matter in a given space in a certain volume of liquid.
- Density = Mass / Volume

Some other examples of Physical Properties:

- Color/Shiny
- Odor
- Thermal Conductivity- heat transfer (energy transfer)
- State of Matter- Solid, Liquid, Gas
- Solubility- Ability to dissolve in another substance.
- Ductility- Ability to bend onto wire.
- Malleability- Ability to be rolled or pounded into sheets.

Physical Change

- A change in matter from one form to another WITHOUT changing what it is made of.
- Change of State
- Dissolving
- Bending
- Molding

Chemical Properties of Matter

- A property that describes how matter can change into NEW matter with DIFFERENT properties.
- Flammability- the ability to burn
- Reactivity- the ability to combine and form a new substance.

Chemical Changes

- When one or more substances change into new substances with DIFFERENT properties.
- Most of the time the change cannot be reversed.
- Indicators of change: bubbles of gas, color, odor, heat/light.

Properties of Acids and Bases

Acids

- Taste sour or tart.
- Feel like water.
- Stinging sensation on the skin.
- Electrolyte (good conductor of electricity)
- Reacts with Metal.
- Ex. Vitamin C, Vinegar, and Soda

Bases

- Bitter Taste.
- Feel Slippery.
- Electrolyte (good conductor of electricity)
- Does NOT react with metal.
- Ex. Soap

pH
(The power of Hydrogen)

~ pH scale ranges from 0 -14

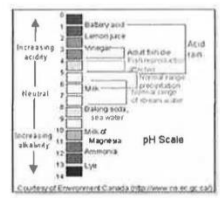
~ pH 7 is neutral

~ Distilled water is pH 7

~Low pH (1-6)= acid

~High pH (8-14)= base

~The closer to the ends of the scale, the stronger the acid or base.



Think... Pair... Share

During lunch, you and your friends decided to eat as many tacos with hot sauce as you could. Now, at the end of the day, you are experiencing heartburn so you decide to ask the school nurse for antacid tablets. You read on the label that the active ingredient is calcium carbonate. Explain to your friends, who are also in pain, how and why the antacid will work in the stomach.

1. All of the following are examples of erosion EXCEPT:

A. The wind in the desert blows sand against a rock.
B. A glacier picks up boulders as it moves.
C. A flood washes over a riverbank, and the water carries small soil particles downstream.
D. An icy winter causes the pavement in a road to crack.

Answer: D

Name: ___________________________
Date: _____________
Period: ________

Properties of Matter Power Point Notes
(Introduction to Matter Textbook Chapter One)

1. What is Matter?
   a. Anything that has ____________ and takes up ___________.
   b. "________________ is made of matter."
2. Physical Properties of Matter:
   a. Physical Properties can be _____________ or ______________ WITHOUT changing the matter.
   b. Volume, ________, Weight, _________, Density.
3. What is Volume?
   a. Volume is the amount of _____________ that is taken up by a form of matter.
   b. Liquid is measured using a _____________ ______________- Units are in _______________.
   c. Solid is measured by using the formula _________________- Units are in __________ ___________.
4. Reading a Graduated Cylinder:
   a. Pour in an amount of liquid.
   b. Get down to __________ ___________.
   c. Looking at the bottom of the _______________, or dip, read the measurement in mL.
5. Volume for an Irregular Object: Displacement method
   a. Pour in an amount of water.
   b. Looking at the bottom of the _______________, or dip, read the measurement in mL.
   c. Add your object.
   d. Once again, look at the _____________ and get the measurement.
   e. Find the _____________. (Subtract)
6. What is mass?
   a. The amount of _____________ in an object.
   b. The mass of an object WILL ________ change throughout the universe.

c. Usually measured in ________ (g), ____________ (kg), or _______________ (mg) with a ___________ ____________.

7. What is weight?
   a. The amount of ______________ _________ exerted on an object.
   b. Usually measured in ____________ (N) using a _________ _________. 1 N = 100 g

8. What is inertia?
   a. The tendency of an object to __________ change in motion.
   b. _________________________- An object in motion will remain in motion and an object at rest will remain at rest unless acted upon by a force.
   c. __________ is a measure of inertia. The _________ the mass, the harder it is to move.

9. What is density?
   a. The amount of _____________ in a given space in a certain _______________ of liquid.
   b. Density = ___________ divided by ___________.

10. Some other examples of Physical Properties:
    a. Color
    b. Odor
    c. Thermal Conductivity- __________ transfer (energy transfer)
    d. State of Matter- ___________, ____________, or _________.
    e. Solubility- ability to ____________ in another substance.
    f. Ductility- ability to _______ into wire.
    g. Malleability- ability to be ___________ or ____________ into sheets. (Mallet)

11. Physical Change:
    a. A change in matter from one form to another __________ changing what it is made of.
    b. Change of __________
    c. Dissolving
    d. ___________
    e. Molding

12. Chemical Properties of Matter:
    a. A property that describes how matter can change into _______ matter with ____________ properties.
    b. Flammability- the ability to ___________.

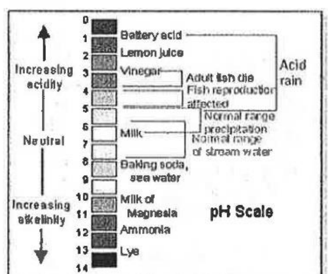
c. Reactivity- the ability to _________ and form a _____ substance.

13. Chemical Changes:
    a. When one or more substances change into ________ substances with ___________ properties.
    b. Most of the time the change ________ be reversed.
    c. Indicators of change: _______ of gas, color, _____, heat/ _________.

14. Acids
    a. Tastes ___________or tart.
    b. Feels like _____________.
    c. Stinging sensation on the skin.
    d. Electrolyte (good ____________________ of electricity)
    e. ______________ with Metal.
    f. Ex. Vitamin C, Vinegar, and Soda

15. Bases
    a. ____________ Taste.
    b. Feels Slippery.
    c. Electrolyte (good ______________ of electricity)
    d. Does NOT react with metal.
    e. Ex. Soap

16. pH
    a. pH scale ranges from 0 -14
    b. pH 7 is _________________
    c. Distilled water is pH 7
    d. Low pH (1-6)= __________________
    e. High pH (8-14)= base
    f. The closer to the ends of the scale, the stronger the acid or base.



Courtesy of Environment Canada (http://www.rs.ec.gc.ca/)

Crime Scene Lab

Using chemistry to solve crimes is a very common practice. Chemical and physical properties of substances can be used to match a suspect to a crime scene. This is very frequently done with blood samples, but as no one was willing to donate about a quart of blood for this experiment, we will have to use simpler substances.

Question: **Can you match a suspect to the crime scene?!**

Materials:

-Test tube samples (given by teacher)
-1 towel
-1 test tube rack
-tape
-pen
-Sample of iodine
-sample of vinegar
-sample of water

Procedure:

1-place a placemat on the desk to keep your desk clean
2-get one test tube rack
3-get 3 of each test sample for your rack
4-at your desk, label each sample (to help keep track)
5-use the medicine dropper to test each sample for each test
(**Water will be added to every sample**)
6-record your results in the data table on the back
7-when your tests are completed; wash out each test tube in the sink
(**failure to clean up, will result in loosing 50% off your score**)
8-return your CLEAN test tubes and CLEAN racks to the front
9-complete the questions that follow

KEY:

Use the following terms to fill in your table based upon the lab results:

No change = no rxn occurs (they just form a mixture)
Dissolved = the particles are simply dissolved in the liquid
Fizzed = reaction caused bubbles to actively form
Turned (Color) = describe a specific color resulting from the rxn

Sample	Test: Adding **Water**	Test: Adding **Vinegar**	Test: Adding **Iodine**
Cornstarch (Control Sample)			
Baking soda (Control Sample)			
Baking powder (Control Sample)			
Powdered Sugar (Control Sample)			
Crime Scene (Test Sample)			
Suspects A (Test Sample)			
Suspect B (Test Sample)			

Questions: 2pts each

1) **Which test was most helpful to determine the different substances present for the Crime scene and the Suspects?**

2) **Can you connect a suspect to the crime scene?**

3) **Which substance did both the crime scene and the suspect have in common?**

4) **What were some possible factors (variables) that made analyzing the results difficult?**

5) **Why is a simple observation of only physical properties alone not sufficient to make solid conclusions of our substances?**

6) **Which suspect did you infer was the guilty one (circle one)?**
SUSPECT A   SUSPECT B   BOTH INNOCENT   BOTH GUILTY

OOBLECK LAB PHASES OF MATTER

Purpose: (+ 1) To determine the state of matter of an unknown substance (Oobleck)

Hypothesis: (+ 2) If we mix cornstarch & water, then the substance's state of matter will be ______________________________. I believe this because...__________________________
____
______

(Write at least two sentences to explain why you made the hypothesis that you did. Use at least 2 scientific vocabulary words in your explanation)

LIST 3 PROPERTIES FOR EACH:

SOLID:

LIQUIDS

GASES

DATA TABLE TEST FOR THE FOLLOWING AND RECORD OBSERVATIONS:

WHAT I DID I DO	WHAT HAPPENED	BEHAVIOR(STATE OF MATTER)
PUSH IT		
PICK IT UP		
POUR TEST		
SHAPE TEST		
TRY TO CUT IT		
SLAP TOP OF IT		
MAKE A SNAKE AND PULL IT APART		
MAKE A BALL IN YOUR HAND		

WRITE CONCLUSION PARAGRAPH MAKE A CLAIM (THE ANSWER TO THE QUESTION) GIVE SUPPORTING EVIDENCE FROM THE DATA YOU COLLECTED AND PROVIDE REASONING (THE SCIENCE BEHIND IT) USED SCIENCE ACADEMIC VOCABULARY.

QUESTION: WHAT STATE OF MATTER IS OOBLECK?

http://chburrellscience.weebly.com/properties-of-matter-unit.html

Properties of Matter Unit Vocabulary

Main Concepts of Properties

1) All ______________ is made up of ____________________ and/or __________________.
2) ____________________ are dependant upon the amount of ____________ ____________________ the substance. And how the _____________ affects ____ in the substance.
3) All substances _______________________ at a certain temperature unique for that substance. __________ and _____________ don't matter…
4) The _________________ difference between each phase is the ____________ of _______________ the atoms and molecules have.

Vocabulary Terms:

1) **Chemistry**
   Definition:

2) **Matter**
   Definition:

3) **Substance**
   Definition:

4) **Mixture**
   Definition:

   Examples (write multiple):

5) **Elements**
   Definition:

   Examples:

6) **Molecules**
   Definition:

   Examples:

7) Properties

Definition:

Fill in the chart:

8) Changes:

Fill in the chart:

9) Phases:

What are phases?

What are the main phases?

