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Television Lies: A Phenomenological Study of Television's Influence on Students' Expectations of High School Chemistry

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Television Lies: A Phenomenological Study of Television's Influence on Students' Expectations of High School Chemistry

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Dedication

I dedicate this dissertation to my children, Kenleigh and Grayson. May you know the importance of education and remember that nothing comes without hard work. Follow your dreams and dream big.

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Abstract

TELEVISION LIES: A PHENOMENOLOGICAL STUDY OF TELEVISION'S INFLUENCE ON STUDENTS EXPECTATIONS OF HIGH SCHOOL CHEMISTRY

High school students bring with them preconceived notions as to what types of laboratory experiments they will perform and content they will learn in chemistry class. Some of what students have learned about chemistry may have been derived from watching television in which chemistry is portrayed. There are many widely popular shows that portray science on television, and the narratives are over dramatized, simplified, or distorted for the sake of entertainment. Often the science portrayed on television is rooted in chemistry practices and thus influences students' perceptions and attitudes of chemistry class. Though there is research in both fields of students' attitudes towards chemistry and television's impact on adolescents there is not research that directly addresses televisions impact on students' perceptions of chemistry and chemistry laboratory. Therefore, this dissertation set out to investigate (1) students' realities of chemistry class that are constructed while watching television and (2) how students' expectations of laboratory compare to what they do in the high school chemistry laboratory. Multiple theoretical frameworks guided the methodological design of this dissertation. A qualitative phenomenological study was utilized, consisting of 2 phases: (1) surveys to reveal students' attitude and image of a chemist and (2) laboratory recordings of students to provide insight into students' laboratory experiences. Students' attitudes contribute to the overall reality that the students have constructed about chemistry prior to taking the class. Students find chemistry to be cognitively demanding but emotionally satisfying. Based on preconceived expectations, students often wanted grander results in the laboratory, and as a result were disappointed when lab results were less spectacular than expected. Students expressed varying attitudes in the laboratory from being disappointed, excited, and having reservations about chemicals. The findings of this dissertation could be used in the classroom to assess the varying expectations that students bring to chemistry class and allow the instructor to meet the cognitive and affective needs of the students.

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Statement of the Problem

High school students bring with them preconceived notions as to what types of laboratory experiments they will perform and what content they will learn in chemistry class. Some of what students learned about chemistry may have been derived from watching television in which chemistry is portrayed. The knowledge is incidentally acquired through watching television even if the intention is only for entertainment purposes (Stokes, 1985; Whittle, 2003). Television is the most popular form of media due to its accessibility. Television shows are available through cable subscriptions, streaming capabilities like Netflix, Hulu, and YouTube, or the internet. Media is more accessible now than it was 20 years ago, and the increased accessibility creates more opportunities for students to be exposed to chemistry portrayal on television. Television dominates leisure time and is a narrative of the cultural landscape (Crotreau & Hoynes, 2013). Television shows are aimed to entertain the public, and thus the storylines depict topics that interest viewers.

There are many widely popular shows that portray science on television. The evolution of science on television has shifted from space exploration in *Star Trek*, time traveling with *Dr. Who*, medical mystery with *House* and *Grey's Anatomy*, forensic crime dramas on *CSI*, to a rogue chemistry teacher on *Breaking Bad.* Shows based on the science narrative appeal to individuals because they allow them to experience aspects of life that they normally would not be able to. Most individuals will not go to space, time travel, solve a crime, discover the cure to rare illnesses, or become a drug lord, so watching it on television is the next best thing. Television is an integral part of many people's lives and serves as a portal of entertainment for individuals. The science narrative on television has provided an entertaining medium for people to watch; however, the entertainment value of television often outweighs the accuracy in science depiction. Individuals experience science in their daily lives and how science is portrayed on television matters. The science on television is often shown without context, neglecting the process of science and the nature of science (NOS) (Lafollette, 1982, 2002). Television often neglects to portray the mathematical supports or intellectual capacity necessary in scientific processes (Goodfield, 1981). The narratives are over dramatized, simplified, or distorted for the sake of entertainment.

As science is continuously portrayed on television, there will be a significant impact on how individuals perceive science. Prior to taking chemistry class, students have a cognitive expectation as to what chemistry class will be like before they even take the class. Often the science depicted on television has roots in chemistry, and this repetitive image leads students to believe that the chemistry displayed on television is real chemistry. As a high school chemistry teacher, the researcher is interested in uncovering why students think that the chemistry displayed on television will be replicated in the classroom. Students often enter chemistry class with the notion that they will "blow stuff up" and make magical potions. For most students, the only exposure to chemistry is through television prior to taking the class. Unrealistic ideas about chemistry can be problematic for chemistry teachers because what is portrayed on television is not the same as what students will experience in class, causing the students to have discontinuity in thought as to what chemistry really is. The significance of the mismatch between television images of chemistry and real-world chemistry is that television messages have the potential to strongly influence student perceptions (Bandura, 2001) of chemistry and pursuit of a chemistry-based career.

Television's dilution of NOS minimizes the importance of the nature of science. In science education, there has been a significant amount of research and emphasis on the importance of teaching and learning about NOS. The goal of science education for many years has been to increase societal understanding and make individuals aware of the relevance of science in our daily lives (DeBoer, 2000). The ongoing reform of science education has focused on improving pedagogical practices to meet the goal of increased societal understanding. Lederman (2007) ascertained that the prolonged emphasis of NOS research has continued for 100 years because evidence has demonstrated that high school graduates do not possess an understanding of NOS. For individuals to become scientifically literate, they must have a clear understanding of NOS. Scientific literacy is the ability to understand how the world works, use scientific practices to make decisions, and become a responsible citizen (Lederman, 2007; National Research Council, 1996; Smith & Scharmann, 1999). Scientific literacy is indirectly taught in classrooms through content standards, laboratory practices, and consciousness of the nature of science (NOS).

Currently science education advocates are working reform are working to increase scientific literacy through nationally adopted science standards, the Next Generation Science Standards (*NGSS*). *NGSS* are research-based standards modeled after the National Research Council Framework for Science Education that contains three aspects: disciplinary core ideas (DCI), cross-cutting concepts, and science and engineering practices (Cooper, 2013; *NGSS*, 2013). This three-part approach to teaching and learning is referred to as 3-dimensional learning in which students focus on explaining phenomena or designing a solution to a problem using the DCI, cross-cutting concepts, and science and engineering practices. The *NGSS* include student performance expectations that encompass the 3-dimensions of learning (Krajcik, 2015). These performance tasks are aligned with the science and engineering practices established by the

NGSS. The science and engineering practices allow students to engage in scientific inquiry and engineering design while mastering the core concepts. Students are no longer receivers of science information but are required to do science. This implies that with the adoption of *NGSS* standards the amount of laboratory experiences should increase in chemistry classrooms.

The laboratory is an integral component to learning chemistry (NSTA, 2007). The laboratory (or lab) allows students to visualize the macroscopic part of chemistry and hands-on experiences. The science and engineering practices outline what laboratory skills the students should possess. Skills acquired during labs include opportunities to design experiments, engage in scientific reasoning, manipulate variables, record and analyze data, and discuss the findings (NSTA, 2007; NRC, 2006). The lab serves as a medium for students to ask questions and conduct experiments to make sense of the natural world and is an inquiry-based process.

The *NGSS* outlines the tasks that students should be able to do in lab, but are these the same skills that students think they will do in chemistry laboratory? There has been a significant amount of research investigating students' attitudes towards chemistry (Bauer, 2008; Demircioglu, Aslan, & Yadigaroglu, 2014; Yunus & Ali, 2012). Student attitudes towards chemistry are important because there is a significant body of research that has linked student attitude with student achievement (Osborne, Simon, & Collins, 2003). Chemistry is a difficult subject that consist of abstract concepts and mathematical integration. These two components are intimidating to students and, thus, impact their perception of chemistry. A branch of chemistry education research has aimed at assessing students' attitudes towards chemistry using various instruments (Dalgey, Coll, & Jones, 2003; Grove & Bretz, 2007; Xu & Lewis, 2011).

In addition to assessing student attitudes, researchers are concerned with students' perception of the image of a scientist. The seminal study by Mead and Metraux (1957) uncovered a stereotypical image of the scientist. This image deduced from the study portrays a scientist as a man who wears a white coat and works in a laboratory. This stereotypical image of the scientist that emerged from the study in 1957 is still the prominent image of a scientist today. Over the past sixty years there have been many confirmatory studies that uncovered the same stereotypical image of the scientist (Basalla, 1976; Ward, 1977; Finson, 2002; Cam, Topcu, & Solun, 2015). The prominent instrument used to assess students' image of a scientist is the Drawing a Scientist Test (DAST) developed by Chambers (1983). These studies utilize student drawings to discern the image of the scientist. The stereotypical image of a scientist often mimics a man dressed in a white lab coat, with unruly hair, working in a lab surrounded by apparatus and equipment indicative of a chemist (Finson, 2002; Kahle, 1987).

Purpose and Research Questions

Science education research has long been concerned with how students think and feel about science and scientists. The need for science education researchers to study student attitudes was due to the decline in interest of adolescents pursuing scientific careers (NAEP,1969 & NSF and Department of Education, 1980; Osborne, Collins, Ratcliffe, Millar, & Duschl, 2003). In addition to the need for researching student attitudes toward science, there is an equal need to create a curriculum that encompasses the NOS and increases scientific literacy. The goal of science curriculum is to fill two distinct roles: preparing future scientists and teaching individuals to engage in science in their everyday lives (Tytler, 2014). One way students engage in science in their everyday life is through portrayal of science on popular television. This portrayal of science is often rooted in chemistry practices and thus influences students' perceptions of chemistry. Though there is research in both fields of students' attitudes towards chemistry and television's impact on adolescents there is not research that directly addresses televisions impact on students' perceptions of chemistry and chemistry laboratory. Galloway (2015) investigated students' perceptions of their learning in undergraduate chemistry laboratory. A portion of the methodology for this study will be modeled after Galloway's methodology but will focus on the high school chemistry classroom. This study aims to eliminate the gap in current literature.

The purpose of this phenomenological study is to uncover the lived experiences of high school chemistry students as it relates to the influence of television. To capture the essence of students' perceptions of chemistry, data must be collected. The specific research questions guiding this study are:

1. What are the realities of chemistry class that students construct while watching television?
    a. What are students' images of a chemist?
    b. What are students' attitudes and beliefs towards chemistry?
2. How do students' expectations of laboratory compare to what they do in the high school chemistry laboratory?

To answer these questions a qualitative phenomenological study was utilized consisting of 2 phases: (1) surveys to reveal students' attitude and image of a chemist and (2) laboratory recordings of students to provide insight into students' laboratory experiences. This study contributes to the knowledge base of chemistry teachers by providing insight into students' perceptions of chemistry and expectations of the laboratory. In-service and pre-service teachers can use the findings of this study to guide curriculum development and learning activities.

Conceptual Framework

The appropriate research design for this study is a qualitative phenomenological study. Phenomenological study describes the lived experiences of individuals as it relates to some phenomenon (Creswell, 2013). The phenomenon that will be investigated is the influence that television has on the beliefs, attitudes, expectations in laboratory, and images of chemists in high school chemistry students. All students who take chemistry have a preconceived image of chemists and an expectation of what they will learn and do in chemistry class. Phenomenology focuses on collecting data from the perspective of the participant and deriving meaning of the phenomena (Denzin, 2001). This study will collect data from individuals through surveys, interviews, and video recordings so that a composite description of the essence of the experience of watching chemist and chemistry on television can be conveyed to the audience (Creswell, 2013). Phenomenology is an interpretive process that investigates a phenomenon from the perspective of another person (Flick, 2014). Phenomenology is concerned with the relationship of a person's internal perception of an external object (Moustakas, 1994). Individuals' perceptions are derived from their personal experiences. When individuals watch television, they develop their own perceptions of objects displayed on television.

Television portrays multiple shows with varying messages. This leads to multiple interpretations based on the culture and context of the recipient (Kellner, 2011). Reception theory focuses on the audiences' interpretation of a show, which leads to a better understanding of the television show. Research that analyzes media through reception theory are concerned with the experience of watching television and how meaning is created through that experience (Morley, 2005). Individuals spend a significant amount of time watching television, which can lead to developing values and ideas about the world around them (Gale, 2007). Watching television is a social endeavor just as is science. It is human nature for individuals to seek out meaning of the world around them. This need to pursue meaning is the foundation for social constructivism. Lev Vygotsky, the father of social constructivism, places learning as a social process and those social interactions play a role in the cognition process (Kozulin, 2003). Television is part of students' social process and contributes to the construction of knowledge. This construction of knowledge influences students' expectations of chemistry class.

Definition of Terms

The following terms are defined to help the reader with the context of the terms used in this study.

Attitude: Refers to the students' perspective towards chemistry and is linked to the images and views that students have developed about chemistry (Khitab, Zaman, Ghaffar, & Jan, 2019).

Chemistry: This refers to the chemistry classroom in a high school setting. The content is outlined by curriculum standards and encompasses both content standards and Science and Engineering Practices.

Science: Science is an umbrella term that comprises all science domains.

Laboratory: The laboratory, in a chemistry classroom, is designed to support and illustrate chemical concepts. The laboratory is a place for students to learn techniques, enhance critical thinking, and experience chemistry (NRC, 2006).

Organization of Study

The remainder of this dissertation is comprised of four chapters. Chapter 2 provides a comprehensive review of literature on science education reform, student attitudes towards chemistry, and laboratory in the chemistry classroom. In Chapter 3, the research methodology and specific details on how the study was conducted is discussed. The remaining chapters discuss the actual research that was conducted. Chapter 4 presents a detailed description of the research findings followed by an interpretation of findings in Chapter 5.

Chapter 2: Literature Review

This chapter reviews the relevant literature pertaining to this dissertation. The chapter is broken up into three parts: (1) historical analysis of past science education reform that influenced the development of *Next Generation Science Standards*, (2) current research related to: student attitudes towards chemistry, image of a chemist, chemistry on television, and students' expectations of laboratory *(3)* and the theoretical underpinnings of this study.

Introduction

Over the past 30 years, science education reform has aimed to increase student and public understanding of science by teaching students to be scientifically literate (American Association for the Advancement of Science, 1989, 1994; National Research Council, 2000, 2012; *NGSS*, 2013). Scientific literacy is the ability to understand how the world works, use scientific practices to make decisions, and become a responsible citizen (National Research Council, 1996; Smith & Scharmann, 1999; Lederman, 2007). Scientific literacy is indirectly taught in classrooms through content standards, laboratory practices, and consciousness of the nature of science (NOS). Nature of science, a tenet of scientific literacy, is the epistemological approach to learning science (Lederman, 2007; Osborne et al., 2003). Teaching students about how scientific knowledge is constructed is a key aspect of NOS. Scientific knowledge is comprised of multiple facets that collectively make up the learning construct of NOS. Some of the key tenets include (a) science is a way of knowing about the natural world (Crowther, Lederman, & Lederman, 2005; NSTA, 2000), (b) science is a human endeavor that is based upon evidence (Crowther et.al, 2005; Lederman 2007), and that (c)science is reliable but can change with new discoveries, technological advances, and new data (NSTA, 2000; Lederman, 2007; Elby & Hammer, 2001). These are some of the characteristics of NOS that makes science a unique discipline.

A comprehensive understanding of NOS is a major principle to increasing scientific literacy. Current science education reformers are working to increase scientific literacy through nationally adopted standards. In 2012, the Obama administration initiated educational reform *Race to the Top* (*RTTT*), which required states to create common standards that vertically aligned from K-12. In response to *RTTT*, the *Next Generation Science Standards* (*NGSS*) were created. *NGSS* are research-based standards modeled after the National Research Council (NRC) *Framework for Science Education* that contain three aspects: disciplinary core ideas (DCI), cross-cutting concepts, and science and engineering practices (Cooper, 2013; *NGSS*, 2013). The DCI are key concepts that are further explored as the student progresses through school and allows for deeper understanding. Patterns, cause and effect, scale, proportion and quantity, systems and system models, energy and matter, structure and function, and stability and change are concepts appearing in all domains of science (*NGSS*, 2013). These seven cross-cutting concepts are ways to link different domains of science and provide a connectedness to the content learned in multiple science classes. The science and engineering practices are the practices that students should be doing in the science classroom. These practices provide the students with experiences that scientists and engineers use to explore, analyze, and solve problems (Krajcik & Merritt, 2012). The incorporation of the science and engineering practices has shifted the focus from rote memorization in the classroom to an application of knowledge. The *NGSS* standards provide educators with the expectations of what content students should know and skills that students should be able to do.

However, the classroom is not the only venue where students learn about science. There are three venues from which students construct understanding and learn science: formal education, family, and free choice learning (Faulk, 2002). These three venues consist of persuasive factors that influence learning. Formal education consists of K-12 schools and higher education. At school, textbooks, science lessons, and teachers' behaviors and personalities exert influence on students' perceptions of science. Family values can also influence a students' attitude toward science. Children develop attitudes towards science during childhood because of direct parental influence. Since a child is more closely attached to their parents and spends a significant amount of time with them, it is understandable that their attitudes reflect the parents' attitudes. The last venue for students to learn science is the free choice learning sector. The free choice learning sector is comprised of social interactions, which includes media. Television is a key source by which individuals are exposed to science (National Science Foundation, 2004). Television is accessible in most parts of the world. The portrayal of science on popular television is often over dramatized and over contextualized, thus leading students to have unrealistic images of science and scientists (Finson, 2002). Popular shows like *Breaking Bad, Grey's Anatomy*, and *CSI* perpetuate many unrealistic ideas about science and scientists. The consistent Hollywood image of science and scientists on television could influence students' perceptions of science (Collins, 1987; Lafollette, 2002; Barnett, Wagner, Gatling, Anderson, Houle, & Kafka, 2006). Often the science portrayed on television is grounded in chemistry with mixing chemicals and ornate glassware. The consistent portrayal of chemistry on television can impact students' perceptions of chemistry class.

The purpose of this phenomenological research study is to explore students' attitudes of of high school chemistry and beliefs about chemists based on the portrayal of chemistry on television. These attitudes and beliefs encompass students' perception of chemistry. Students' perceptions may include the following elements: the students' image of a chemist, the subject of chemistry class, and expectations of, and attitudes about chemistry laboratory. Some of the students' perceptions may be influenced by images of chemists and chemistry portrayed on popular television shows. Prior to high school, students have been exposed to a plethora of shows depicting chemistry in the form of cartoons, comedies, and dramas. This extended exposure of chemistry portrayal on television can cause incidental learning (Stokes, 1985; Bandura, 2001) and can influence a student's perception of what chemistry class will be like in a high school setting, as well as expectations in the laboratory. Students' expectations of chemistry class are often different than what is portrayed on television. A student who has a wide-ranging understanding of NOS and is scientifically literate is better prepared to discern real chemistry verses dramatized chemistry.

Historical analysis of past science education reform that influenced the development of *NGSS*

The goal of science education for many years has been to increase societal understanding and make individuals aware of the relevance of science in our daily lives (DeBoer, 2000). The ongoing reform of science education has focused on improving pedagogical practices to meet the goal of increased societal understanding. Each reform movement has focused on a key word or phrase that encompasses that movement's goal. This portion of the chapter will look at the evolution of science education and the development of scientific practice in the classroom.

Scientific Literacy

Early on in science education, as scientific knowledge progressed, society's interest in science increased. Science educators began to push the need for individuals to become scientifically literate so that individuals could understand how the world works and engage in public discourse about science (NRC, 1996). In 1989, Project 2061 released *Science for all Americans* (*SFAA*), a framework for science educators to create more scientifically literate individuals (AAAS, 1989). The goal of *SFAA* was to encourage educators to collaborate and agree upon skills that students should possess to be considered scientifically literate. In 1994, project 2061 released the *Benchmarks for Science Literacy*, a set of guidelines for science educators to teach science literacy (AAAS, 1994). Scientifically literate students are ones who could ask questions, think critically and independently, and understand the basic tenets of science as it pertains to daily living (AAAS, 1994). The *Benchmarks* were a call for science educators to take an active interest in overhauling the science curriculum to promote science learning for all. The *Benchmarks* were the first attempt to vertically align science from kindergarten to high school. Guidelines outlined skills and knowledge that students should possess at each grade level.

Shorty, after the release of the *Benchmarks*, the *National Science Education Standards* (1996) were released as a response to the need for an overhauled science curriculum. These national standards delineated what the "students need to know, understand, and be able to do to be scientifically literate at different grade levels" (NRC, 1996 p. 2). The standards were a call to action for educators to revise their current practices and engage students in learning science. These standards were not focused solely on content to be taught but skills that a scientifically literate individual should have. Learning science is an active process that includes hands-on activities and is more than recitation of facts.

Inquiry

In the height of scientific literacy reform, the emergence of inquiry as a pedagogical practice developed. Inquiry-based pedagogy has been a central tenet in science education reform as early as the 1960's (Karplus &Thier, 1967; Whitmere, 1974). The early science reform initiatives by Science Curriculum Improvement Study (SCIS), focused on children having direct involvement in learning science (Whitmere, 1974). The goal of SCIS was grounded in scientific literacy and focused on children having "concrete experiences in a context which builds a conceptual framework that will help them interpret and use information they will encounter throughout their lives" (Whitmere, 1974, p. 170). A transition from merely understanding science as a concept to the application of science became the focus of science education. The recurring goal of science education is to create scientifically literate students; however, the pedagogical practices are changing from teacher-centered to student-centered with an inquiry approach.

Inquiry is defined as the way scientists view the world by making observations, posing questions, planning investigations, and proposing explanations based on evidence (NRC, 1996). *Science for all Americans* addresses inquiry as a process that scientists use for discovering information but is an undefined process that has no set steps (1989). Inquiry is the way by which information is acquired. The *National Science Education Standards* directly addressed inquiry, describing it as an active process that students are involved in during hands-on activities. Scientific inquiry is the natural curiosity of how things work and the desire to understand natural processes. The use of inquiry-based pedagogy evokes a sense of wonder from students and triggers curiosity. Using inquiry in the science classroom allows students to explore science concepts and derive understanding. The basic tenets of the inquiry learning cycle consist of three phases: exploration of a problem or phenomena, development of an explanation, and application of this concept to other situations (Lewis & Lewis, 2008). Inquiry is grounded in constructivism and allows students to construct their own knowledge (Tobias & Duffy, 2009).

Over the years, different types of inquiry-based pedagogy have evolved making the definition of inquiry unclear (NRC, 2012; Cooper, 2016). There are different types of inquiry based pedagogical practices: guided inquiry, open inquiry, and structured inquiry. Each type of inquiry has varying roles of the teacher, from minimal involvement in exploration to a structured set of steps (Martin-Hansen, 2002). Educators have varying definitions of what is expected within the different types of inquiry, and over the years the idea of what inquiry should look like has become unclear. The dominant view of inquiry is that it involves hands-on learning, but often teachers do not emphasize that inquiry is a natural scientific process for all scientists (NRC, 2012). Science education researchers realized the muddled use of the term "inquiry" in the literature, when describing approaches to pedagogy, and, thus, stakeholders creating the new reform-based documents opted to reframe inquiry-based pedagogy by introducing the construct of "science and engineering practices". These practices are described in the Framework for Science Education (NRC, 2012). This framework established and provided justification that the new science and engineering practices would serve as benchmarks for the disaggregated components of inquiry. The practices are clearly defined and include skills and knowledge that students should possess at all levels of learning. The Science and Engineering Practices are (1) asking questions and defining problems, (2) developing and using models, (3) planning and carrying out investigations, (4) analyzing and interpreting data, (5) using mathematics, information, and computer technology, and computational thinking, (6) constructing explanations and designing solutions, (7) engaging in argument from evidence, and (8) obtaining, evaluating, and communicating information (GaDOE, 2016, *NGSS*, 2013). The *NGSS* Science and Engineering Practices are derived from the NRC framework and serve as a guide for inquiry in the science classroom.