10) Solid:

a. Amount of Energy:

b. Bond strength:

c. Shape:

d. Volume:

e. Molecule Distance:

11) Liquid:

a. Amount of Energy:

b. Bond strength:

c. Shape:

d. Volume:

e. Molecule Distance:

12) Gas:

a. Amount of Energy:

b. Bond strength:

c. Shape:

d. Volume:

e. Molecule Distance:

13) Melting:

____________________ Turns into ____________________

14) Evaporation (vaporizing):

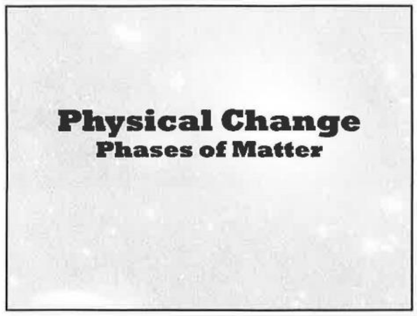
____________________ Turns into ____________________

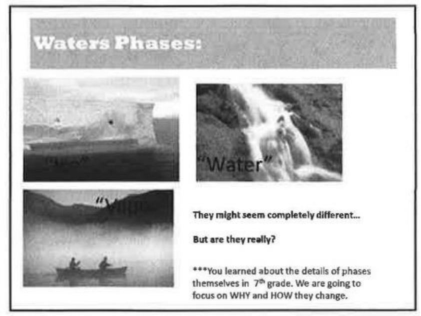
15) Condensing:

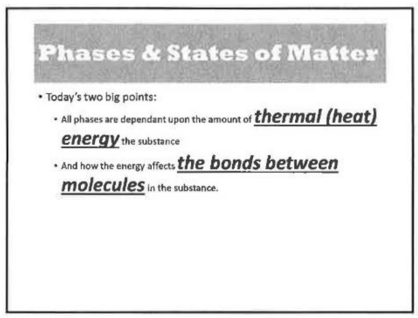
____________________ Turns into ____________________

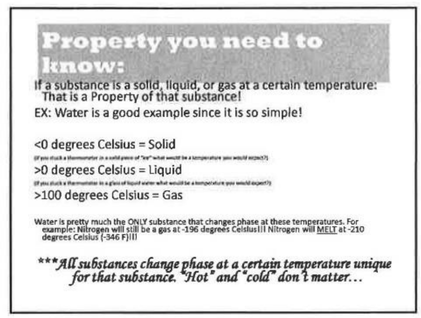
16) Freezing:

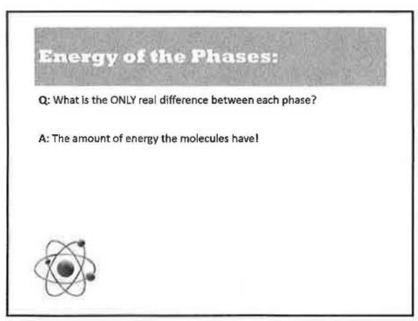
____________________ Turns into ____________________

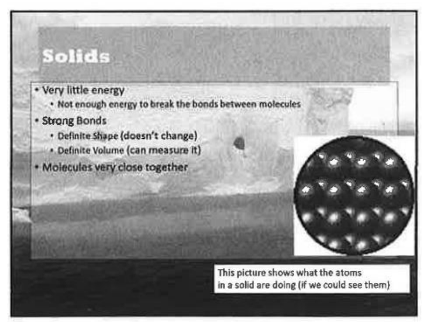

Physical Change
Phases of Matter

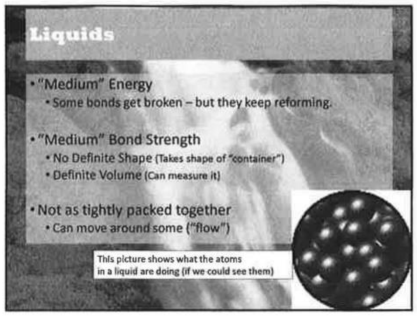

Waters Phases:
"Water"
They might seem completely different...
But are they really?
***You learned about the details of phases themselves in 7th grade. We are going to focus on WHY and HOW they change.

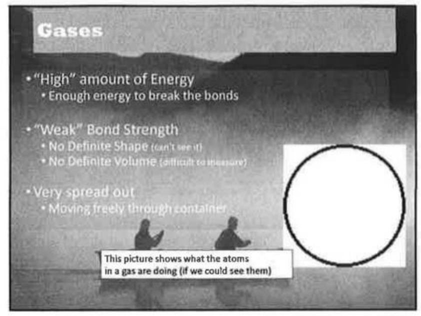

Phases & States of Matter
• Today's two big points:
• All phases are dependant upon the amount of thermal (heat) energy the substance
• And how the energy affects the bonds between molecules in the substance.

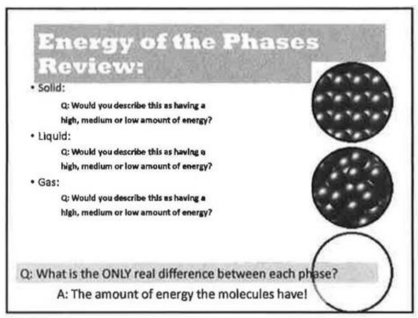

Property you need to know:
If a substance is a solid, liquid, or gas at a certain temperature: That is a Property of that substance!
EX: Water is a good example since it is so simple!
<0 degrees Celsius = Solid
>0 degrees Celsius = Liquid
>100 degrees Celsius = Gas
Water is pretty much the ONLY substance that changes phase at these temperatures. For example: Nitrogen will still be a gas at -196 degrees Celsius!!! Nitrogen will MELT at -210 degrees Celsius (-346 F)!!!
***All substances change phase at a certain temperature unique for that substance. "Hot" and "cold" don't matter...

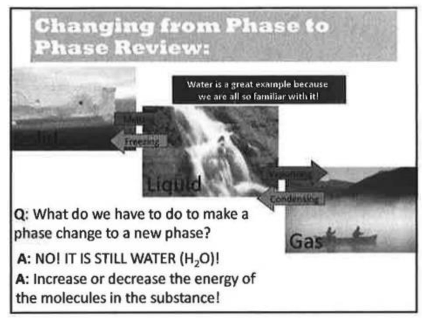

Energy of the Phases:
Q: What is the ONLY real difference between each phase?
A: The amount of energy the molecules have!


Solids
• Very little energy
• Not enough energy to break the bonds between molecules
• Strong Bonds
• Definite Shape (doesn't change)
• Definite Volume (can measure it)
• Molecules very close together
This picture shows what the atoms in a solid are doing (if we could see them)


Liquids
• "Medium" Energy
• Some bonds get broken – but they keep reforming.
• "Medium" Bond Strength
• No Definite Shape (Takes shape of "container")
• Definite Volume (Can measure it)
• Not as tightly packed together
• Can move around some ("flow")
This picture shows what the atoms
in a liquid are doing (if we could see them)


Gases
• "High" amount of Energy
• Enough energy to break the bonds
• "Weak" Bond Strength
• No Definite Shape
• No Definite Volume
• Very spread out
This picture shows what the atoms
in a gas are doing (if we could see them)


Energy of the Phases Review:
• Solid:
Q: Would you describe this as having a high, medium or low amount of energy?
• Liquid:
Q: Would you describe this as having a high, medium or low amount of energy?
• Gas:
Q: Would you describe this as having a high, medium or low amount of energy?
Q: What is the ONLY real difference between each phase?
A: The amount of energy the molecules have!


Changing from Phase to Phase Review:
Water is a great example because we are all so familiar with it!
Freezing
Liquid
Condensing
Gas
Q: What do we have to do to make a phase change to a new phase?
A: NO! IT IS STILL WATER (H_2O)!
A: Increase or decrease the energy of the molecules in the substance!

Boiling Water Lab

Purpose: To find the boiling point of water at our elevation (1640 m, or 4790 ft) as compared to sea level. And to understand the graph that phase changes make.

Materials: 250 mL beaker, ice, thermometer, thermometer clamp, ring stand, Bunsen burner, tubing.

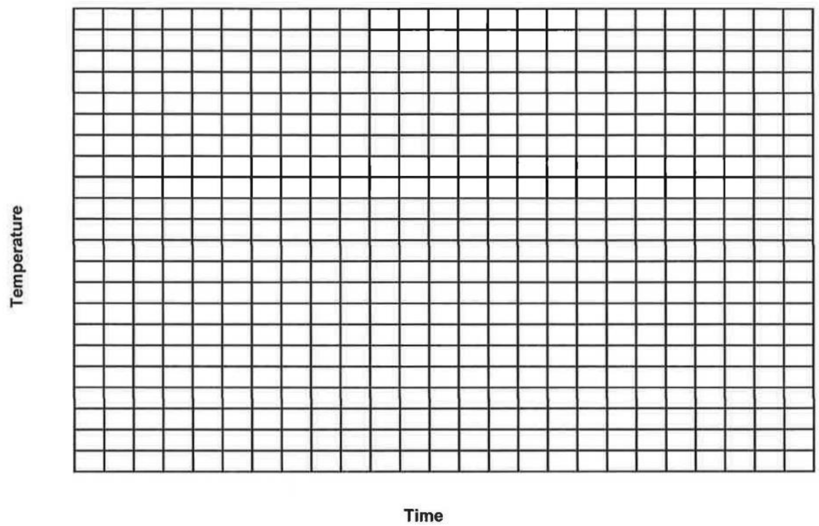
Procedure:

1. Set up apparatus as demonstrated
2. Add ~100 mL of water (fill with ice to top of beaker & a tbs of rock salt)
3. Record the temperature to 3 minutes (6 - 30 second intervals).
4. Light the Bunsen burner.
5. Record the temperature for every 30 seconds **continuously**!!!
6. Indicate on your data table when the water is boiling (as close as possible)
7. Let it boil for 3 minutes
8. Graph your results
9. Clean up the lab – prepare it for another group. Use warm water!!!
10. Answer the questions

Data: (15 points)

Time	Temp	Time	Temp	Time	Temp
0:00		8:30		17:00	
0:30		9:00		17:30	
1:00		9:30		18:00	
1:30		10:00		18:30	
2:00		10:30		19:00	
2:30		11:00		19:30	
3:00		11:30		20:00	
3:30		12:00		20:30	
4:00		12:30		21:00	
4:30		13:00		21:30	
5:00		13:30		22:00	
5:30		14:00		22:30	
6:00		14:30		23:00	
6:30		15:00		23:30	
7:00		15:30		24:00	
7:30		16:00		24:30	
8:00		16:30		25:00	

Graph: Label on the graph as close as possible the boiling point of your water sample (10 points)



Questions: (2 points each)

1. What temperature is your boiling point?
2. Share your data with 3 other groups and calculate the average; What is the average boiling point of the three groups?
3. How does your boiling point temperature compare to the boiling point of San Diego (at sea level) with a boiling point of 100°C?
4. What do you think may have caused the difference?
5. Is boiling a physical or chemical change?
6. How does this lab prove that not all substances will boil at 100 degrees Celsius?
7. What are the "bubbles" in boiling water made of?
8. What is happening to the molecules of water as they are heated?

Conclusion: What are two things you learned? **<u>Be specific and write in complete sentences</u>**.

Jump to text
Researchers in Colorado have made a startling discovery...

...emale?

Below: Text Discuss

Researchers worry about estrogen and pollutants in the water

By Tom Costello
Correspondent

NBC News
updated 11/9/2004 2:54:22 PM ET

BOULDER, Colo. — Researchers in Colorado have made a startling discovery. Fish, apparently male, are developing female sexual organs. Scientists believe it's the result of too much estrogen in the water and they're finding estrogen in rivers across the country.

In Colorado's rivers and streams, scientists are waist-deep in ritual of the season, using electric currents to stun native fish to the surface where they're measured and checked. But what they discovered in the white sucker fish has got even veteran scientists concerned.

"I've done a lot of studies throughout my career which extends back to 1973," says research associate John Woodling. "This is the very first time that what I've found scared me."

"This fish has characteristics of both male and female," says Dr. David O. Norris of the University of Colorado, Boulder.

And scientists have found lots of them in three Colorado rivers, all of them downstream from sewage treatment plants.

In the Boulder Creek, female white suckers outnumbered males five to one and 50 percent of the males also had female sex tissue.

Researchers say the cause is too much estrogen in the water, a natural female hormone that is found in every sewer system. But also, they say, certain chemical compounds in detergents and soaps can mimic estrogen.

Barbara Biggs, of Denver's largest sewage plant, says most of the nation's sewage plants simply can't remove all the estrogen in the water.

"We're concerned about the effect on aquatic life, but we're also concerned about our ability to actually treat for these estrogens and estrogen mimickers," says Biggs.

Estrogen mimickers are believed to be caused by chemicals called nonylphenols, found in everything from paints and rubber to cosmetics and plastics. They are considered a possible cause of kidney, eye, liver and reproductive problems.

They've been banned in much of Europe and are under review in Canada, but are still common in America, where they are flowing out of sewage plants and into clean water flowing into America's rivers.

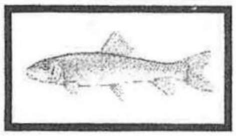
Government researchers recently found natural estrogens and estrogen mimickers in 80 percent of the streams they tested in 30 states.

"We would be ingesting those chemicals, would absorb them, and they would add to whatever natural hormones we already have in the body," says Dr. Norris.