Nature of Science

Every discipline has its own pedagogical underpinnings. For teachers to effectively teach NOS, they must understand the contributions history, sociology, and psychology have on the teaching and learning of science (McComas, Clough, & Almazoa, 1993; Weinburgh, 2003). Over the past three decades, there has been a paradigm shift in the view of NOS by science education researchers and philosophers of science. The traditional positivistic view is one in which science is confirmatory and based on observable measurable evidence (Mellado, Ruiz, Bermejo, & Jimenez, 2006). This view is based on the reproducibility of science and the objective measures that can be ascertained from types of experimentation. The initial shift from positivistic to more subjective characterization of science began with the works of Thomas Kuhn (1970) and continue today with the works of Lederman and his colleagues (2007). The premise of science as a partially subjective entity is that science is driven by choice (Kuhn, 1970). Scientists choose what domain of science they will study, how they will conduct research, and there is an innate bias of the scientist which impacts the interpretations of data (Hoyningen-Huene, 1993). The shift in view of NOS from positivistic to subjective is evident in science education research and recent science education reform.

Positivist vs. Subjective Views of NOS

The focus of this section of the literature review is to explore the paradigm shift of NOS through analysis of key researchers who championed this shift. Science education is a social endeavor and reflects what society deems valuable and necessary for students to learn (AAAS, 1994; Driver, Asoko, Scott, & Mortimer, 1994; Osborne et.al.,2003). In recent years, the central tenet of science education has been scientific literacy with an emphasis on the nature of science. The traditional philosophical view of NOS is a positivistic one. Positivism, founded by Auguste

Comte in the early 1800's, is a theory that relies on empirical analysis and is restricted to quantitative, experimental, and correlational research (Alters, 1997; Stefanidou & Skordoulis, 2014). Empirical research allows individuals to test theories and discover natural laws that guide society and science (Comte, 1800). Individuals can infer about the workings of the world through observations. Many aspects of science education manifest in positivistic traditions. In traditional science classes, students are taught the scientific method, a stepwise process, used to investigate science. The scientific method has been used as a pedagogical tool for students to observe a phenomenon, gather evidence, and confirm a well-known theory (McComas & Nouri, 2016). Experiments are a demonstration of the positivistic influence on school science and can show causality, and students can observe the outcomes. The testability of theories is a fundamental aspect of positivism and closely aligns to the methodology of the scientific method (Laudan & Kukla, 1996). However, this method of scientific discovery does not capture the creativity and inquiry process that accompanies scientific investigation.

In recent science education research initiatives, there has been a shift from the positivistic view of science to a more subjective view. Lederman (2007) describes science as the invention of explanations derived from experience. When individuals are experiencing science they have prior knowledge, theoretical beliefs, experiences, and cultural influences that help shape the inferences made during observations (Chalmers, 2013; Driver et. al, 1994; Lederman, 2007). Scientists go through training that shapes the attitude and expectations of the scientific investigation. The factors that shape the mindset of the scientist influence the way in which that scientist investigates a problem and makes observations (Lederman, 2007). Thomas Kuhn was one of the first philosophers of science that began the philosophical shift from positivism to subjectivity. Kuhn (1999) did not believe in the existence of a single scientific method; instead he believed that scientists came to the same inferences using different methods and not one agreed upon method. Feyerbend (1993) claimed that the scientific method was an artificial construct that restricted free thought. The philosophy of science was ever changed by the works of Kuhn and Feyerbend. In the 1990's, a branch of science education research emerged that focused on the more socially constructed aspects of science and questions how this perspective could be taught in the classroom. However, within the science classroom and scientific community both positivistic and subjective views are present today.

Current and past science education reformers have tried different initiatives to increase scientific literacy and NOS. Most teachers understand the importance of students learning about NOS, but there is less agreement on what NOS means (Crowther et.al, 2005; Lederman, 2007; Osborne et.al, 2003; Smith & Scharmann, 1998). The creation and dissemination of new national science standards aims to clear up confusion associated with NOS and how science should be taught inside of the K-12 classroom.

Nature of Science and *NGSS*

Science education reform mirrors the ideology of politics and science education research. As science education shifts from a positivistic stance to a more neutral subjective view, so do the science curriculum standards. As a part of the scientific literacy initiative of the past thirty years there has been a greater focus on teaching and learning NOS. Initiatives like *Science for All Americans* (AAAS, 1989), *Benchmarks for Science Literacy* (AAAS, 1994), *National Science Education Standards,* (NRC, 1996), and the Next Generation Science Standards (*NGSS*, 2013) have recommendations for NOS teaching and learning. NOS as an instructional domain will allow students to see how science really works, understand how science knowledge is obtained, and differentiate between science and non-science (McComas & Nouri, 2016). The new science standards, *NGSS*, aim to unify science teaching and learning and emphasize the true nature of science.

The *NGSS* directly addresses the domains of DCI, cross-cutting concepts, and scientific practices; however, the NOS elements are embedded in the standards. The initial draft of the *NGSS* did not specifically address NOS. The indirect display of the NOS elements gave the impression that NOS lacked relevance (McComas & Nouri, 2016). Through a revision process, the NOS elements were added in the appendix of *NGSS* (Table 1). The elements of the NOS align with the science and engineering practices and cross-cutting concepts. The writers of *NGSS* made sure to include a caveat that NOS is not a fourth dimension of science but is a complimentary aspect to the DCI, crosscutting concepts, and science and engineering practices (*NGSS*, 2013). How *NGSS* addresses NOS could lead educators to minimize the importance of NOS.

Table 1

Nature of Science Elements from Appendix H in the NGSS

Nature of Science Themes in *NGSS*
• Scientific Investigations Use a Variety of Methods
• Scientific Knowledge is Based on Empirical Evidence
• Scientific Knowledge is Open to Revision in Light of New Evidence
• Scientific Models, Laws, Mechanisms, and Theories Explain Natural Phenomena
• Science is a Way of Knowing
• Scientific Knowledge Assumes an Order and Consistency in Natural Systems
• Science is a Human Endeavor
• Science Addresses Questions About the Natural and Material World

Laboratory in the Chemistry Classroom

The emphasis on Science and Engineering Practices within the *NGSS* is a continuation of past science education reform. The science and engineering practices clearly articulate student expectations within the science classroom. Students are expected to be active participants in the science they are learning. The Science and Engineering Practices are (1) asking questions and defining problems, (2) developing and using models, (3) planning and carrying out investigations, (4) analyzing and interpreting data, (5) using mathematics, information, and computer technology, and computational thinking, (6) constructing explanations and designing solutions, (7) engaging in argument from evidence, and (8) obtaining, evaluating, and communicating information (GaDOE, 2016, *NGSS*, 2013). The Science and Engineering Practices allow students to engage in scientific inquiry and engineering design while mastering the core concepts. With the inception of the *NGSS*, a national goal for science education emerged for students to become scientifically literate and engage and use science and engineering practices correctly (*NGSS*, 2013). Nineteen states adopted the *NGSS* and twenty-one states developed their own standards based on the *NGSS* (NSTA, 2016).

State standards prior to *NGSS* included an expansive amount of content, and there was no mention of the Science and Engineering practices. The standards were often vague and left to teacher interpretation of what was expected of the student. This expectation varied from classroom to classroom and lacked continuity. The *NGSS* and Science and Engineering Practices clearly define the expectations for students and teachers. The practices are not merely a description of what a student should be able to do, but also intended as an instructional tool for teachers. The standards outline the process by which students should meet the standard while the science and engineering practices outline the skills and knowledge that the student must exhibit for scientific literacy. Science and Engineering practices provide a framework as to what inquiry should look like in the classroom, with the intent to remove the vagueness that once accompanied inquiry.

The science and engineering practices help provide an integration of content and laboratory. The practices encompass what it means to engage in scientific discovery through laboratory experiments. Prior to the 1960's, science was taught as a stepwise process that did not promote scientific inquiry (Bybee, 2014). When students learn science outside of the context of science practices then science education loses its fidelity (Bamberger & Tal; 2007). The traditional laboratory investigations that follow stepwise instructions disillusion students on the trial and error and revisions that occur in science (Driver & Millar, 1996). Students begin to anticipate the results and they lose the investigative nature of science. Incorporating the Science and Engineering Practices, students can explore the natural world and develop critical thinking and problem-solving skills. It should be noted that the science and engineering practices are the same for all science contents; however, the practices may look different from one content area to another due to the difference in content expectations. This study will look at the impact of the science and engineering practices as they relate to the chemistry classroom and laboratory.

Attitudes in the Laboratory

Laboratory is an integral part of science education that helps students to develop a deep understanding of science (NSTA, 2007). The laboratory has the potential to make the abstract concepts tangible and can create positive attitudes towards chemistry (Galloway, 2015). Laboratory provides students with a macroscopic view of microscopic concepts. The current education reform has changed the chemistry curriculum so that laboratory experiences are necessary to fully grasp the chemistry content and the true nature of science. Chemistry is a science based on laboratory experimentation, and thus experimentation as a learning tool is integral to learning chemistry (Kurbanoglu & Akim, 2010). Laboratory is a time for exploration and discovery, and the laboratory activities have the potential to improve students' achievement, conceptual understanding, understanding of the nature of science, and understanding their attitudes and cognitive growth (Hofstein & Mamlock-Naaman, 2007; Kurbanoglu & Akim, 2010; Lazarowitz & Tamir, 1994). Laboratory experimentation in chemistry is multifaceted because it develops interest, curiosity, positive attitudes toward chemistry, creativity, and problem-solving ability in science (Azizoğlu & Uzuntiryaki, 2006).

Laboratory in the chemistry classroom has cognitive advantages that are impacted by affective dimensions of learning. Students' attitudes, apprehension, and self- efficacy play a role in the impact that laboratory has on teaching and learning in chemistry (Kurbanoglu & Akim, 2010). In laboratory experimentation there is a level of uncertainty that influences students' attitudes and can cause anxiety. When students have high levels of anxiety in the chemistry laboratory, the anxiety influences students' performance and cognitive understanding (Kurbanoglu & Akim, 2010; Udo, Ramsey, & Mallow, 2004; Wynstra & Cummings, 1993). There are many causes for students' anxiety in the lab that range from a bad experience in a past science class, anxious science teacher, gender or racial stereotypes, and the stereotyping of scientists in popular media (Kurbanoglu & Akim, 2010).

In addition to anxiety, self- efficacy can play a role in laboratory experimentation in chemistry. Self- efficacy is a person's belief in their ability to perform a certain task (Bandura, 1986; Nieswandt, 2007). Individuals have perceptions of themselves that are rooted in past experiences (Duschl, & Bybee, 2014; Nieswandt, 2007). This means that chemistry students are influenced by their past laboratory experiences and these experiences shape how students construe themselves. Students with a high self- efficacy believe that they can succeed in chemistry related tasks and activities. The students will be more likely to complete chemistry related tasks and activities and complete them successfully (Britner & Pajares, 2006). Students with low self- efficacy will avoid chemistry related activities for fear of failure (Kurbanoglu & Akim, 2010). Thus, self- efficacy and anxiety in labs, are considered to be contributing factors for students' attitudes towards chemistry and chemistry laboratory.

Laboratory Research Studies

Science education researchers have focused on different aspects of the science laboratory from instructional methods in the laboratory (Coulter, 1966) to the laboratory environment (McRobbie & Fraser, 1998; Kwok, 2015). Coulter (1966) compared student performed experiments to teacher demonstrations and found that there was no difference in students' learning. Other studies regarding science laboratory have investigated the effects of learning environment and student attitude in the laboratory. McRobbie and Fraser (1993) used the Science Laboratory Environment Inventory (SLEI) in 92 high school chemistry classrooms to assess students' attitude toward the laboratory. The results of the SLEI stated that student outcomes were enhanced when inquiry-based labs were used versus non-laboratory instruction (McRobbie & Fraser, 1998). A modified SLEI, the Chemistry Laboratory Environment Instrument (CLEI) in conjunction with the Questionnaire on Chemistry Related Attitudes (QOCRA), was used in a study to assess gifted students' attitudes towards chemistry and laboratory environment (Lang, Wong, & Fraser, 2005). The gifted students preferred the open-endedness of the inquiry labs and had favorable attitudes towards the laboratory environment.

In the field of chemistry education, there is a growing amount of research in the significance of laboratory in the undergraduate chemistry course (Hofstein & Lunetta, 1983; Tobin, 1990; Hofstein & Mamlok-Naaman, 2007; Sevian & Fulmer, 2012). The role of laboratory in chemistry varies from confirmatory (Hofstein & Lunetta, 1983), where students do the lab which provides confirmation of the content learned in class, to inquiry based (Sevian &

Fulmer, 2012) where students use lab as an exploration. Regardless of the type of lab, the skills that the students gained from the laboratory experience were deemed valuable for their learning. The skills acquired during lab were communication, problem solving, data collection, critical thinking, rationalizing, and evidence-based decisions (Galloway, 2015).

Most of the research involving laboratory in chemistry has focused on the value that the lab adds to students' learning but not the process of learning in the lab. However, Kurbanoglu and Akim (2010), researched the impact that anxiety and self- efficacy had on college students' performance in the chemistry lab. It was found that anxieties associated with lab hindered students' performance in the laboratory. More recently, Galloway (2015) investigated students' perceptions of learning while students were doing the lab. Students went through a three-part process where they were recorded doing a laboratory experiment and asked about their perceptions of learning chemistry through lab experiences. The learning process was divided into three parts: affective, cognitive, and psychomotor based on Novak's theory of meaningful learning (Novak, 2010). The initial interview asked students how they felt about chemistry laboratory, the second stage recorded the students doing a lab, and the final stage was watching the recording and collecting a running commentary of their experience. The recording and the commentary provided the researchers with interpersonal accounts of the laboratory experience and insight into students' perceptions of the lab (Galloway, 2015). Most students associated the lab with that act of doing lab and did not attribute the lab to the content knowledge (Galloway, 2015).

Attitudes Toward Chemistry

Defining Attitude

Student attitudes towards chemistry have received a lot of attention over several decades.

The American Association for the Advancement of Science (1989), describes attitude, knowledge, and skills as necessary components that students should acquire through their science experiences in school to become scientifically literate. Understanding student attitudes towards chemistry is important because these attitudes can influence career choices, learning outcomes, and student interest (Koballa, 1988; Kurbanoglu & Akim, 2010; Nieswandt, 2007). Attitude is a multifaceted construct that is often referred to unidimensionally. The components of attitude vary amongst researchers. There is a body of science research that defines attitude as having three parts: cognitive, affective, and psychomotor (Finch, 2000; Han & Carpenter, 2014). The cognitive portion of attitude is the ability to respond to stimuli. Cognition is the ability to think systematically and problem solve (Rice, Barth, Guandagno, Smith, & McMullen, 2013). Affective is the emotional aspect of attitude that includes student motivation, feelings, beliefs, stereotypes, and values (Galloway, 2015; Kristiani, Susilo, & Alloysius 2015). The psychomotor portion involves the ability to act. In Novak's Human Constructivism, affective, cognitive, and psychomotor are classified as three domains of learning, and to have meaningful learning students must experience all three domains (Bretz, 2011; Novak, 2010). Other researchers define attitude as a 2-dimensional construct of cognitive and affective (Dalgey, Coll, & Jones, 2003; Grove & Bretz, 2007; Xu & Lewis, 2011). In the studies reviewed, cognitive responses are how students think about chemistry and affective responses are how students feel about chemistry. The 2-dimensional definition will be used in this dissertation.

Research on Students Attitudes in Chemistry

Much of attitude research has linked attitude with student achievement (Osborne et al., 2003; Bauer, 2008; Yunus & Ali, 2012; Demircioglu, Aslan, & Yadigaroglu, 2014). Researchers agree that assessing student attitudes in chemistry is important, but there is variance in how the attitudes should be assessed and evaluated. The Chemistry Attitudes and Experiences Questionnaire (CAEQ) was designed to measure self- efficacy and attitudes towards tertiary level chemistry students (Dalgey, Coll, & Jones, 2003). This instrument utilizes Likert Scale analysis and was designed to assess enrollment choices in first year chemistry majors. Another instrument that utilizes the Likert scale is The Chemistry Expectations Survey (ChemX). ChemX assesses students' cognitive expectations of undergraduate chemistry courses (Grove & Bretz, 2007). A more recent instrument that was developed to measure high school students' attitudes toward chemistry is the Attitude toward the Subject of Chemistry Inventory (ASCI). ASCI is a 25-question semantic differential survey that measures the multi facets of student attitude. Xu and Lewis modified the ASCI to include only 8 questions (2011).

Image of a Scientist

Many instruments used to uncover student attitudes towards science have revealed that students have a stereotypical image of a scientist. In a seminal study by Mead and Metraux (1957), the perception of scientists through the eyes of the students and how that contributes to their overall attitude towards science was investigated. Students' perception of a scientist is…

> The scientist is a man who wears a white coat and works in a laboratory. He is surrounded by equipment: test tubes, Bunsen burners, flasks and bottles, jungle gym of blown glass and weird machines with dials. He spends his days doing experiments. He pours chemicals from one test tube into another. He peers rapidly through microscopes. He scans the heavens through a telescope (Mead & Metraux, 1957, p. 317).

This stereotypical image of the scientist that emerged from the study in 1957 is still the prominent image of a scientist today. Over the past sixty years, there have been many confirmatory studies that uncovered the same stereotypical image of the scientist (Basalla, 1976;

Ward, 1977; Finson, 2002; Cam, Topcu, & Solun, 2015). The prominent instrument used to assess students' image of a scientist is the Drawing a Scientist Test (DAST) developed by Chambers (1983). These studies utilize student drawings to discern the image of the scientist. The prevalent stereotype of a scientist is a male Caucasian working indoors on chemistry experiments (Finson, 2002; Kahle, 1988).

Chemistry on Television

Television is the dominant form of media in the 21st century and an unavoidable part of modern culture (Croteau & Hoynes, 2013). Television plays an integral part in peoples' lives and serves as a portal of entertainment, news, education, and sports. Today people are immersed in television from infancy to the grave. Television, once only accessible for those who could afford it, is now available anywhere and anytime with the streaming capabilities of companies like Netflix and Hulu. Television is accessible in most parts of the world and is more accessible now than it was 20 years ago. The increased accessibility has increased television's impact on society. Television dominates leisure time and is a narrative of the cultural landscape (Croteau & Hoynes, 2013). Television shows are aimed to entertain the public, and thus the storylines depict topics that viewers are interested in.

In recent years, there has been an increase in the amount of television shows that portray science and scientists such as *CSI*, *Breaking Bad*, and *Big Bang Theory*. The science narrative on television has provided an entertaining medium for people to watch; however, the entertainment value of television often outweighs the accuracy in science depiction. The narratives are over dramatized, simplified, or distorted for the sake of entertainment. As science is continuously portrayed on television, there will be a significant impact on how individuals perceive science.

As television watching has increased so has the amount of research in the field of media studies and mass communication. The increased accessibility of television has expanded the cultural influence of television. Much of media research has been on the portrayal of violence on television. The prevailing theme amongst researchers is adolescents who watch television with violence in it have increased instances of violence (Coyne, 2016). Legal scholars have researched the implications of forensic science crime dramas, like *CSI*, on the legal system. These shows portray forensic science as high-tech magic wherein crime solving occurs quickly (Schweitzer & Saks, 2007). Legal scholars are concerned that these types of shows create unrealistic ideas about law enforcement and have called this the *CSI* effect. The *CSI* effect arises when individuals have raised expectations for the kind of forensic evidence that could and should be offered at trials to such heights that jurors are disappointed by the real evidence with which they are presented (Schweitzer &Saks, 2007). The *CSI* effect is one way that scholars have established the implications of television watching on individual's perception of science. Other media studies have investigated influence of television with adolescents. Iannottie and Wang (2013) investigated the relationship between watching television and the increase in adolescent obesity. Among researchers and society, television watching has a negative connotation and thus a body of research has focused on the negative impact television has on adolescent behavior (Gaddy,1986; Espinoza, 2009).

Theoretical Framework

Constructivism

Constructivism is a learning theory, rooted in the works of Piaget and Vygotsky, concerned with how individuals construct knowledge. Constructivism is when individuals seek understanding of the world that they live and work and develop subjective meaning through experiences and these meanings are directed towards an object (Creswell, 2013; Moustakas, 1994). Interpretations of objects and events are influenced by prior knowledge, conceptions, and beliefs and therefore can differ from one individual to another. The meanings are socially constructed based on historical and cultural context (Crotty, 1998; Schwandt, Lincoln & Guba, 2007; Moustakas, 1994).

According to Piaget, knowledge is based on prior knowledge, and knowledge does not exist outside of the learner (Jones & Araje, 2002). Piaget's perspective on knowledge construction did not account for social influences. However, Vygotsky's contribution to the constructivist theory incorporates the social influences that impact learning. Vygotsky's sociocultural theory of constructivism states that learning is a social process and those social interactions play a role in the cognition process (Kozulin, 2003). Television is part of students' social process and contributes to the construction of knowledge. Vygotsky's theory indicates that learning happens in a cultural context and is mediated by language and symbols (John-Steiner & Mahn, 1996). The language and symbols surrounding science on television has increased in recent years, and these symbols of science can impact students' perception of science and more specifically chemistry. On television, there are repetitive images of chemistry that become common symbols for society (Gerbner, Gross, Morgan, & Signorelli, 1986).

The ontological assumption of this study is that realities of science are constructed while watching popular television shows that infuse science. Individuals generate their own realities while watching television. The way that an individual interprets chemistry portrayal on television is never considered incorrect, but this interpretation can be based on less informed notions. This inaccurate interpretation is due to the lack of experience or understanding of chemistry. The epistemological assumption for this study is that knowledge is socially constructed through watching science on television (VanManen, 2016). The knowledge is incidentally acquired through watching television even if the intention is only for entertainment (Stokes, 1985; Whittle, 2003). Television is part of students' social process and contributes to their construction of knowledge.

Reception Theory

Audience reception is the analysis of how the audience constructs meaning from a text. In this study, the text incudes television shows that depict scientific practices. Television is polysemic and is interpreted based on the culture and context of the recipient (Kellner, 2011). Reception theory focuses on the audiences' interpretation of a show that leads to a better understanding of the text. Research that analyzes media through reception theory are concerned with the experience of watching television and how meaning is created through that experience (Morley, 2005). A key aspect of reception theory is that the television show has no inherent meaning, only the meaning derived by the viewer (Staiger, 2008). Television is encoded with messages from the producer, and the audience decodes the meaning (Hall, 1973). The text can be decoded in different ways and not always in the way the producer intended. Factors, such as education, life experience, and cultural values can influence the viewer's interpretation of the intended message. Previous audience reception research merely measured if the television was on and what show was being watched. However, watching television does not happen in a bubble, and there are many factors that influence the television watching experience. Brunson and Morley (2005) described "television watching as a complex and variable mode of behavior, characteristically interwoven with other, simultaneous activities" (p.179). Individuals spend a significant amount of time watching television that can lead to developing values and ideas about the world around them (Gale, 2007). The encoded meaning within a television show can have an effect or influence on an individual's cognition, behavior, ideology, or perception (Hall, 1973).