No one is certain what the impact is on humans. But since finding evidence that estrogen may be turning male fish into female fish, scientists are now looking at what it means for the nation's drinking water.

In a state that prides itself on living in harmony with nature, this is evidence, say researchers, of a hormonal imbalance.

Fishy Mixture Water Quality Lab: Properties of Mixtures



name:_______________________
period: ________________

Are there different types of Mixtures?
Look at the different mixtures to make observations.

Background Research #2:

1. Use the materials at your table to explore the three different mixtures. Complete the chart using your observations and research conducted.

	Definition/Drawing	Homogeneous or Heterogeneous?	Particle Size	Particle settling (shake and observe)	Light scattering (shine flashlight)	Examples	Separation Method
Solution							
Suspension							
Colloid							

Fish sex change investigated
CU group establishes treatment plant effluent as culprit

By Boonsri Dickinson and Todd Neff, Camera Staff Writers
Sunday, December 10, 2006

In 2004, David Norris reported that fish just below the Boulder Wastewater Treatment Plant's outflow pipe were changing sex.

Two years later, the University of Colorado integrative physiology professor has expanded his study, which now involves one "Fish Exposure Mobile" research trailer in operation and a second on the way.

Science done in the trailer has verified Norris' 2004 study and shown that surprisingly low concentrations of treatment-plant effluent can change male fish into females.

The 2004 study showed that certain chemicals from pharmaceuticals and personal-care products made it through the Boulder Wastewater Treatment Plant and into Boulder Creek. Ninety percent of the white suckers swimming downstream of the plant were female. Upstream, there was an even split.

The female fish -- both the transsexuals and the original girls — had smaller-than-average ovaries. The remaining males produced less sperm, showing the water effluent also has contraceptive effects, he said.

The chemicals are believed to come from excreted birth-control hormones, natural female hormones and detergents flushed down toilets and drains. In the ecosystem, they are known as endocrine disrupters, settling into cell receptors intended for hormones and garbling the body's chemical communications.

"I consider the city an equal partner," Barber said. "Without their cooperation and encouragement to do good science and answer questions regardless of implications, it wouldn't have happened."

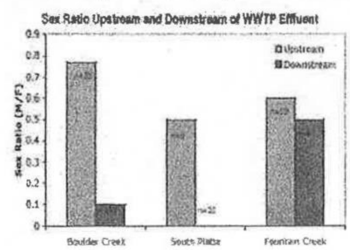
Human estrogen, or 17 beta estradiol, affects fish at concentrations as low as one part per trillion — the equivalent of a pinch of salt in an Olympic pool, Norris said. Barber said volumes of human estrogen in the pure treatment-plant effluent range from one part per trillion to about 10 parts per trillion.

The Fish Exposure Mobile, parked next to the creek on sewage treatment plant property, pulls water directly from the plant's outflow pipe and can dilute it using precise volumes of upstream Boulder Creek water.

Fathead minnows swim in two identical tanks inside, each 200 gallons. One fills with upstream creek water; the other with varying degrees of wastewater plant effluent. Such control lets researchers see how fish react to varying effluent concentrations.

They aimed to create a controlled experiment and confirm if estrogen and other compounds from the treatment plant were responsible for the fish sex change.

"The males were feminized in seven days," Norris said. "You don't need a Ph.D. to sex them." The males have bumps on the forehead and often attack each other. The fish exposed to the effluent water lost their bumps and acted like girls. It confirmed effluent to be the culprit.



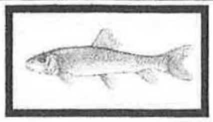
Diluting the treatment plant's effluent 50 percent feminized breeding male fish in a week to 15 days, Norris said. Some of the effects remained evident even when the wastewater plant effluent was diluted 75 percent.

"We were excited to get these results, but at the same time we're a little bit appalled at what we've seen," Norris said.

Sheila Murphy, a hydrologist with the U.S. Geological Survey in Boulder, said the Fish Exposure Mobile work has been important to counter skeptics who attribute transsexual fish in the Potomac River and other waterways to temperature changes or other environmental influences. "What it's showing is that it's indeed from the wastewater plant," Murphy said.

Excerpt Source: http://www.dailycamera.com/news/2006/dec/10/fish-sex-change-investigatedx l/

Fishy Mixture Water Quality Lab: Article Analysis



name:________________________
period: ____________________

Save the White Sucker!

You are an environmental consultant asked to help the Boulder Wastewater Treatment Facility clean up the water below the treatment plant. Choose an article to read for background information and complete this organizer. When you are finished, meet up with your consultant group to compare your findings. Add to/revise your organizer to include information from all of the articles.

Background Research #1:

Main Idea/Problem	**Important Facts (3)**
How does the article relate to physical science?	**I want to know more about...**

Effluent- liquid waste: liquid waste discharged from a sewage system, factory, nuclear power station, or other industrial plant

Endocrine- bodily system that is instrumental in regulating mood, growth and development, tissue function, metabolism, sexual function and reproductive processes.

Estrogen- hormone that promotes the growth and maintenance of the female reproductive system

Excreted- released from the body

Fathead Minnows- a type of fish

Pharmaceuticals- drug used in medicine

Transsexual- an organism that portrays traits of the opposite sex

Name: ____________________
Date: _________
Period: _______

Elements, Mixtures, Compounds, and Solutions
Power Point (Intro to Matter Chapter 3)
Note Sheet

1. What is an Element?
   a. _______ Substance
   b. Cannot be separated into simpler substances by physical or _____________ means.
   c. Contains only ____________ type of atom.
   d. _______, Silver, Copper, ________, Calcium, Hydrogen, ___________, Helium.

2. Types of Elements:
   a. ________: shiny, malleable, ductile, can conduct heat and electric current. Ex. Gold, Silver, _______
   b. _____________: dull, cannot conduct heat or electric current easily. Ex. __________, Helium, Calcium
   c. ______________: it has properties of both metals and non-metals. Ex. ______________

3. What is a Compound?
   a. Substance made up of atoms of ______ or more ________________ elements joined by chemical bonds. (______________ the original properties of the components.)
   b. Can be broken down by _____________ or ________________ or by ______________ means.
   c. Na (____________) + Cl (___________) → NaCl (__________)
   d. H (_____________) + O_2 (___________) → H_2O (__________)

4. What is a Mixture?
   a. Combination of ____ or more substances that are NOT chemically combined. (ex. ___________)
   b. Can be separated by ______________ means without any change in the properties of the components.
   c. Examples of separating mixtures:
      i. _______________ (boiling point)
      ii. ______________(metals)
      iii. _______________ (uses density)

5. Types of Mixtures:
   a. Homogenous Mixture:
      i. Particles are ______________ dispersed.
      ii. ____________ see particles.
      iii. SOLUTIONS
   b. Heterogeneous Mixture:
      i. Particles are dispersed.
      ii. Can ______ particles.
      iii. SUSPENSION
      iv. COLLOID

6. What is a Solution?
   a. _______________ Mixture of 2 or more substances that are uniformly dispersed throughout a single phase. (_____________)
   b. Appears to be a single substance.
   c. ___________: substance being dissolved.
   d. ___________: substance in which the solute dissolves. (_____________ is the Universal Solvent!)

7. Solutions Vocabulary:
   a. ___________: the ability to dissolve.
   b. Insoluble: _____ able to dissolve.
   c. _____________: the measure of the amount of solute that is dissolved in a solution.
   d. _____________: the ability of a substance to dissolve in another substance at a given temperature and pressure.

8. What makes a substance dissolve faster?
   a. ___________
   b. ___________
   c. ___________

9. What is a Suspension?
   a. A mixture in which the particles are dispersed throughout a ___________ or __________ but are large enough to settle out.
      i. _______________
      ii. _______________

10. What is a Colloid?
   a. A mixture in which particles are dispersed but not heavy enough to settle.
      i. ________________
      ii. ________________
      iii. ________________
      iv. ________________
      v. ________________
      vi. ________________

What is an Element?

- Pure substance
- Cannot be separated into simpler substances by physical or chemical means
- Contains only **one** type of atom

- Gold
- Silver
- Copper
- **Lead**
- Calcium
- Hydrogen
- Oxygen
- Helium

Types of Elements:

- Metals: shiny, malleable, ductile, can conduct heat and electric current.
  - Gold, Silver, Iron
- Non-Metals: dull, cannot conduct heat or electric current easily.
  - Hydrogen, Helium
- Metalloid: has properties of both metals and non-metals
  - Arsenic

What is a Compound?

- Substance made up of atoms of 2 or more DIFFERENT elements joined by chemical bonds. (Changes the original properties of the components.)
- Can be broken down by heat or electric current or by chemical means.
- Na (sodium)+ Cl (Chlorine)→ NaCl (salt)
- H_2 (Hydrogen) + O_2 (Oxygen)→ H_2O (water)

What is a Mixture?

- Combination of 2 or more substances that are not chemically combined. (ex. Pizza)
- Can be separated by physical means without any change in the properties of the components.

- Examples of separating mixtures:
  - Distillation (boiling point)
  - Magnet (metals)
  - Centrifuge (uses density)

Types of Mixtures:

- Homogenous Mixture:
  - particles are evenly dispersed.
  - Cannot see particles.

  - ***Solution***
  - ***colloid***

- Heterogeneous Mixture:
  - Particles are dispersed.
  - Can see particles.

  - ***Suspension***

What is a Solution?

- Homogenous MIXTURE of 2 or more substances that are uniformly dispersed throughout a single phase. (Dissolved)
- Appears to be a single substance

- Solute: substance being dissolved
- Solvent: substance in which the solute dissolves (Water is the Universal Solvent!)

Solutions Vocabulary:

- Soluble: the ability to dissolve
- Insoluble: NOT able to dissolve
- Concentration: the measure of the amount of solute that is dissolved in a solution
- Solubility: the ability of a substance to dissolve in another substance at a given temperature and pressure.

What makes substances dissolve faster?

- Mixing
- Heating
- Crushing

What is a Suspension?

- A MIXTURE in which particles are dispersed throughout a liquid or gas but are large enough to settle out.
  - Muddy water
  - Snow Globe

What is a Colloid?

- A MIXTURE in which particles are dispersed but not heavy enough to settle.
  - Milk
  - Mayonnaise
  - Deodorant
  - Gelatin (Jello)
  - Whipped cream
  - Hair gel

Directions: Name: ________________

Place the definition next to the correct vocabulary word. Glue the definition into the correct box.

Matter	
Atoms	
Molecules	
Compound	
Heterogeneous	
Homogeneous	

www.middleschoolscience.com 2008

Mixture	
Solution	
Solute	
Solvent	
Colloid	
Suspension	

Directions: Cut out each definition and place it next to the correct vocabulary word.

Can see the particles with the naked eye and they will settle out over time.

Uniform distribution.

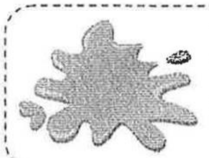
Example: sugar in water

Groups of molecules that are mixed in a completely even distribution.

A solute dissolved in a solvent.

Parts do not combine completely or evenly.

Example: sand and water



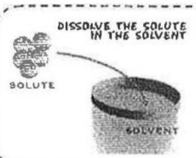
The one doing the dissolving.

Water is a universal one.

No chemical change

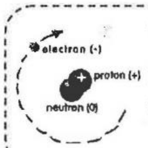
Each keeps its own properties

Can be separated



The substance to be dissolved.

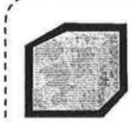
Example: sugar



The building blocks of matter.

Made up of protons, electrons, and neutrons.

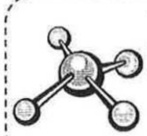
Particles are larger than in a solution but do not settle out.



Anything that has a mass and a volume.

A molecule that has two or more *different* elements bonded together.

Example: H and O = H_2O



Two or more atoms are joined together chemically. Elements can be different *or* the same.