When individuals watch television and decode meaning, the meaning is then transposed into the consciousness (Hall, 1973).

The subjectivity of reception theory has led to discontinuity amongst media studies researchers (Brunson & Morley, 2005). There is not a definitive way to encapsulate the entire perception of the viewer as they watch a television show. Thus, researchers in the realm of reception theory aim to identify a range of possible reactions and interpretations of a show (Staiger, 2008). Considerations should be made for the individuals' preconceived notions about the show and the different subject positions. Subject positions are the identities, such as, race, age, gender, level of education, and socioeconomic status, to which a person identifies themselves as (Brunson & Morley, 2005; Staiger, 2008). These subject positions are how a person categorizes themselves within society and this impacts their view of the television show (Morely, 2005). These subject positions can be identified or unidentified within the individual.

Synopsis

In a media driven world where chemistry is continuously portrayed on television, the way in which individuals perceive chemistry will be significantly impacted by many external factors. The consensus in science education research is that students need to learn NOS so that they understand the underpinnings of science and increase scientific literacy. However, there is dissonance amongst the science education researchers on the elements that comprise the NOS. There has been a paradigm shift in the philosophy of science from a positivistic to a more subjective view. This shift is evident in the way science is taught in schools and the design of the new national science standards. Science educators are shifting from the teachings of one scientific method and embracing the nature of science that fosters creativity and invention.

Current education reform has overhauled science education through creation of new standards, the *NGSS*. The *NGSS* is framed around 3-dimensional learning which includes, DCI, cross-cutting concepts, and science and engineering practices. The new standards promote scientific inquiry while providing more realistic experiences that mimic practices of real scientists. However, school is not the only venue where students learn and experience science. In a media-driven world, where science is continuously portrayed on television, there will be a significant impact on how individuals perceive science. The *NGSS* provides a framework that introduces students to the science and engineering practices that are accepted by the scientific community. These science and engineering practices students observe on television may not coincide with the practices outlined by the *NGSS*. It is the job of science educators to create scientifically literate individuals who can make educated decisions about the world around them and discern what is real science from pseudo-science.

Chapter 3: Methodology

The qualitative design of this dissertation will be described in this chapter. The chapter begins with a description of the phenomenological approach, followed by a description of the data collection and analysis of the survey instrument used, laboratory recordings, and student interviews.

Phenomenology

The appropriate research design for this study is a qualitative phenomenological study. Phenomenological study describes the lived experiences of individuals as it relates to some phenomenon (Creswell, 2013). The phenomenon that will be investigated is the influence that television has on the beliefs, attitudes, expectations in laboratory, and images of chemists in high school chemistry students. All students who take chemistry have a preconceived image of chemists and an expectation of what they will learn and do in chemistry class. Phenomenology focuses on collecting data from the perspective of the participant and deriving meaning of the phenomena (Denzin, 2001). This study will collect data from individuals through surveys, interviews, and video recordings so that a composite description of the essence of the experience can be conveyed to the audience (Creswell, 2013).

To fully capture the essence of phenomenology, it is important for the researcher to understand the diverse aspects that comprise phenomenological research. An important source of knowledge for this study is Edmund Husserl's (1970) philosophy of phenomenology and the interpretation of Husserl's work by Moustakas (1994). The chapter will examine the underpinnings of phenomenology and describe the research design. The chapter will be divided into four parts: epistemology and ontology, stages of phenomenological research, research design, and trustworthiness and credibility. Understanding the philosophical assumptions of phenomenology will enable the researcher to provide a rich description of the phenomena and add knowledge that will contribute to educational practices in the field of chemistry education.

Epistemology and Ontology

Qualitative research is an interpretive process that investigates a phenomenon from the perspective of another (Flick, 2009). Phenomenology, a qualitative approach, is based on the relationship that exists between the external object and internal perceptions (Moustakas, 1994). The philosophy of phenomenology is grounded in the context that an individual's perception of reality is formed through the meaning derived from personal experience (Moustakas, 1994). In television where different realities are presented in every show, individuals construct their own perceptions of the world around them. In phenomenology, perception is the primary source of knowledge (Moustakas, 1994), and understanding how individuals construct that knowledge requires examination of the philosophical assumptions of ontology and epistemology.

Ontology is concerned with the nature of reality and what there is to know in the world (Ormstom, Spencer, Barnard, & Snape, 2014, Heidegger, 2010). Ontological assumptions are concerned with *what is* (Scotland, 2012). Phenomenologists believe that an essential part of life is existing in the world and understanding the context in which life is lived (Lester, 1999). Reality is individually constructed, and potential for co-construction of realities exist (Scotland, 2012). Television researchers account for the different realities by collecting different sources of data and presenting the emerging themes (Creswell, 2013). The correctness of a reality cannot be determined but is a mere idea of the individual (Moustakas, 1994; Lester, 1999). A paralleled philosophical assumption to ontology is epistemology. Epistemology is concerned with how individuals justify what is knowledge. In a phenomenological study, the researcher is focused on how the subjective knowledge can be created, acquired and communicated (Cohen, 1997). Knowledge is known through the subjective experiences of the individuals (Creswell, 2013). Researchers identify criteria for the type of knowledge sought and use different methods to elicit this knowledge from the individuals (Cohen, 1997; Lester, 1999).

These philosophical assumptions of this study are imbedded within the interpretive framework of constructivism. Constructivism occurs when individuals seek understanding of the world they live and work. Individuals develop subjective meaning through experiences and these meanings are directed towards an object (Creswell, 2013; Moustakas, 1994). Objects are real, but the interpretation of them is purely subjective. The meanings are socially constructed based on historical and cultural context (Crotty, 1998; Moustakas, 1994; Schwandt, Lincoln, & Guba, 2000). The ontological assumption of this study is that realities of chemistry are constructed while watching popular television shows that embed conceptions of chemistry. Individuals generate their own realities while watching television. The way that an individual interprets chemistry portrayed on television is never considered incorrect, but this interpretation can be based on less informed notions of the canonical view of chemistry. These inaccurate interpretations may be due to the lack of experience or understanding of chemistry as a scientific enterprise. The epistemological assumption is that knowledge is socially constructed through watching chemistry on television (VanManen, 2016). Knowledge about chemistry and a chemist is incidentally acquired through watching television even if the intention is only for entertainment (Stokes, 1994; Whittle, 2003).

Stages of Phenomenological Research

Another important principal of phenomenology is understanding the four key stages of phenomenological research as described by Moustakas (1994). Epoche, phenomenological reduction, imaginative variation, and synthesis are the four stages that help a researcher construct meaning of a phenomenon. This process allows for the researcher to reflect on subjective thoughts of an individual and derive meaning of an object through the individual's thoughts (Husserl, 1970; Moustakas, 1994).

To provide fidelity to the phenomenological study, a researcher must ensure that an experience is described exactly how it occurs. In the essence of epoche, a researcher must account for their own natural attitude by making oneself aware of personal ideas and feelings. Therefore, it is important to understand the conceptual lens from which the research was gathered, analyzed, and interpreted (Sword, 1999). To provide context to this study, a statement about my experiences that influenced this research is provided below.

> As a child, I always loved going to school. I think I loved going to school because I was good at it. Everything came so naturally for me. I loved all subjects, but it was not until high school that I found my love for science. During high school a cognizance of the magnitude of science emerged. I realized that each domain of science contributed to the different aspects of life and how the world works. Biology taught me about how the body works, physics taught me how the world works, and chemistry showed me what the world is made of. My favorite science class in high school was biology. I liked it so much I chose to take anatomy and physiology my senior year. My interest in life science steered me toward the idea of going to college and pursuing a medical degree.
>
> I think that every parent wants their child to be a doctor. The title of doctor holds a level of prestige and financial gain. When I was in high school my mother was obsessed with the show *ER.* Our family would watch the show together every Thursday night. It was during our time together watching this show that the thought of being a doctor

emerged. The producers of ER made the job of a doctor appear appealing and glamorous. My mother was infatuated with the doctors and I thought that if I were a doctor people would see me the same way. However, the show did not depict the aspects of becoming a doctor. In the show there was no mention of the cost of medical school, the immense amount of student loan debt you will incur when attending medical school, the endless hours of studying, and the additional years of college you will need to become a doctor. Just before I was to go off to college, my mother took me to the pediatrician. During our visit, she informed him that I wanted to be a doctor. He quickly informed me that I would be in school forever and never get any sleep. As a high school senior, I was ending my thirteenth year in school. I did not want to embark on another thirteen years of school, so I decided to scrap my pursuit of becoming a doctor. I knew that I was still very interested in biology and the medical field, so I decided to major in nursing. I would still get to take a lot of science classes and be in the medical field.

During my first year of college I took biology and intro to nursing courses. The science and nursing classes were terrible, and I did not enjoy them. Biology was only memorizing, and the nursing classes were not what I had expected. I was beginning to realize that I was not actually interested in nursing. During my sophomore year I was beginning to consider changing my major. In the fall of my sophomore year I took chemistry. I had heard that chemistry was the most difficult course in the nursing program and most students would fail the class. Failure of a class would result in removal from the program. I secretly hoped I would fail and then I would have to choose another major. However, this was not the case. I earned an A in chemistry and soon realized that I was really interested in the subject. I enjoyed it so much that I changed my major to chemistry.

People were always impressed with me when I told them I was a chemistry major. They would always ask me what I was going to do with a degree in chemistry. I never really had an answer for them. During my senior year of college, one of my professors encouraged me to pursue a career in chemistry education. I came from a long line of teachers, including my mother, and teaching was something I always said I did not want to do. My mother always made teaching seem so difficult and she complained that society did not respect teachers. I surely did not want a job where no one saw the value in it. As my senior year in college came to an end I found myself in a state of confusion. I was about to have a degree in chemistry, but I had no idea what I was going to do with it. Through a lot of encouragement from my family I decided to pursue a Master of Arts in Teaching chemistry. It was during this program that I found my true passion. Teaching provided me an opportunity to share my love of chemistry with other people.

My first year of teaching provided many opportunities for learning, for me and my students. Though the job was demanding it was also rewarding. As the years continued my passion for teaching chemistry was nurtured. I became more comfortable and established as a teacher. With every passing year, I began to see patterns in my students' behavior. I could grow to expect that on the first day of school someone would ask me if we were going to "blow stuff up". The more I was asked this question, the more intrigued I grew with the origin of this idea. I would ask students why they thought they were going to experience explosions. Their reply was "because that is what I see on television". When the show *Breaking Bad* came about, students inevitably thought that I made methamphetamines as a side job. The comments and remarks of students intrigued me. Why is that students thought what they saw on television was a replication of what they were going to learn in class?

Therefore, I approach this dissertation with the idea that chemistry educators need to know what students' expectations of chemistry are and use these expectations to influence our instructional practices. Based on my experience as a teacher, students construct their knowledge of chemistry prior to taking the course and this construction can be influenced by chemistry portrayed on television. I have firsthand experience with how television can influence the mind of a teenager as I was willing to choose a career based on the portrayal of medicine on television.

After reflecting on the personal experiences that framed this study, I engaged in 'systematic efforts to set aside prejudgments regarding the phenomenon being investigated" (Moustakas, 1994, p.22). The removal of prejudgments frees the researcher from preconceptions and beliefs that may have been obtained from professional knowledge and prior experiences. During epoche the researcher has a fresh perspective (Creswell 2013).