Example: O + O = O_2

Lab Title:	**Name:**
	Period:

1. Question – State question I am trying to answer or problem I am trying to solve.

How does ____(Independent Variable = IV)

affect ____ ?(Dependent Variable = DV)

2. Background Research: Describe what I know about the problem that could impact the experiment.

1. Read the article and complete the organizer.
2. Complete the Mixtures Investigation.
3. Examine the mixture. Determine what kind of mixture you have.
4. Complete the data table to record the chemicals you think are in the mixture and ideas for separation.

3. Hypothesis: Describe what I think will happen and why based on my background research.

If the ______________________(IV) affects ________________________(DV), then

____ (describe what will

occur) because ____. (describe your

reasons)

4. Design Experiment: List the materials, variables, constants, procedure steps and safety concerns.

Independent Variable: What I will change.

Dependent Variable: What I will measure or look for to see if my independent variable had an effect.

Controlled Variables: What I will keep constant (the same).

Safety Concerns: List precautions after you write procedure.

Materials: List all materials with quantities after you write procedure.

Procedure: Write step by step instructions.		
	Plan (State what you will do to separate parts of mixture):	Reason (Explain why it will separate the chemical based on its physical or chemical properties):
	1.	
	2.	
	3.	
	4.	
	5.	
	6.	

5. Perform Experimental Tests and Collect Data: Make and complete data tables, record observations, make diagrams.

1. Write down qualitative observations of which separation methods are successful and which are not successful in the space:
2. <u>Your Final Water Quality Score:</u>

6. Analyze Data and Draw Conclusions: Answer analysis questions to decide if your results agree with your hypothesis. Graph results if necessary.

1. Write a RECALL summarizing what you have learned about separating mixtures.
2. Use the planning sheet first.
3. Take your planning and write it as a FINAL paragraph or paragraphs (3 paragraphs = Extension)

R (Recall: 1) What was the purpose of the experiment? 2) What were the variables tested? 3) What was your hypothesis?)

E (Explain: 1) What did we do to test the hypothesis?)

C (Call back: 1) What were the results of the experiment?)

A (Analyze: 1) Did your results agree with your hypothesis? 2) Why did the results occur? Use evidence and examples.)

L (Lapses: 1) What were the errors, mistakes or unanswered questions that happened in this experiment?)

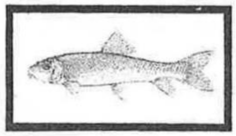
L (Light bulb: 1) What is one conclusion you can make from the experiment?)

RECALL Checklist:

- ❒ Lab Title and Platt Heading are at the top of the page
- ❒ Paragraphs are indented
- ❒ Check Spelling
- ❒ Purpose of lab is stated near the beginning of first paragraph
- ❒ Independent and Dependent Variables are stated
- ❒ Hypothesis is stated
- ❒ Basic steps of procedure are listed
- ❒ Results are stated <u>using data from the lab</u>
- ❒ Results are explained in terms of your scientific understanding
- ❒ Errors or lapses are listed and explained. If no errors, follow-up questions are described.
- ❒ Conclusion sentence states your new understanding of the science topic investigated in the lab

☺ Do your best work!

Fishy Mixture Water Quality Lab: Water Sample Analysis



name:______________________

period: ________________

Background Research #3:

1. Examine your "Fishy Mixture" and conduct test to explain which type of mixture your "Fishy Mixture" is:

____

____

____

____

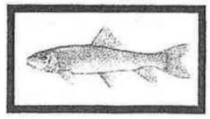
____

Background Research #4:

1. List each of the different chemicals you think make up your "Fishy Mixture". List physical and chemical properties and separation ideas.

Chemical Name	Physical Properties	Chemical Properties	Separation Ideas

Fishy Mixture Water Quality Lab: Water Quality Rubric



name:________________________
period: __________________

Water Quality Scoring Rubric

	4	3	2	1
Water Clarity:	Clear	Almost Clear	Medium Color	Red, very pink, gray, black
Water Quantity:	Full	2/3 +	1/3 – 2/3	<1/3
Resources:	≤ 4	5 – 7	8 – 9	10 +
Final Resources = Total # Resources – (# recycled resources x .5)				
Metal Recovery:		All	Some	None
Total:	_____ + _____ + _____ + _____ = _____ / 4 =			

Write your final score in Box 5 on your lab sheet.

APPENDIX I – Control Group Handouts

PHYSICAL AND CHEMICAL PROPERTIES AND CHANGES

Name _____Key______________________

PHYSICAL PROPERTY	CHEMICAL PROPERTY
1. observed with senses 2. determined without destroying matter	1. indicates how a substance reacts with something else 2. matter will be changed into a new substance after the reaction

Identify the following as a chemical (C) or physical property (P):

_____1. blue color
_____2. density
_____3. flammability (burns)
_____4. solubility (dissolves)
_____5. reacts with acid
_____6. supports combustion
_____7. sour taste
_____8. melting point
_____9. reacts with water
_____10. hardness
_____11. boiling point
_____12. luster
_____13. odor
_____14. reacts with air

PHYSICAL CHANGE	CHEMICAL CHANGE
1. a change in size, shape, or state 2. no new substance is formed	1. a change in the physical and chemical properties 2. a new substance is formed

Identify the following as physical *(P)* or chemical *(C)* changes.

_____1. NaCl (Table Salt) dissolves in water.
_____2. Ag (Silver) tarnishes.
_____3. An apple is cut.
_____4. Heat changes H_2O to steam.
_____5. Baking soda reacts to vinger.
_____6. Fe (Iron) rusts.
_____7. Alcohol evaporates .
_____8. Ice melts.
_____9. Milk sours.
_____10. Sugar dissolves in water.
_____11. Wood rots.
_____12. Pancakes cook.
_____13. Grass grows.
_____14. A tire is inflated.
_____15. Food is digested.
_____16. Paper towel absorbs water.

Physical and Chemical Changes

Part A

Can you recognize the chemical and physical changes that happen all around us? If you change the way something looks, but haven't made a new substance, a **physical change** (P) has occurred. If the substance has been changes into another substance, a **chemical change** (C) has occurred.

1.		An ice cube is placed in the sun. Later there is a puddle of water. Later still the puddle is gone.
2.		Two chemical are mixed together and a gas is produce.
3.		A bicycle changes color as it rusts.
4.		A solid is crushed to a powder.
5.		Two substances are mixed and light is produced.
6.		A piece of ice melts and reacts with sodium.
7.		Mixing salt and pepper.
8.		Chocolate syrup is dissolved in milk.
9.		A marshmallow is toasted over a campfire.
10.		A marshmallow is cut in half.

Part B

Read each scenario. Decide whether a physical or chemical change has occurred and give evidence for your decision. The first one has been done for you to use as an example.

	Scenario	Physical or Chemical Change?	Evidence...
1.	Umm! A student removes a loaf of bread hot from the oven. The student cuts a slice off the loaf and spreads butter on it.		
2.	Your friend decides to toast a piece of bread, but leaves it in the toaster too long. The bread is black and the kitchen if full of smoke.		
3.	You forgot to dry the bread knife when you washed it and reddish brown spots appeared on it.		
4.	You blow dry your wet hair.		
5.	In baking biscuits and other quick breads, the baking powder reacts to release carbon dioxide bubbles. The carbon dioxide bubbles cause the dough to rise.		
6.	You take out your best silver spoons and notice that they are very dull and have some black spots.		
7.	A straight piece of wire is coiled to form a spring.		
8.	Food color is dropped into water to give it color.		
9.	Chewing food to break it down into smaller particles represents a _________ change, but the changing of starch into sugars by enzymes in the digestive system represents a ___________change.		
10.	In a fireworks show, the fireworks explode giving off heat and light.		

Part C: True (T) or False (F)

1.		Changing the size and shapes of pieces of wood would be a chemical change.
2.		In a physical change, the makeup of matter is changed.
3.		Evaporation occurs when liquid water changes into a gas.
4.		Evaporation is a physical change.
5.		Burning wood is a physical change.
6.		Combining hydrogen and oxygen to make water is a physical change.
7.		Breaking up concrete is a physical change.
8.		Sand being washed out to sea from the beach is a chemical change.
9.		When ice cream melts, a chemical change occurs.
10.		Acid rain damaging a marble statue is a physical change.

Name ______________________________ Date ________________ Period ______________

Video Worksheet-Bill Nye "States of Matter"

The questions follow along with the video. Answer as many of the questions as possible.

1.) The universe is made of _______________.

2.) The only difference between molten (liquid) steel and solid steel is the amount of _________ in it.

3.) Solid, liquid, gas area all ______________ of matter.

4.) For matter to "change phase" we must add or take away _________________.

5.) A freezer acts like a heat __________ to remove the energy from inside the freezer to outside the freezer.

6.) The temperature of liquid nitrogen is -_________degrees Celcius.

7.) When you put cool something in liquid nitrogen the molecules _________ down and get closer together

8.) The temperature gauge like a thermometer reads a lower temperature when the molecules of the liquid or gas are moving ________________.

9.) TRUE or FALSE At absolute zero there is absolutely no motion of the molecules that make up the matter.

10.)TRUE OR FALSE It is possible to reach the temperature of absolute zero.

11.)The gas in a can of soda is ______________________.

12.)TRUE or FALSE You can "weigh" a gas.

13.) Glowing gas because it is charged with electricity is called a ________. (Hint: the fourth state of matter)

14.) A ________ and a _______ take the shape of their container but a solid holds its shape

15.) Did you like this video? ________ Why or why not? ______________________________

____

Name: ____________

Period: ____________

Solutions

Ch. 23:1

A SOLUTION is a mixture that is homogeneous at the molecular level.

OR—a solution is a mixture that is so well mixed that is the same throughout, even down to the molecules. And those molecules can be separated physically.

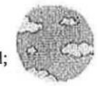
18K gold is a *mixture* of silver and gold

A mixture of two metals is called an **alloy**.

Some Common Solutions:

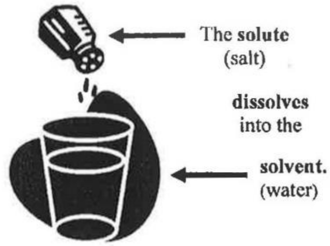
Bottled water; salt water; air; carbonated water; rubbing alcohol; 14 or 18-karat gold.

These are all homogeneous and can be separated physically.



Air is a solution, but not an alloy.

When something goes into solution we say it **dissolves**.
Salt dissolves into water to make salt water—a solution.



One part of the solution is always bigger in amount. This is the **solvent** (what is dissolving). The smaller part is the **solute** (what is being dissolved).

The solvent dissolves the solute.

Solute - smaller word, smaller amount
Solvent - larger word, larger amount

Sugar is **soluble** in water.

Soluble— something that can be dissolved into a solution. Salt is soluble in water.

Insoluble— something that cannot be dissolved. Oil is insoluble in water (or oil is not water soluble).

Oil is **insoluble** in water.

Saturated—When a solution cannot dissolve more solute (it's full).

Unsaturated—When a solution can hold more solute (not full yet).

Supersaturated— When a solution has more solute than it can hold (over full). The solute will fall out of a supersaturated solution.

Mixtures that are not Solutions

Suspensions—a temporary mixture in which the particles eventually settle.

Silt in water is a common suspension.

Colloids—a mixture that has larger particles, like milk, mayonnaise, egg whites. The particles come in clusters, not single molecules (like in solutions) and they don't settle (like in suspensions).

Can tell a colloid by the **Tyndall effect.**

Tyndall effect—scattering of light.

Mixture	Particle size	Scatters Light?	Settles?	Separated by filtering?
Solutions	Molecular (smallest)	No	No	No
Colloids	Slightly larger in clusters	Yes	No	No
Suspensions	Larger particles (often visible)	Yes	Yes	Yes

www.aisd.net/smurray

Name: ____________________

Period: ____________________

Ch. 23:1

Soluble or insoluble in water:	*Circle the solute and underline the solvent.*	*Solution (So), suspension (Sp), or colloid (C)?*
Cooking oil ____________	Salt water	It settles ____________________
Sugar ____________	Sugar water	Doesn't settle or scatter light ________
Soap ____________	A solution of 20% HCl and 80% water.	Scatters light, but doesn't settle ________
Dirt ____________	Chocolate milk	Homogeneous at molecular level ________
Salt ____________	Rubbing alcohol: 60% alcohol; 40% water.	Particles sometimes visible ____________

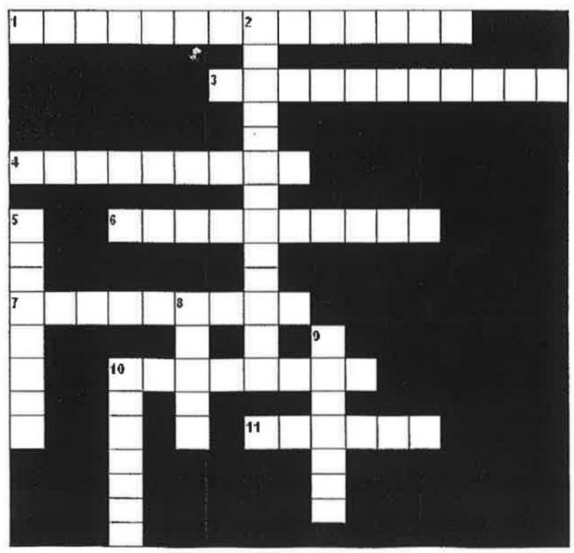
1. Solution	A. When a substance cannot be dissolved into a solution.	1. Supersaturated	A. When a solution can hold more solute.
2. Alloy	B. A mixture of two metals.	2. Saturated	B. When a solution can't hold more solute.
3. Dissolve	C. A mixture that is homogeneous at the molecular level.	3. Tyndall Effect	C. When a solution has more solute than it can hold.
4. Suspension	D. When something seems to disappears into a solution.	4. Unsaturated	D. The part of a solution that is biggest. (The water in salt water.)
5. Colloid	E. A mixture that scatters light and the particles do not settle out.	5. Solute	E. The scattering of light in a colloid.
6. Insoluble	F. A temporary mixture; the particles will eventually settle.	6. Solvent	F. The part of a solution that is smallest. (The salt is salt water.)

Across:

1. When a solution has more solute than it can hold.
3. When a solution can hold more solute.
4. When a substance cannot be dissolved into a solution.
6. A temporary mixture; the particles will eventually settle.
7. When a solution can't hold more solute.
10. A mixture that is homogeneous at the molecular level.
11. The part of a solution that is smallest (The salt in salt water.

Down

2. The scattering of light in a colloid.
5. When something seems to disappear in a solution.
8. A mixture of two metals.
9. A mixture that scatters light and the particles do not settle out.
10. The part of a solution that is biggest. (The water in salt water.



Name ______________________ Class ______________ Date __________

What are three types of matter?

Lesson Review

Decide which type or types of matter—element, compound, or mixture—are being described. Write the correct terms in the spaces provided.

__________ 1. A substance made up of one type of atom

__________ 2. A chemical combination of two or more substances

__________ 3. Each sample has the same properties as every other sample.

__________ 4. Elements are chemically combined in a fixed ratio.

__________ 5. A physical combination of two or more substances

__________ 6. Kinds of matter are present in any amounts.

__________ 7. Is classified as a substance

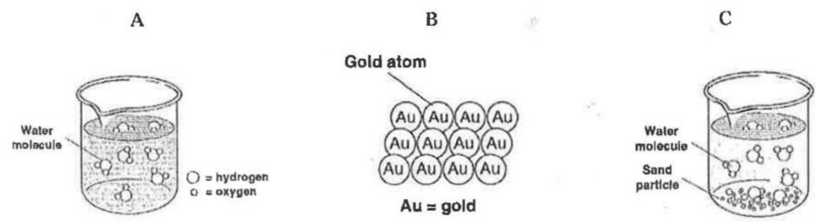
__________ 8. Cannot be chemically broken down into a simpler substance

__________ 9. Each sample does not necessarily have the same properties as every other sample.

Skill Challenge

Skills: *classifying, applying*

Study the diagrams below. Circle the letter of the diagram that is described by each phrase. Some phrases may describe more than one diagram.



1. an element A B C
2. a compound A B C
3. a mixture A B C
4. a substance A B C

Name Class Period Date

MIXTURE LAB

Lab Title

1. Question- State question I am trying to answer or problem I am trying to solve.

Example: How does ______________________________________ (IV=independent variable) affect
____ (dependent variable =DV)

2. Hypothesis:

If ____then (describe what will occur) ____because (describe your reasons).

3. Design Experiment: List the material, variables, constants, procedure steps and safety concerns. (I must sign off on your procedure before you begin for the entire lab group.

Independent variable: what I will change.

Dedendent Variable: What I will measure or lo for to see if my independent variable had an effect.

Constants: What I will keep the same?

Safety Concerns: List safety procedures

Materials : List all material s with quantities after you write procedure

Mass of beginning mixture:__________________________

Mass of items after separation list each item separately and add together

Item 1 name______________ mass__________

Item 2 name______________ mass___________

Item 3 name______________mass___________

Total mass=______________________

APPENDIX J – SPSS Output

SPSS OUTPUT

Mini Unit 1

Table 1

4. Period * Mini1

Measure: MEASURE_1

Period	Mini1	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Control	1	47.692	5.905	35.665	59.720
	2	58.615	5.562	47.285	69.946
Experimental	1	58.238	4.646	48.775	67.701
	2	68.238	4.376	59.324	77.153

Mini Unit 2

Table 2

4. Period * Mini2

Measure: MEASURE_1

Period	Mini2	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Control	1	45.136	3.044	39.015	51.258
	2	61.273	3.740	53.753	68.792
Experimental	1	43.464	2.699	38.038	48.890
	2	58.357	3.315	51.692	65.022

Mini Unit 3

Table 3

4. Period * Mini3

Measure: MEASURE_1

Period	Mini3	Mean	Std. Error	95% Confidence Interval Lower Bound	Upper Bound
Control	1	34.348	2.729	28.866	39.830
	2	55.870	3.482	48.875	62.864
Experimental	1	33.103	2.431	28.222	37.985
	2	55.000	3.101	48.771	61.229

Student Attitude Survey

All Factors Included

Table 4

4. Class * Survey

Measure: MEASURE_1

Class	Survey	Mean	Std. Error	95% Confidence Interval Lower Bound	Upper Bound
Control	1	3.039	.052	2.934	3.144
	2	2.593	.134	2.324	2.861
Treatment	1	2.946	.045	2.855	3.038
	2	2.955	.116	2.723	3.188

Factor 1

Table 5

4. Class * Factor1

Measure: MEASURE_1

Class	Factor1	Mean	Std. Error	95% Confidence Interval Lower Bound	Upper Bound
Control	1	3.090	.068	2.953	3.228
	2	2.636	.064	2.507	2.764
Treatment	1	3.011	.060	2.889	3.132
	2	2.831	.056	2.717	2.945

Factor 2

Table 6

4. Class * Factor2

Measure: MEASURE_1

Class	Factor2	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Control	1	2.913	.097	2.717	3.108
	2	3.033	.079	2.873	3.193
Treatment	1	2.945	.081	2.782	3.108
	2	3.077	.066	2.944	3.210

Factor 3

Table 7

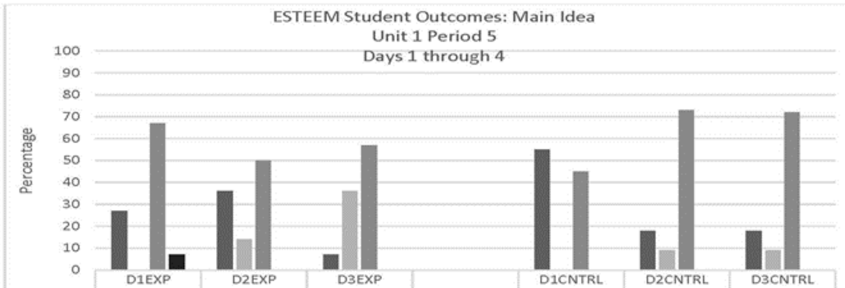
4. Class * Factor3

Measure: MEASURE_1

Class	Factor3	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Control	1	2.918	.076	2.764	3.072
	2	2.825	.084	2.655	2.995
Treatment	1	2.840	.066	2.706	2.974
	2	2.889	.073	2.741	3.037

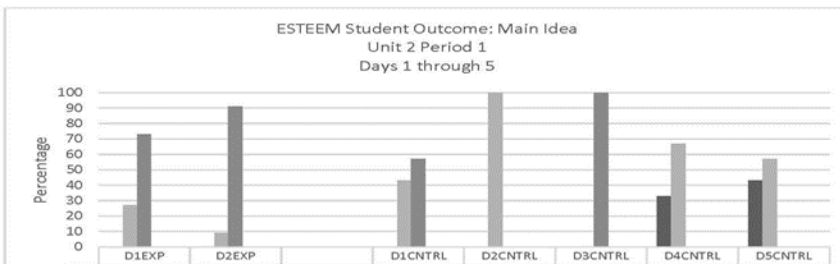
APPENDIX K – ESTEEM Data

Figure 3



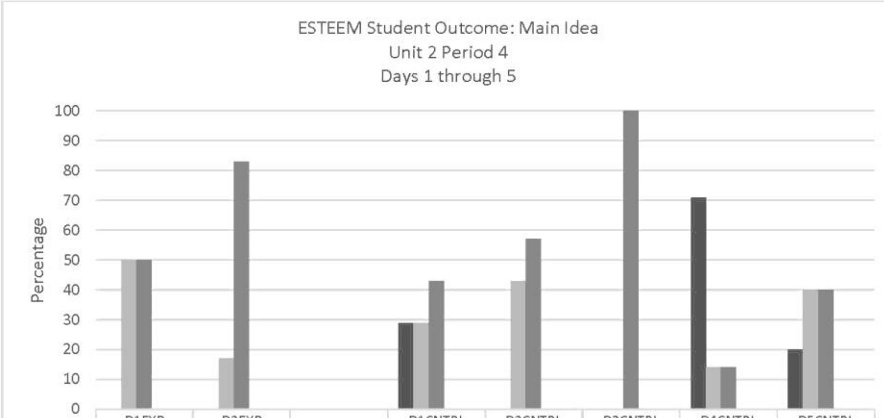
	D1EXP	D2EXP	D3EXP		D1CNTRL	D2CNTRL	D3CNTRL
1	27	36	7		55	18	18
2	0	14	36		0	9	9
3	67	50	57		45	73	72
4	7	0	0		0	0	0

Figure 4



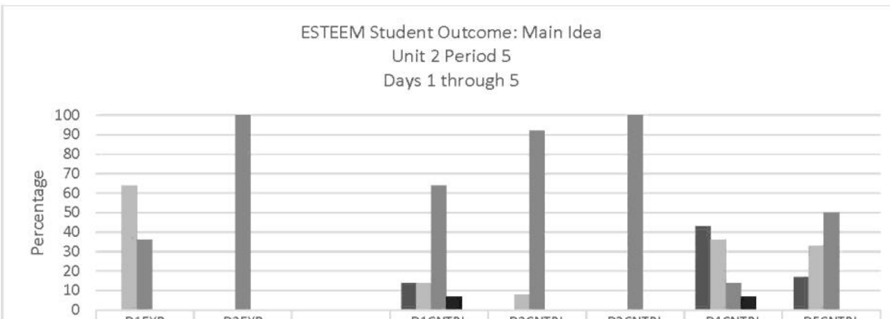
	D1EXP	D2EXP		D1CNTRL	D2CNTRL	D3CNTRL	D4CNTRL	D5CNTRL
1	0	0		0	0	0	33	43
2	27	9		43	100	0	67	57
3	73	91		57	0	100	0	0
4	0	0		0	0	0	0	0
5	0	0		0	0	0	0	0