Once judgment is suspended then the bias of the researcher needs to be addressed through reduction, which describes the experience just as it is (Moustakas, 1994; Schmitt, 1967). Memoing is a method of reduction that allows the researcher to capture the true essence of the phenomena (Glaser, 1998). In this study, memoing was used to give context of the situation and provide the researcher insight into the ways in which the participants perceived chemistry and chemists, according to their own descriptions. Memoing was based upon the video recordings of the laboratory experiments. Another method of reduction included verbatim transcription of all interviews. This means that all recording was transcribed exactly as it was delivered. Memoing and verbatim transcription as reductive processes permit a textural description of the phenomena, what participants experienced, just as it is providing a relationship between the phenomenon and self (Moustakas, 1994). The next stage in phenomenological research is imaginative variation. Moustakas (1994) describes imaginative variation as the ability to derive structural themes from textural descriptions obtained during the reduction phase. Individuals seek possible meanings through imagination using a set of heuristics as a plausible inference (Jonkus, 2014). The steps of imaginative variation are identifying the meanings that underlie textural meanings, determining a theme, understanding the context of the phenomenon, and then providing a structural description of the phenomenon (Moustakas, 1994). Imaginative variation was achieved in this study through open and axial coding. The final stage of phenomenological research is the synthesis of meanings. Husserl (1970) describes synthesis as a final truth. During synthesis, the textural descriptions are structured into meaning, and the essence of the phenomenon emerges.

Understanding how meaning is derived from epoche, reduction, imaginative variation, and synthesis is important in phenomenological research. These stages of phenomenology allow the researcher to derive knowledge from the perceptions of individuals. These stages allow for intersubjective knowing of experiences. Intersubjectivity is the congruence of consciousness of the researcher and the subject, meaning that there is an agreement on a set of meanings associated with a phenomenon, resulting in a common constructed meaning, grounded in experience for a phenomenon (Husserl, 1970; Moustakas, 1984).

Research Design and Research Questions

The research design and methodological perspective is phenomenology. This qualitative study follows an interpretivist framework where knowledge is considered a social development. Phenomenology aims to understand phenomena as they are directly experienced (Moustakas, 1994). A phenomenological methodology allows the researcher to understand the meanings constructed by high school chemistry students' perceptions of chemistry and expectation of the laboratory based on their exposure to chemistry on television. When developing a research question, attention to the social significance and personal meaning should be considered (Moustakas, 1994). Thematic analysis was used to delineate common meaning of the data and provide an authentic description of the students' experience of the phenomenon (Jonkus, 2014). At times frequencies and averages were used to make conclusions about the data.

This phenomenological study will uncover the lived experiences of the high school chemistry students as it relates to the influence of television. To better understand the lived experience of the high school chemistry students as it relates to the influence of television, two research questions guided this study.

1. What are the realities of chemistry that students construct while watching television?
    a. What are students' images of chemists?
    b. What are students' attitudes towards chemistry?
2. How do students' expectations of laboratory compare to what they do in high school chemistry laboratory?

To capture the essence of students' perceptions of chemistry, data was collected and analyzed through phenomenological methods. These research questions are rooted in social and personal significance and will provide insight for chemistry teachers.

Data Collection

Data collection involved a three-part process: administration of surveys, collecting video recordings of the students doing a laboratory experiment, and conducting semi-structured interviews. Since the study involves human subjects, approval from Kennesaw State's Institutional Review Board (IRB) (Appendix A) was obtained and then IRB approval from Cobb County School District (Appendix B). Once IRB approval was established and consent and assent (Appendix C) confirmed, each chemistry class in the school was asked to complete a survey instrument.

Survey. The survey was used to answer research question one and the goal of the survey was to uncover the realities that students have about chemistry and chemists. The survey was conducted during class time, taking approximately 15 to 30 minutes. The survey is comprised of four sections: demographic, open ended questions, drawing, and semantic differential questions. The demographic questions include identifying questions of race, gender, and level of chemistry class. The open ended, drawings, and semantic differential questions seek to uncover students' perception of chemistry and image of a chemist. The last part of the survey consists of eight semantic differential questions obtained from the adapted Attitude Toward the Subject of Chemistry Inventory (ASCI) (Xu & Lewis, 2011). The survey was pilot tested in a pilot study of 70 high school chemistry students. The goal of the pilot study was to ensure the mechanics and optimize the usefulness of the survey. The results of the pilot study yielded interesting results, but some clarification and content changes were necessary. The initial survey focused on both television and movies; however, based on the results it became clear that the focus needed to be narrowed to just television. Mechanical changes occurred in the directions and wording of questions. There were many places where the directions were unclear, and the questions too broad. This was deduced by student feedback and the types of responses given by the students during the pilot study. Therefore, the survey used in this study was modified based on the results from the pilot study. The complete survey may be found in Appendix D.

Recordings of students implementing laboratory procedures. The survey narrowed down participants who experienced the phenomena. Those participants were asked to record themselves while performing a laboratory experiment. The laboratory recordings served as a data collection method for the second research question. This method is adopted from Galloway (2005) in which the video recordings were used to elicit real time feedback on student experiences while performing laboratory experiments. *Eken Action Cameras* were used to record the lab experiment. The camera fit on the students' forehead, faced away from the student, and captured everything the student does, says, or sees from the first-person perspective. The participants were instructed on how to use the camera and the researcher was present to help with the functionality of the camera.

The recordings occurred within two different chemistry classes and took place during the *Chemical Reactions* unit. This unit was selected because it is in the third unit of chemistry and allowed for adequate time to obtain the consent and assent. The laboratory experiments that were recorded were the Endothermic and Exothermic Lab (Appendix E) and the Indicators of Chemical Reactions lab (Appendix F). These labs were chosen because they have many of the components that students often associate with chemistry: production of gas, bright colors, fire, and changes in temperature. Two different labs within the same unit were selected to provide more opportunities to record students, as there are limited numbers of *Eken Action Cameras*. Ten students were recorded while performing the laboratory experiments. The number of students recorded during the lab was dependent on the number of *Eken Action Camera* available and students who experienced the phenomena of observing chemistry portrayed on television.

Interview. The purpose of the interview was for the students to provide context to their laboratory experience. Participants were interviewed and watched the lab recording within 24 to 48 hours after the laboratory experiment so that the experience was still fresh in the students' memory. Prior to watching the video, the students were shown a list of 18 affective words found in Table 2. The words on the list were derived from the pilot study, Galloway's (2005) list of affective words, and the ASCI (Xu & Lewis, 2011). The students were asked to 1) circle any of the words that they felt described their chemistry class, 2) put a star next to words that described chemistry on television, and 3) cross out any words that they feel do not describe chemistry or chemistry class. It should be noted that within the scope of this study chemistry class is a chemistry course with an embedded laboratory component. In the state of Georgia and with *NGSS*, the standards outline the laboratory expectations within the content standards. Thus, when students are asked to circle words that describe their chemistry class, the connotation also includes the laboratory portion. The words were printed on Livescribe paper, and the students were instructed on how to use the Livescribe pen to complete the task (Livescribe, 2017). The Livescribe pen was used to record the interview so that it could be played back, and the essences of their descriptions could be captured. Students were asked to describe their word choices and instructed to use these words as points of discussion while watching their lab experience recording.

Table 2

List of Affective Words Used Prior to Watching the Video

Intimidated	Confused	Nervous
Confident	Nerdy	Curious
Creative	Lost	Excited
Interested	Worry	Comfortable
Bizarre	Chaotic	Challenged
Organized	Frustrated	Inspired

A semi-structured interview protocol was created to elicit students' affective experiences in the laboratory, to discern their attitudes toward chemistry las, as well as, their perceptions of chemistry on television. The interviews lasted about 30 minutes and took place outside of class time either before or after school. The interview served as an opportunity for more in-depth analysis into the students' learning experiences in the laboratory. An interview guide can be found in Appendix G. However, in a phenomenological study the interview is an interactive process that is guided by the participant (Moustakas, 1994), so the guide served as points of discussion but left opportunities for perspectives of participants to be further explored.

The interviews, survey responses, and recordings provided triangulation of the data. Triangulation involves using multiple sources to provide corroborating evidence (Creswell, 2013; Stake, 2010). In summary, the survey contributed evidence of students' attitudes towards chemistry and chemists, the interviews provided evidence of students' attitudes in the laboratory, and the laboratory recordings provided real time feedback into the students' laboratory experiences. These sources of data provided a rich description of the students' experiences of chemistry.

Context & Participants

Criterion sampling was used in this phenomenological study. In criterion sampling, the participants must meet some criteria (Creswell, 2013). The first criterion was the participants have taken a science class prior to chemistry and were currently enrolled in a high school general or honors chemistry class at a high school in the southeastern part of the United States where I teach. The second criterion was the students must complete the survey in its entirety to be considered for the study. All students who met these criteria were considered for the study. The results of the survey allowed the researcher to narrow down the participants who have experienced the phenomena (Moustakas, 1994; Creswell, 2013) of observing chemistry on television. To fully encapsulate the true essence of the phenomena, it was important to interview students with varying viewpoints.

A sample size of 55 students completed the survey. The survey was conducted in two different chemistry classes. The diverse sample consisted of participants of varying ethnicities, grades, and ages. The participants ranged in age from 14-17 years old with an average age of 16.2 years old. Within the sample, grade levels 9th through 12th grade were represented, with 2 seniors, 47 juniors, 7 sophomores, and 1 freshman. The diversity amongst the participants is representative of the population of the school. The descriptive statistics of the survey participants can be found in Table 3.

Table 3

Descriptive Statistics for Survey Participants, n=55

Gender	**Male**		**Female**	
	26		29	
Course	**General Chemistry**		**Honors Chemistry**	
	22		33	
Ethnicity	**Black**	**Hispanic**	**Caucasian**	**Other**
	28	14	11	2
Grade Level	**9th**	**10th**	**11th**	**12th**
	1	7	45	2

Of those 55 students 10 students were selected to participate in the video recordings and interviews. The ten students were purposefully selected from the original pool of participants based on their survey responses. Students who experienced the phenomena of viewing chemistry on television were selected to participate in the video recordings. Considerations to students' gender, ethnicity, and teacher were made to ensure that the demographics of the participants mirrored the demographics of the school. The ten students recorded and interviewed were five males and five females with seven in honors chemistry and three in general chemistry. There was one freshman, two sophomores, and seven juniors. Table 4 lists the demographic profiles of the participants. Participants were given pseudonyms to protect their identity.

Table 4

List of Participating Students and Their Characteristics

Pseudonym	**Course**	**Experiment**	**Year**
David	Honors Chemistry	Chemical Reactions	10^{th}
Emily	Honors Chemistry	Chemical Reactions	11^{th}
Frank	Honors Chemistry	Chemical Reactions	9^{th}
James	General Chemistry	Endothermic vs Exothermic	11^{th}
Jessica	Honors Chemistry	Chemical Reactions	11^{th}
Joe	General Chemistry	Endothermic vs Exothermic	11^{th}
Leslie	Honors Chemistry	Chemical Reactions	11^{th}
Meghan	General Chemistry	Endothermic vs Exothermic	11^{th}
Mark	Honors Chemistry	Chemical Reactions	11^{th}
Zaria	Honors Chemistry	Chemical Reactions	10^{th}

To ensure ethical research, an informed consent and assent were used. The informed consent and assent serve as a clear agreement between the researcher and research participants. The informed consent and assent detailed the aim of the research and how it will be disseminated. Participants should be aware of their right to refuse to participate; understand the extent to which confidentiality will be maintained; and be aware of the potential uses to which the data might be used (Corti, Day, &Backhouse, 2000; Moustakas, 1984). Participation in the study was completely voluntary.

Data Analysis

The goal of the data collected in this study was to capture the lived experience of chemistry class and laboratory experiments that adolescents derive from watching popular television shows. The meaning is derived from the descriptions given by the participants and determined through analysis by the researcher. When analyzing phenomenological data, there is not a stepwise protocol for a researcher to follow; however, a systematic approach to analyzing the data can be followed. This approach includes reading the transcripts and surveys to find patterns, establish meanings expressed as phenomenological concepts, and tie together a general description of the experience (Priest, 2006).