Figure 5



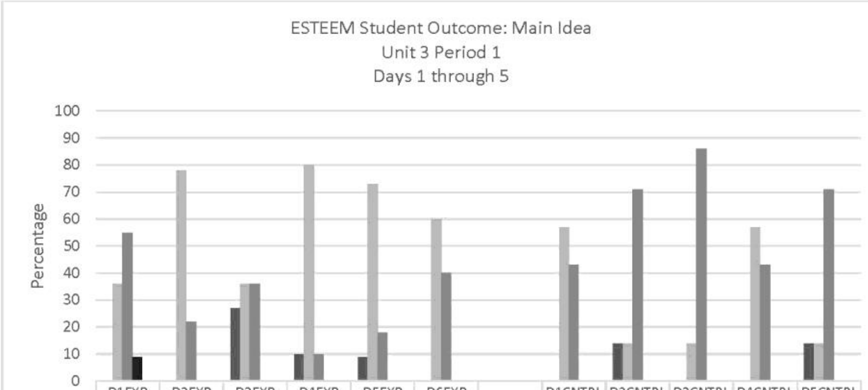
	D1EXP	D2EXP		D1CNTRL	D2CNTRL	D3CNTRL	D4CNTRL	D5CNTRL
1	0	0		29	0	0	71	20
2	50	17		29	43	0	14	40
3	50	83		43	57	100	14	40
4	0	0		0	0	0	0	0
5	0	0		0	0	0	0	0

Figure 6



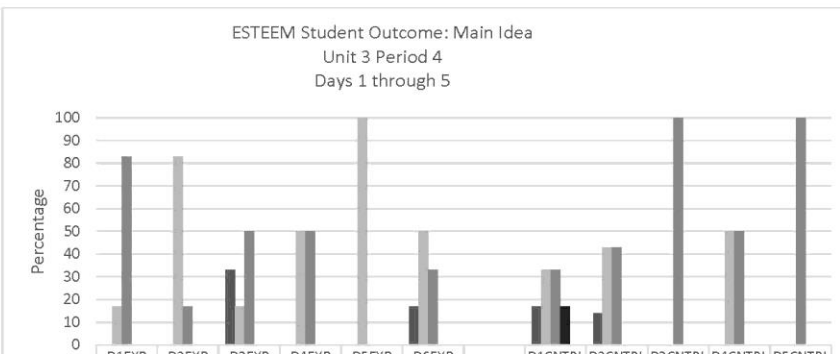
	D1EXP	D2EXP		D1CNTRL	D2CNTRL	D3CNTRL	D4CNTRL	D5CNTRL
1	0	0		14	0	0	43	17
2	64	0		14	8	0	36	33
3	36	100		64	92	100	14	50
4	0	0		7	0	0	7	0
5	0	0		0	0	0	0	0

Figure 7



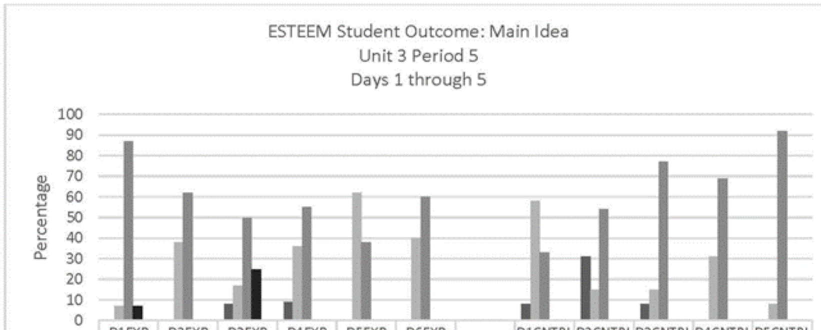
	D1EXP	D2EXP	D3EXP	D4EXP	D5EXP	D6EXP		D1CNTRL	D2CNTRL	D3CNTRL	D4CNTRL	D5CNTRL
1	0	0	27	10	9	0		0	14	0	0	14
2	36	78	36	80	73	60		57	14	14	57	14
3	55	22	36	10	18	40		43	71	86	43	71
4	9	0	0	0	0	0		0	0	0	0	0
5	0	0	0	0	0	0		0	0	0	0	0

Figure 8



	D1EXP	D2EXP	D3EXP	D4EXP	D5EXP	D6EXP		D1CNTRL	D2CNTRL	D3CNTRL	D4CNTRL	D5CNTRL
1	0	0	33	0	0	17		17	14	0	0	0
2	17	83	17	50	100	50		33	43	0	50	0
3	83	17	50	50	0	33		33	43	100	50	100
4	0	0	0	0	0	0		17	0	0	0	0
5	0	0	0	0	0	0		0	0	0	0	0

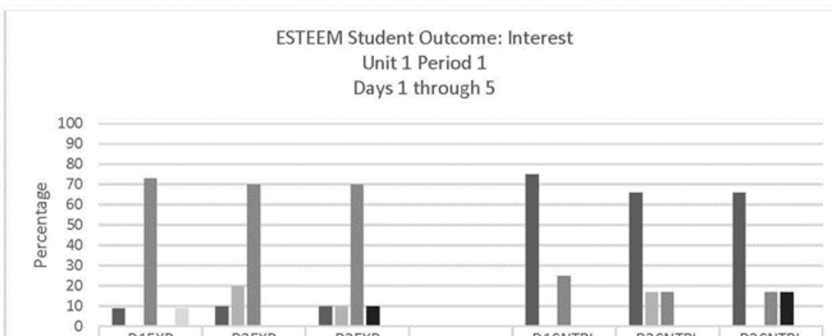
Figure 9



	D1EXP	D2EXP	D3EXP	D4EXP	D5EXP	D6EXP		D1CNTRL	D2CNTRL	D3CNTRL	D4CNTRL	D5CNTRL
1	0	0	8	9	0	0		8	31	8	0	0
2	7	38	17	36	62	40		58	15	15	31	8
3	87	62	50	55	38	60		33	54	77	69	92
4	7	0	25	0	0	0		0	0	0	0	0
5	0	0	0	0	0	0		0	0	0	0	0

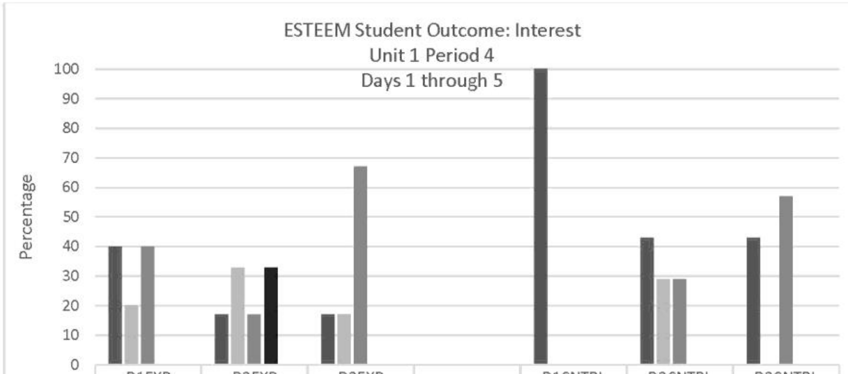
Research Question 6

Figure 10



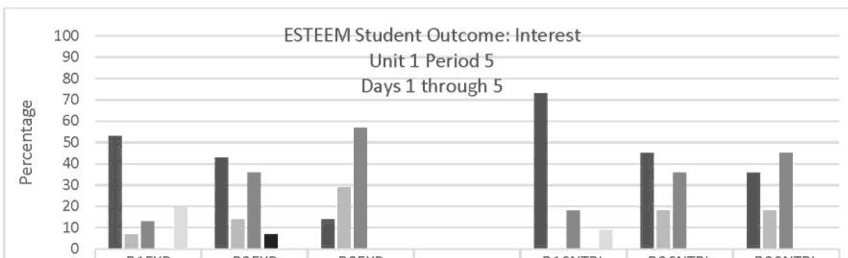
	D1EXP	D2EXP	D3EXP		D1CNTRL	D2CNTRL	D3CNTRL
1	9	10	10		75	66	66
2	0	20	10		0	17	0
3	73	70	70		25	17	17
4	0	0	10		0	0	17
5	9	0	0		0	0	0

Figure 11



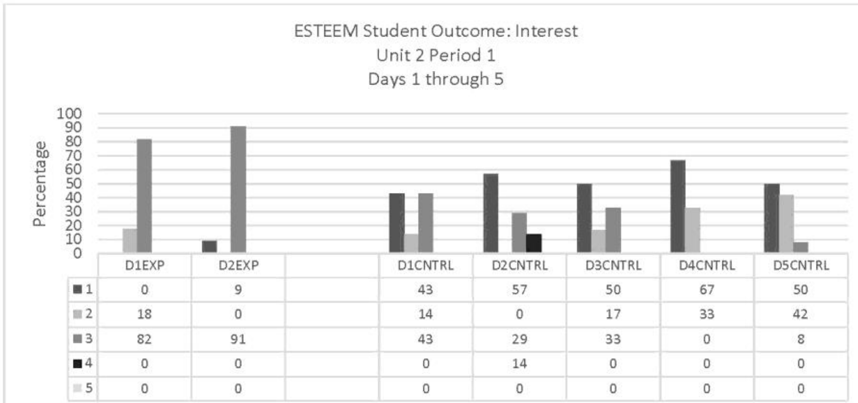
	D1EXP	D2EXP	D3EXP		D1CNTRL	D2CNTRL	D3CNTRL
1	40	17	17		100	43	43
2	20	33	17		0	29	0
3	40	17	67		0	29	57
4	0	33	0		0	0	0
5	0	0	0		0	0	0

Figure 12



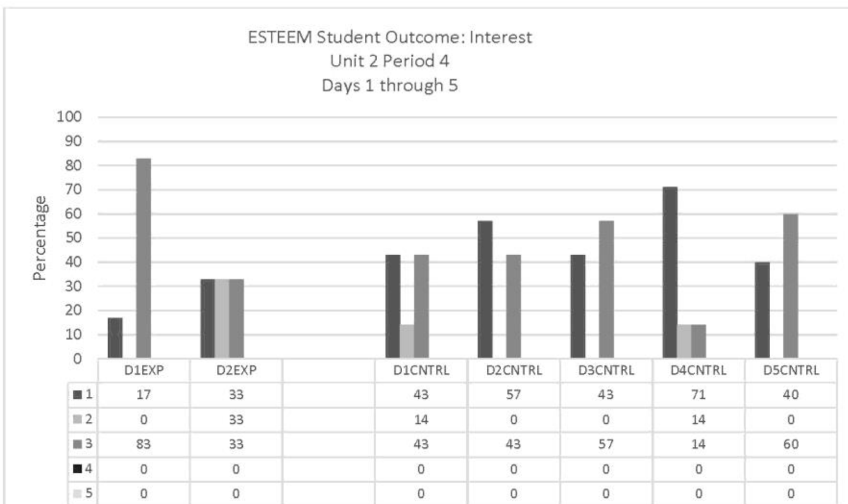
	D1EXP	D2EXP	D3EXP		D1CNTRL	D2CNTRL	D3CNTRL
1	53	43	14		73	45	36
2	7	14	29		0	18	18
3	13	36	57		18	36	45
4	0	7	0		0	0	0
5	20	0	0		9	0	0

Figure 13



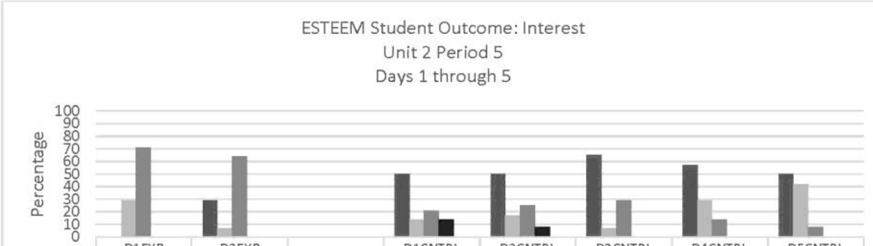
	D1EXP	D2EXP		D1CNTRL	D2CNTRL	D3CNTRL	D4CNTRL	D5CNTRL
1	0	9		43	57	50	67	50
2	18	0		14	0	17	33	42
3	82	91		43	29	33	0	8
4	0	0		0	14	0	0	0
5	0	0		0	0	0	0	0

Figure 14



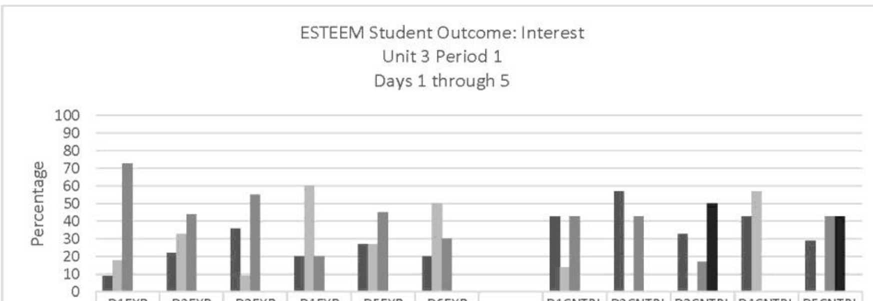
	D1EXP	D2EXP		D1CNTRL	D2CNTRL	D3CNTRL	D4CNTRL	D5CNTRL
1	17	33		43	57	43	71	40
2	0	33		14	0	0	14	0
3	83	33		43	43	57	14	60
4	0	0		0	0	0	0	0
5	0	0		0	0	0	0	0

Figure 15



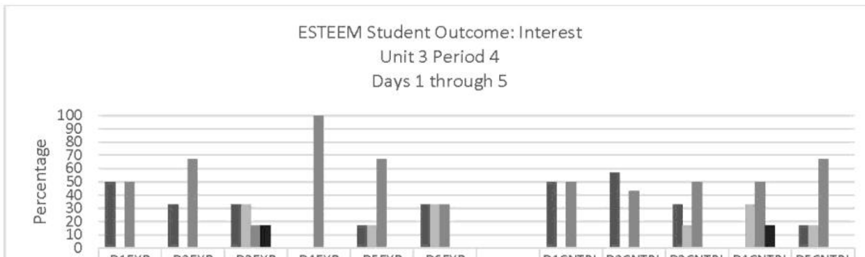
	D1EXP	D2EXP		D1CNTRL	D2CNTRL	D3CNTRL	D4CNTRL	D5CNTRL
1	0	29		50	50	65	57	50
2	29	7		14	17	7	29	42
3	71	64		21	25	29	14	8
4	0	0		14	8	0	0	0
5	0	0		0	0	0	0	0

Figure 16



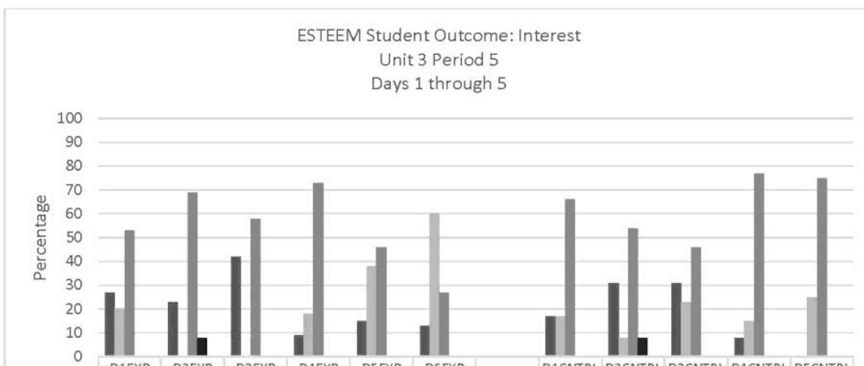
	D1EXP	D2EXP	D3EXP	D4EXP	D5EXP	D6EXP		D1CNTRL	D2CNTRL	D3CNTRL	D4CNTRL	D5CNTRL
1	9	22	36	20	27	20		43	57	33	43	29
2	18	33	9	60	27	50		14	0	0	57	0
3	73	44	55	20	45	30		43	43	17	0	43
4	0	0	0	0	0	0		0	0	50	0	43
5	0	0	0	0	0	0		0	0	0	0	0

Figure 17



	D1EXP	D2EXP	D3EXP	D4EXP	D5EXP	D6EXP		D1CNTRL	D2CNTRL	D3CNTRL	D4CNTRL	D5CNTRL
1	50	33	33	0	17	33		50	57	33	0	17
2	0	0	33	0	17	33		0	0	17	33	17
3	50	67	17	100	67	33		50	43	50	50	67
4	0	0	17	0	0	0		0	0	0	17	0
5	0	0	0	0	0	0		0	0	0	0	0

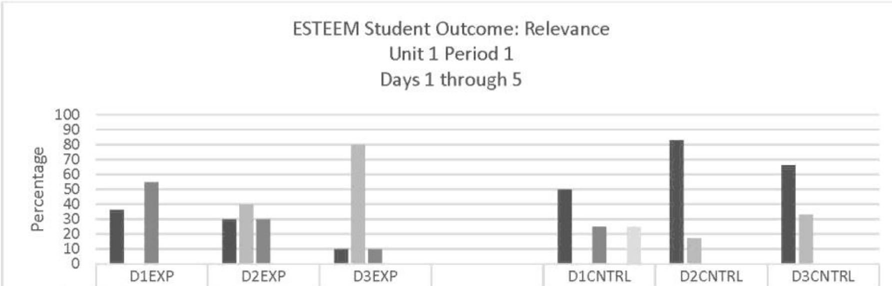
Figure 18



	D1EXP	D2EXP	D3EXP	D4EXP	D5EXP	D6EXP		D1CNTRL	D2CNTRL	D3CNTRL	D4CNTRL	D5CNTRL
1	27	23	42	9	15	13		17	31	31	8	0
2	20	0	0	18	38	60		17	8	23	15	25
3	53	69	58	73	46	27		66	54	46	77	75
4	0	8	0	0	0	0		0	8	0	0	0
5	0	0	0	0	0	0		0	0	0	0	0

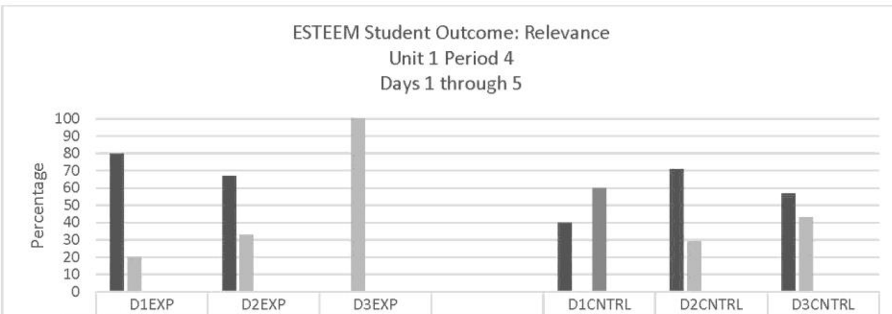
Research Question 7

Figure 19



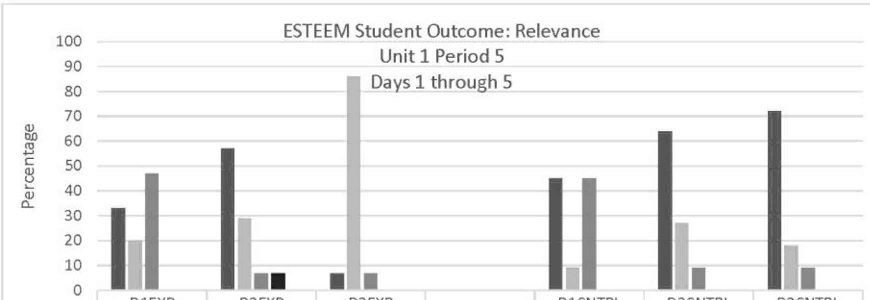
	D1EXP	D2EXP	D3EXP		D1CNTRL	D2CNTRL	D3CNTRL
1	36	30	10		50	83	66
2	0	40	80		0	17	33
3	55	30	10		25	0	0
4	0	0	0		0	0	0
5	0	0	0		25	0	0

Figure 20



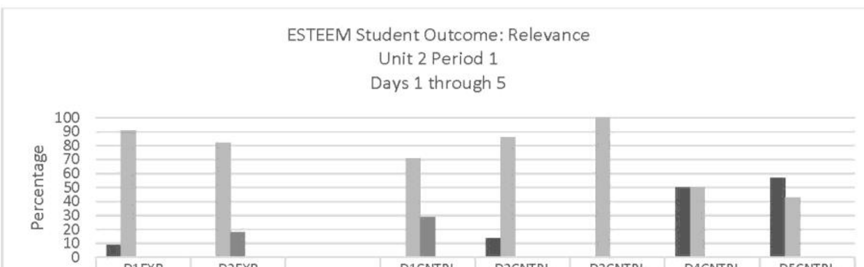
	D1EXP	D2EXP	D3EXP		D1CNTRL	D2CNTRL	D3CNTRL
1	80	67	0		40	71	57
2	20	33	100		0	29	43
3	0	0	0		60	0	0
4	0	0	0		0	0	0
5	0	0	0		0	0	0

Figure 21



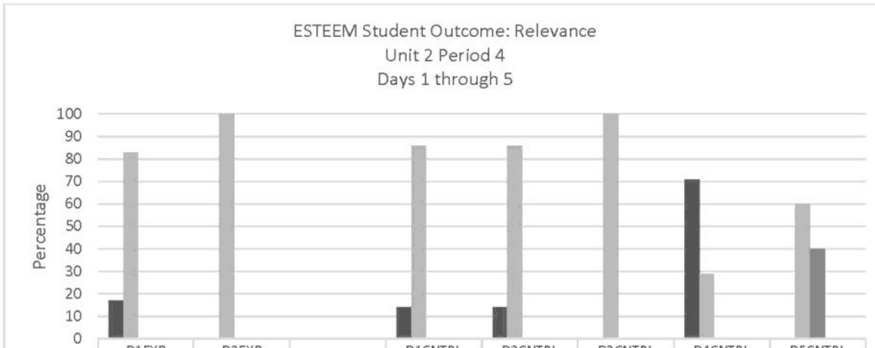
	D1EXP	D2EXP	D3EXP		D1CNTRL	D2CNTRL	D3CNTRL
1	33	57	7		45	64	72
2	20	29	86		9	27	18
3	47	7	7		45	9	9
4	0	7	0		0	0	0
5	0	0	0		0	0	0

Figure 22



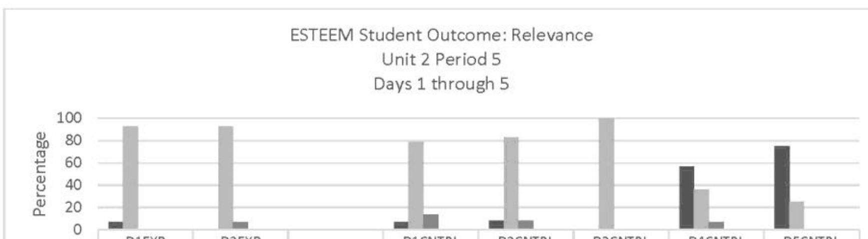
	D1EXP	D2EXP		D1CNTRL	D2CNTRL	D3CNTRL	D4CNTRL	D5CNTRL
1	9	0		0	14	0	50	57
2	91	82		71	86	100	50	43
3	0	18		29	0	0	0	0
4	0	0		0	0	0	0	0
5	0	0		0	0	0	0	0

Figure 23



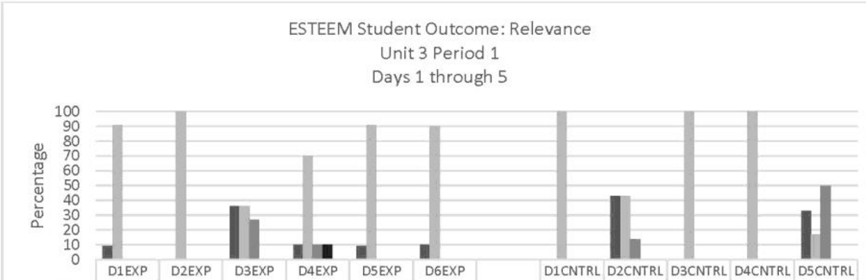
	D1EXP	D2EXP		D1CNTRL	D2CNTRL	D3CNTRL	D4CNTRL	D5CNTRL
1	17	0		14	14	0	71	0
2	83	100		86	86	100	29	60
3	0	0		0	0	0	0	40
4	0	0		0	0	0	0	0
5	0	0		0	0	0	0	0