Survey. Initial analysis of the survey included three parts: deriving themes from the open-ended questions, calculating descriptive statistics for the semantic differential, and analyzing the drawings. The open-ended questions were analyzed to see emerging themes as they relate to individual experiences. Within the survey, questions 1-4 aimed to uncover the students' image of a chemist. These questions elicited written responses and drawings with the aim to reveal the students' image of a chemist. The multimodal collection of data provided the researcher with a detailed description of the students' image. Questions 1-3 were coded using an open coding system. The initial process involved reading the student responses and in vivo codes were used. The in vivo codes highlighted specific words and phrases that the students used while doing he laboratory (Manning, 2017). The frequency of the response was denoted. The open codes were then analyzed to see if any of the in vivo codes could be combined with codes of similar meaning. Question 4 of the survey consisted of the students drawing of a chemist. The images drawn in question 4 were analyzed using a modified Drawing of a Scientist (DAST) protocol. Chambers (1983) outlined the standard images of a scientist as lab coat, eye glasses, facial hair, symbols of research (scientific instruments or laboratory equipment), symbols of knowledge (books or filing cabinet), technology, or relevant captions (Eureka!). Since this study focused on the students' image of the chemist, the standard images were modified to fit the scope of this study. The standard images (Table 5) for this study were: lab coat, eyewear, facial hair or crazy hair, lab equipment, symbols of knowledge (Periodic Table, books, pocket protector, etc.), smoke, and fire. For every "standard image" that was present in the students drawing 1 point was earned. The images were given a score from one to seven based on the indicators (lab coat, eyewear, facial hair, lab equipment, symbols of knowledge, smoke, or fire) that were present. The higher the score on a drawing the more stereotypical images are present. Inter-rater reliability was used to ensure the images were correctly coded and results could be duplicated.

Table 5

Standard Images of a Chemist Modified from DAST.

Standard Images of a Chemist
Lab Coat
Eyewear
Facial Hair/Crazy Hair
Lab Equipment
Symbols of Knowledge
Smoke
Fire

Question 5 and 6 aimed to reveal the students experiences with chemistry on television. Question 5 was analyzed using the same open coding system as mentioned above. Responses to Question 6 were tallied and then analyzed for frequency. The semantic differential portion of the survey was manually transcribed and given a score of 1-7. Appropriate statistics were tested on the quantitative data using Excel and SPSS.

Video recordings. Prior to the student playback of the laboratory recording I watched the video recordings which provided me with talking points. The video recordings were transcribed in its entirety, and the transcripts were analyzed using Atlas.ti (Muhr, 2004). An example of a transcript can be found in Appendix H. The 18 affective words list was analyzed for frequency of words selected and the associated descriptions by the students. A student sample of the affective words can be found in Appendix I. Additionally, the students' descriptions of the video were compared to their behavior during the video.

Video and Interview Transcripts. The last stage of analysis consisted of analyzing video and interview transcripts. I watched the videos along with the students and a running commentary was created (Galloway, 2015). The commentary along with the interview was transcribed verbatim, and the transcripts were uploaded and analyzed using the software Atlas.ti (Muhr, 2004). The transcripts were read multiple times so that the researcher became familiar with the data. The data was sorted into emerging topics and themes using an open coding process. Open coding is the process of reading the data and assigning identifiers to pieces of data (Creswell, 2013). Open coding was necessary because concepts emerged from the raw data and then the data was categorized through axial coding (Khandkar, 2009). The code categories were progressively changing as the data took on new meanings or as the data turned up new stories (Stake, 2010). Once the codes were established, themes emerged through imaginative variation. Themes are units of information that consist of several codes that form a common idea (Creswell, 2013). The emerging themes were constructed through a systematic analysis of the subjects' literal words and categorized into conceptual categories (Khandkar, 2009; Ratner, 2002). Appendix J provides a table of codes that emerged during data analysis.

Trustworthiness

There is skepticism with the inherent subjective nature of qualitative research. Thus, qualitative researchers must ensure the research is trustworthy and credible. Guba (1981) established four facets that should guide a trustworthy study: credibility, transferability, dependability, and confirmability. To ensure credibility, the researcher used a recognized research method of phenomenology to gain a deep understanding of a phenomenon. Credibility ensures that the ideas expressed are that of the participant and not the view point of the researcher (Collier-Reed, Ingerman, Berglund, 2009). To ensure credibility, the research process was reflexive in reviewing the entire research process. Persistent observation of the data was conducted by reading and re-reading the transcripts, coding and recoding to ensure the true essence of the data emerged.

Transferability is the degree to which the results can be generalized (Guba, 1981). In qualitative research, naturalistic generalizations arise when the reader gains insight from a study and relates that to a personal experience (Stake, 2010). Therefore, a thick description of the data collection and data analysis was provided so that the behavior and experiences become meaningful to the reader (Korstjen & Moser, 2018). The participants of this study are unique individuals but share similar experiences with other high school chemistry students. Therefore, the results for this study can be generalized to a degree but the individuality of the participants and the culture in the classroom must be considered.

Dependability is the consistency in the data interpretation (Collier-Reed, Ingerman, Berglund, 2009). A thorough description of the steps in the research process and a detailed analysis of the findings enhances the dependability in this study. Additionally, inter-rater reliability was assessed to ensure that other scholars can replicate the same codes.

Confirmability is the ability of the researcher to be aware of subjectivities and convey the ideas of the informant and not of the researcher (Finlay, 2006; Guba, 1981). In phenomenological research the research relies on intersubjectivity, the relationship between how the researcher obtains knowledge and the impact of self experience impact the research (Thompson, 2005). Intersubjectivity was employed in this study, as I am a high school chemistry teacher who has experienced chemistry portrayed on television. Therefore, awareness of any of my subjectivities were addressed to ensure that the interpretation is grounded in the data. The data was collected and analyzed through systematic procedures. Multiple sources of data collection were used to enhance the confirmability through triangulation. A survey instrument, video recordings, and an interview provided multiple sources of data. It is the goal of this study to design a phenomenological research methodology that adequately encompasses the lived experience of the students as it relates to the phenomena of chemistry portrayal on television and students' expectations of chemistry class.

Chapter 4: Findings

The purpose of this chapter is to present the findings of the data collected in this phenomenological study. The evidence will be presented to answer the two research questions of this dissertation: (1) What are the realities of chemistry that students construct while watching television? and (2) How do students' expectations of laboratory compare to what they do in the laboratory during high school chemistry? This chapter will first discuss the findings as they relate to the first research question. To fully answer this question two sub-questions were used to analyze the findings: (1) What are students' image of a chemist? and (2) What are students' attitudes or beliefs towards chemistry? The second portion of the chapter will discuss the findings of the second research question. The chapter concludes with a synopsis of major findings as it relates to the image of a chemist, attitudes towards chemistry, laboratory expectations, and television's influence on students' perceptions of chemistry and the laboratory.

What are the Realities of Chemistry that Students Construct While Watching Television?

The survey instrument was used to uncover the realities that students have about chemistry and chemists. As mentioned in Chapter 3, the survey consisted of open-ended questions, drawings, and semantic differential scale questions. Within the survey, a rich description of the students' image of a chemist and attitude toward chemistry was collected, and the findings will be presented in this chapter.

Image of a Chemist

Within the survey, questions 1-4 aimed to uncover the students' image of a chemist. These questions elicited written responses and drawings with the intention to reveal the students' image of a chemist. The multimodal collection of data provided the researcher with a detailed description of the students' image. The next portion of the chapter will look at the results of questions 1-4 of the survey as they describe the students' image of a chemist.

What does a chemist do? In question 1, students were asked, "What does a chemist do?" This question was used as the initial open-ended question in the survey to provide context to the survey and get the students thinking about chemists. The initial in vivo coding uncovered 10 different responses. Within these different responses, it was decided to combine the original codes that referred to mixing or using chemicals into one code: experiment with, use, or mix chemicals. That left seven responses for what a chemist does: experiment, use, or mix chemicals; solve equations; chemistry; make new discoveries; use elements and gases; measure abstract things; and determine how chemicals work in the world (Table 6). Experiment with, use, or mix chemicals was the most prominent response with 34 responses. The overwhelming response demonstrates that students associate chemicals with what a chemist does. The remaining responses occurred five or fewer times.

Table 6

Survey Response to Question 1: What Does a Chemist Do?

Response	Frequency of Response
Experiment, use, or mix chemicals	34
Solve equations	1
Chemistry	5
Make new discoveries	5
Use elements and gases	2
Measure abstract things	1
Determine how chemicals work in the world	2

All the responses to question 1 of the survey were things that a chemist would do, and most of the responses have laboratory implications, meaning things that a chemist would do within the laboratory. The responses indicate that the reality students have constructed for themselves, as well as the prominent image of a chemist presented to students involves the laboratory work a chemist would do. There were two responses that are not rooted in laboratory practices: solve equations and measure abstract things. These concepts are rooted in the content of chemistry. Solving equations and measuring abstract things are practices that are true to chemistry and can happen outside of the laboratory. The chemical equation is a physical representation of the idea of chemistry. The response, measure abstract things, was a surprise and seemed very perceptive for a high school student. Upon interviewing this student, it was revealed that he had taken a chemistry-based course in another state where the abstract nature of chemistry was discussed.

What does a chemist look like? Question 2 of the survey asks the students, "What does a chemist look like?" This question was designed to evoke a written description of the students' image of a chemist. In question 4 students were asked to draw their image of the chemist. The multimodal response provided a more complete image of the chemist. The student responses in question 2 uncovered 12 physical features that a chemist would possess. A list of survey responses for question 2, and the frequency of responses can be found in Table 7. The three most prominent characteristics for a chemist, as described by the students' responses, were goggles/glasses (22), lab coat (26), and gloves (4). Like question 1, the most prominent responses have laboratory implications. A lab coat, goggles, and gloves are protective wear that a chemist would use in the lab. A typical response was that a chemist "is a normal person with a lab coat and safety glasses." The notion that chemistry can be done by average people, but protective wear is a prerequisite, is a recurring theme within the study. One student described a chemist as someone in a hazmat suit. The need to describe a chemist in protective wear demonstrates that the students view chemistry as dangerous with the potential to harm or that when students see a chemist on television they are always wearing protective wear. Other student responses have laboratory implications such as lab and beakers, but these responses do not describe what a chemist looks like. The lab and beaker are merely an accessory to the chemist.

Table 7

Survey Response to Question 2: What Does a Chemist Look Like?

Response	Frequency of Response
Bald	1
Goggles/Glasses	22
Hazard Suit	1
Beard	1
Walter White	3
Weird personality	1
Lab coat	26
Lab	2
Beakers	2
Gloves	4
Old	1
Middle-aged man	1

Some students described the physical appearance of a chemist with descriptions as old, middle-aged man, bald, a beard, or Walter White. All these physical descriptions, except for old, are grounded in masculinity. The idea that a chemist is male is comparable to the results of the

Mead and Metraux study (1957) and the Drawing of a Scientist Test (DAST) (Chambers, 1983) where the stereotypical image of a scientist was a male. The description of a chemist as "Walter White" is derived from the television show *Breaking Bad*, where a rogue chemistry teacher makes methamphetamine to earn money for his cancer treatment. In the show, the character often wears a hazmat suit when working with the chemicals. The student who used hazmat as a description drew Walter White in their response to question 4. One can deduce that the student made the connection between a chemist and the television show.

In what ways does a chemist look different from a scientist? Question 3 asked, "In what ways does a chemist look different from a scientist?". Much of the previous science education research focused on the image of a scientist. This research aims to uncover the students' image of a chemist. Thus, the goal of this question is to get the students thinking about a chemist and a scientist separately. The answer to this question informs the researcher of the student's differentiation between a scientist and chemist or if the students do not distinguish a difference between the two.