Figure 24



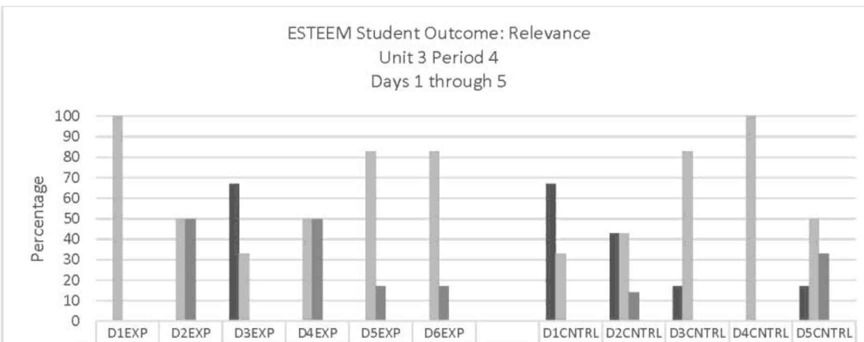
	D1EXP	D2EXP		D1CNTRL	D2CNTRL	D3CNTRL	D4CNTRL	D5CNTRL
1	7	0		7	8	0	57	75
2	93	93		79	83	100	36	25
3	0	7		14	8	0	7	0
4	0	0		0	0	0	0	0
5	0	0		0	0	0	0	0

Figure 25



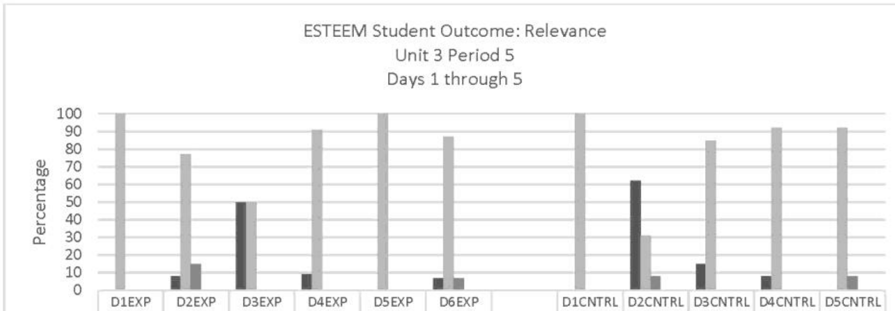
	D1EXP	D2EXP	D3EXP	D4EXP	D5EXP	D6EXP		D1CNTRL	D2CNTRL	D3CNTRL	D4CNTRL	D5CNTRL
1	9	0	36	10	9	10		0	43	0	0	33
2	91	100	36	70	91	90		100	43	100	100	17
3	0	0	27	10	0	0		0	14	0	0	50
4	0	0	0	10	0	0		0	0	0	0	0
5	0	0	0	0	0	0		0	0	0	0	0

Figure 26



	D1EXP	D2EXP	D3EXP	D4EXP	D5EXP	D6EXP		D1CNTRL	D2CNTRL	D3CNTRL	D4CNTRL	D5CNTRL
1	0	0	67	0	0	0		67	43	17	0	17
2	100	50	33	50	83	83		33	43	83	100	50
3	0	50	0	50	17	17		0	14	0	0	33
4	0	0	0	0	0	0		0	0	0	0	0
5	0	0	0	0	0	0		0	0	0	0	0

Figure 27



	D1EXP	D2EXP	D3EXP	D4EXP	D5EXP	D6EXP		D1CNTRL	D2CNTRL	D3CNTRL	D4CNTRL	D5CNTRL
1	0	8	50	9	0	7		0	62	15	8	0
2	100	77	50	91	100	87		100	31	85	92	92
3	0	15	0	0	0	7		0	8	0	0	8
4	0	0	0	0	0	0		0	0	0	0	0
5	0	0	0	0	0	0		0	0	0	0	0

REFERENCES

Akerson, V. L., Townsend, J. S., Donnelly, L. A., Hanson, D. L., Tira, P., & White, O. (2009). Scientific Modeling for Inquiring Teachers Network (SMITN): The influence on elementary teachers' views of nature of science, inquiry, and modeling. *Journal of Science Teacher Education, 20*(1), 21-40. doi: 10.1007/s10972-008-9116-5

Apedoe, X. S., Ellefson, M. R., & Schunn, C. D. (2012). Learning together while designing: Does group size make a difference? *Journal of Science Education and Technology, 21*(1), 83-94.

Beltran, D., Sarmiento, L. E., & Mora-Flores, E. (2013). *Science for English language learners: Developing academic language through inquiry-based instruction*. Huntington Beach, CA: Shell Educational Publishing.

Beskeni, R. D., Yousuf, M. I., Awang, M. M., & Ranjha, A. N. (2011). The effect of prior knowledge in understanding chemistry concepts by senior secondary school students. *International Journal of Academic Research, 3*(2), 607-611.

Boddy, N., Watson, K., & Aubusson, P. (2003). A trial of the five Es: A referent model for constructivist teaching and learning. *Research in Science Education*, *33*(1), 27-42.

Brandon, A. F., & All, A. C. (2010). Constructivism theory analysis and application to curricula. *Nursing Education Perspectives*, *31*(2), 89-92.

Bransford, J. D., Brown, A. L., & Cocking, R. R. (2000). *How people learn: Brain, mind, experience, and school*. Washington, DC: National Academy.

Burry-Stock, J. (1995). *Expert science teaching educational evaluation model (ESTEEM) instruments* (1st ed.). Kalamazoo, MI: Center for Research on Educational Accountability and Teacher Evaluation.

Burry-Stock, J., & Oxford, R. (1994). Expert science teaching education evaluation model (ESTEEM): Measuring excellent in science for professional development. *Journal of Personnel Evaluation in Education, 8*, 267-297.

Bybee, R. W. (1995). *Redesigning the science curriculum: A report on the implications of standards and benchmarks for science education*. Colorado Springs, CO: Biological Sciences Curriculum Study.

Bybee, R. W. (2010). *The teaching of science: 21st century perspectives*. Arlington, VA: National Science Teachers Association Press.

Bybee, R. W. (2013). *The case for STEM education challenges and opportunities.* Arlington, VA: NSTA.

Bybee, R. W., & DeBoer, G. E. (1994). Goals for the science curriculum. In D. L. Gabel (Ed.), *Handbook of research on science teaching and learning* (pp. 357-387). New York, NY: MacMillan.

Bybee, R., Taylor, J., Gardner, A., Van Scotter, P., Carlson, J., Westbrook, A., & Landes, N. (2006). *The BSCS 5E instructional model: Origins, effectiveness, and applications*. Colorado Springs, CO: BSCS.

Çam, A., & Geban, Ö. (2011). Effectiveness of case-based learning instruction on epistemological beliefs and attitudes toward chemistry. *Journal of Science Education and Technology*, *20*(1), 26-32. doi: 10.1007/s10956-010-9231-x

Cavanagh, S. (2007). Lessons drawn from Sputnik 50 years later. *Education Digest*, *73*(4), 31-34.

Chall, J. S. (2000). *The academic achievement challenge: What really works in the classroom*? New York, NY: Guilford.

Chen, M.-P., Wong, Y.-T., & Wang, L.-C. (2014). Effects of type of exploratory strategy and prior knowledge on middle school students' learning of chemical formulas from a 3D role-playing game. *Educational Technology Research and Development*, *62*(2), 163-185. doi: 10.1007/s11423-013-9324-3

Colburn, A. (2000). Constructivism: Science education's 'Grand Unifying Theory.' *Clearing House, 74*(1), 9-12.

De Houwer, J., Barnes-Holmes, D., & Moors, A. (2013). *Psychonomic Bulletin Revised, 20,* 631. doi: 10.3758/s13423-013-0386-3

Duran, E., Duran, L., Haney, J., & Scheuermann, A. (2011). A learning cycle for all students. *Part of a special issue: Science for all, 78*(3), 56-60.

Eisenkraft, A. (2003). Expanding the 5E Model. *Science Teacher*, *70*(6), 56-59.

Engler, J. (2012). STEM education is the key to the U.S.'s economic future: U.S. News and World Reports.

Hamayan, E., & Freeman, R. F. (Eds.). (2012). *English language learners at school: A guide for administrators* (2nd ed.). Philadelphia, PA: Caslon.

Khan, S. H. (2013). Constructivism: An innovative inquiry-based approach to classroom teaching; with special reference to teaching of science. *Journal of Progressive Education, 6*(1).

Krashen, S. D. (1981). Bilingual education and second language acquisition theory. *Schooling and Language Minority Students: A Theoretical Framework*, 51-79.

Matthews, W. J. (2003, Summer). Constructivism in the classroom: Epistemology, history, and empirical evidence. *Teacher Education Quarterly*, 51-64.

Mayer, R. W. (2004). Should there be a three-strikes rule against pure discovery learning? *American Psychologist, 59*(1), 14-19.

National Research Council. (1999). *How people learn: Bridging research and practice*. Washington, DC: National Academy Press.

National Research Council. (2006). *America's lab report: Investigations in high school science*. Washington, DC: National Academies Press.

National Research Council. (2012). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas*. Committee on a Conceptual Framework for new K-12 Science Education Standards, Board on Science Education, Division of Behavioral and Social Sciences and Education. Washington, DC: National Academies.

Novodvorsky, I. (1993). Development of an instrument to assess attitudes towards science. *Dissertation Abstracts International A*, *54*(11), 4054.

Patrick Ajaja, O. o. y. c. (2013). Which strategy best suits biology teaching? Lecturing, concept mapping, cooperative learning or learning cycle? *Electronic Journal of Science Education*, *17*(1), 1-37.

Porter, A., McMaken, J., Hwang, J., & Yang, R. (2011). Common core standards: The new U.S. intended curriculum. *Educational Researchers*, *40*, 103. doi: 10.3102/0013189X11405038

Powell, K. C., & Kalina, C. J. (2009). Cognitive and social constructivism: Developing tools for an effective classroom. *Education*, *130*(2), 241-250.

Rolloff, M. (2010). A constructivist model for teaching evidence based practice. *Nursing Education Perspectives, 31*(5), 290-293.

Shanahan, T. (2015). What teachers should know about common core: A guide for the perplexed. *Reading Teacher, 68*(8), 583-588. doi: 10.1002/trtr.1368

Tenam-Zemach, M., & Flynn, J. (2011). America's race to the top, our fall from grace. *Curriculum and Teaching Dialogue*, *13*(1/2), 113-124.

Tuna, A. (2013). The influence of the 5E model on the elimination of misconceptions on the subject of trigonometry. *International Journal of Academic Research, 5*(3), 14-21. doi: 10.7813/2075-4124.2013/5-3/A.3

Wagner, S., & King, T. (2012). *Implementing effective instruction for English language learners: 12-key practices for administrators, teachers, and leadership teams.* Philadelphia, PA: Caslon.

Weiss-Weiss, E. (2014). *The Education Digest*. Ann Arbor, MI:

Wilson, C. D., Taylor, J. A., Kowalski, S. M., & Carlson, J. (2010). The relative effects and equity of inquiry-based and commonplace science teaching on students' knowledge, reasoning, and argumentation. *Journal of Research in Science Teaching, 47*(3), 276-301. doi: 10.1002/tea.20329

Woellert, L. (2012, July 25). *Companies say 3 million unfilled positions in skill crisis*: Jobs. *Bloomberg*. Retrieved from http://www.bloomberg.com/news/2012-17-25/companies-say-3-million-unfilled-positions-in-skill-in-crisis-jobs.html

Wong, K. K., & Day, J. R. (2009). A comparative study of problem-based and lecture-based learning in junior secondary school science. *Research in Science Education, 39*(5), 625-642

Yager, R. E. (2000). The history and future of science education reform. *Clearing House, 74*(1), 51.