There were 14 different codes that emerged from the analysis of student responses to question 3, "How is a chemist different than a scientist?" The list of responses and their frequencies are listed in Table 8. The data as it is presented represents how the students described the chemist and not the scientist. The students who noted the difference between a scientist and a chemist described the characteristics of a chemist and did not specifically mention a scientist. An example response to question 3 is, "A chemist works with chemicals and reactive things." There was no mention of a scientist, but the researcher inferred that the student meant that this is how a chemist is different from a scientist. Thirteen students noted that there is no difference in the appearance of a chemist and a scientist. The prevalent response for how a chemist differs in appearance from a scientist is the need for protective wear. The second most frequent response as to how a scientist and chemist differ is that a chemist uses chemicals and conducts experiments. The notion that a chemist must wear protective gear and use chemicals is a common assumption among students in this study. These results are similar to the results in question 2.

Table 8

Survey Response to Question 3: In What Ways Does a Chemist Look Different from a Scientist?

Response	Frequency of Response
Uses chemicals/Experiments	9
Not geeky	2
Crazy	1
Stains on shirts	1
Curious expression	1
Protective Wear	22
Frustrated	1
Majors in chemistry	1
Figure stuff out	1
unorganized	1
No difference	13
Deep observations	1
Periodic Table	1
Complicated	1

Other responses to this question relate to how a chemist behaves or their appearance. Students described a chemist as crazy, stains on shirt, frustrated, unorganized, and not geeky.

These adjectives lend to the perception of a mad scientist, but in this case, it is not the mad scientist but the mad chemist. This question specifically asks students to tell differentiating characteristics of a chemist from a scientist. The major difference between a chemist and a scientist is the protective wear and the behavior of the chemist. Based on the responses, students are using the irrational behavior of the chemist to set him/her apart from a scientist.

Draw a chemist doing science. In question 4, students were asked to draw a chemist doing science. As mentioned in chapter 3, the student drawings were analyzed using the indicators of the standard image of a chemist modified from the standard indicators detailed in DAST (Chambers, 1983). Since this study focuses solely on the image of a chemist, the DAST indicators needed to be modified to fit the scope of this study. The indicators of a standard image of a chemist were extracted from the student responses in survey questions 1-3 and blended with the stereotypical images that have been uncovered in previous research studies. For every standard indicator that is present in the student's drawing, 1 point was earned. The drawings were given a score from 1 to 7 based on the indicators that were present. Table 9 list the indicators of a standard image of a chemist. The higher the score on a drawing, the more stereotypical the image. The mean score for the total sample is 2.82. The highest score was a 5 and the lowest score a 1. In Figure 1 there is an example of a student drawing that earned a score of five. In this drawing, the student has the chemist wearing goggles, a lab coat and gloves, an Erlenmeyer flask with steam coming out of it, and a beaker with fire coming out of it.

Table 9

Indicators of standard image of a chemist
Lab Coat
Eye glasses or goggles
Crazy hair or facial hair
Lab equipment
Symbols of knowledge
Smoke or gas production
Explosions

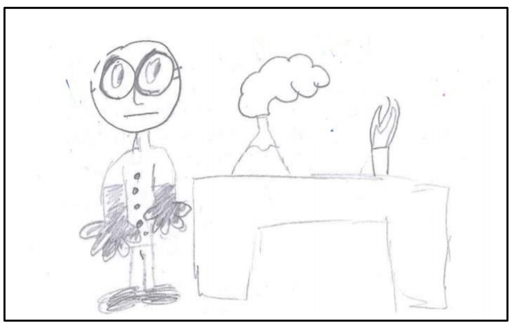

Figure 1. Student drawing of a chemist scoring a 5

In addition to the 7 standard indicators, other factors were considered when analyzing the drawings. These factors were indications of danger, references to television, and gender of the chemist. In the sample, 40% drew a male chemist, 18% drew a female chemist, and 42% of the drawings had no apparent gender. Since the students did not specifically designate the gender of their chemist, the gender was implied by the researcher. Inter-rater reliability was used to demonstrate consistency among multiple coders in assigning gender to the images. The inter-rater reliability results for gender were 100%. The determining factor for assigning gender to the images was predominately the hairstyle but other identifying factors were considered. Images classified as a female had feminine characteristics like long hair, buns, and curvy lips, the male images had facial hair or no hair, and the drawings with no gender had no apparent characteristics that indicated gender (Figure 2).

Figure 2. Student drawing of a chemist with no indication of gender

In the original DAST (Chambers, 1983), the female representations of a scientist were only drawn by female students. In this study, it was more common for a male student to represent the chemist as a female than it was for a female student. In the 10 drawings that had a female chemist, male students drew seven of them. The students in this study were sampled from two different chemistry classes, one with a male teacher and one with a female teacher. The initial analysis would call attention to the gender of the teacher, because 32 of the students sampled are taught chemistry by a female, and that could bias them to draw a female scientist. However, when analyzing the data based on teacher gender (Table 10), an equal number of students from each class drew their chemist as a female. In the class with the male teacher, the mean DAST score of 2.87 was slightly higher than the mean score of the students in the female teacher's class. The mean DAST scores were compared using the Mann-Whitney U test. This was performed because the data was non-parametric and did not follow normal distribution. The Z value was -0.017 with a significance level of 0.987. The p-value is not less than or equal to 0.05, so the result is not significant. There is no statistically significant difference in the mean DAST scores of students who had a male or female chemistry teacher.

Table 10

Drawing a chemist results using a modified DAST protocol, n=55

	Gender of Chemist in Drawing			Mean DAST Score
Student Gender	*Male*	*Female*	*None*	
Male	13	7	12	2.93
Female	9	3	11	2.74
Teacher Gender				
Male	11	5	7	2.87
Female	12	5	15	2.79
Total Sample	22	10	23	2.82

Additional analysis of the images highlighted gender differentiated associations to the images of the chemist. When a student drew a male chemist, there were more standard indicators than when the chemist was a female. Drawings of a male chemist have a mean DAST score of 3.87, while the drawings of female chemist have a mean score of 3.00 (Table 11). The drawings of a male chemist had more instances of smoke and fire, crazy hair, and mad scientist depictions. The images of a female chemist had more indicators of symbols of knowledge (i.e. papers, books, pocket protectors) and their expressions were always smiling. In Figure 3 there is a side by side comparison of two student drawings. Both drawings earned a DAST score of 4. The male drawing consists of the standard indicators: goggles, lab coat, a smoking Erlenmeyer flask, and a flask on fire. The female drawing consists of the standard indicators of goggles, lab coat, pocket protector, and smoke coming out of the glassware. Both images have depictions of active reactions in an Erlenmeyer flask but the male depiction there is an active fire.

Table 11

Drawing a Chemist Results Based on the Gender of the Chemist Drawn

Gender of Chemist in Drawing	**Mean DAST Score**
Male	3.87
Female	3.00
None	1.83

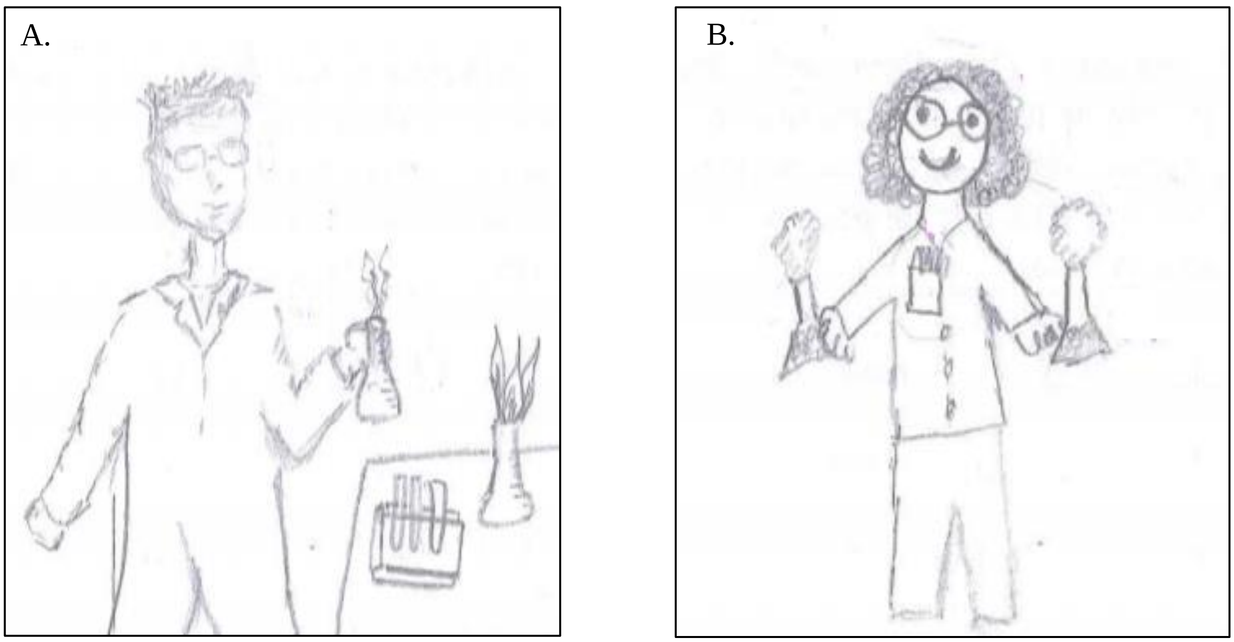

Figure 3. Comparative of students' drawings of a (A) male chemist and (B) female chemist

Realities of Chemistry from Television

Chemistry on Television. In the survey, students were asked what shows that they associate with chemistry and what shows have impacted the students' expectations of this class. However, when interviewing students, it is evident that the students answered the question as, "what shows do you associate with chemistry?" Students were asked to identify sitcoms, cartoons, dramas, and any other television shows they associate with chemistry. There are instances where students listed a show but had it in the wrong category. An example is a student placed *Grey's Anatomy* in the sitcom category, but it is a drama. Therefore, the data is presented with all the shows that the students listed but the researcher recategorized them as needed (Table 12).

Table 12

List of Television Shows that Represent Chemistry

Genre	Television Shows	Number of Responses
Situation Comedy	Big Bang Theory	18
	Disney Channel	2
	Drake and Josh	2
Cartoons	Dexter's Laboratory	24
	Tom and Jerry	5
	Johnny Test	5
	Rick and Morty	6
	Power Puff Girls	6
	Fairly Odd Parent	1
	Jimmy Neutron	17
	Scooby Doo	3
	Lab rats	1
	Magic School Bus	1
	Phineas and Ferb	1
Drama	Breaking Bad	16
	Criminal minds	1
	48 hours	1
	NCIS/CSI	4
	Supernatural	1
	Flash	1
	Grey's Anatomy	6
	House	1
	Bones	1
Other	Bill Nye	3

How is chemistry portrayed on television? In the survey question 5, students are asked, "How is chemistry portrayed on television?" All students surveyed have watched television and have experienced what they think is chemistry portrayed on television. The purpose of this question was to uncover the images of chemistry that students have viewed on television. Understanding what representations of chemistry are on television will help understand the realities that students construct about chemistry and a chemist.

During analysis of responses to question 5, the student responses could be categorized into three domains: chemist, laboratory, and chemistry. The responses that mentioned a chemist directly or a person doing chemistry went into the chemist category. If the response mentioned an experiment, protective wear, or chemicals it was categorized as laboratory. The remaining responses were categorized as chemistry. Table 13 lists the responses to question 5 and their frequencies.

Table 13

Survey Response to Question 5: How is Chemistry Portrayed on Television?

Domains of Chemistry on Television	Chemistry Portrayed on Television	Frequency of Response
Chemist	Genius	1
	Crazy	2
	Take Over the world	1
	Criminals	1
	Disorganized	2
	Mad scientist	2
	Match maker	1
Laboratory	Lab work	1
	Lab coats	4
	Bubbling Liquids	2
	Glassware	6
	Experiments	6
	Colorful	2
	Chemicals	3
	Goggles	2
	Mixing liquids	2
Chemistry	Exciting	1
	Complex	1
	Drugs	7
	Explosions	17
	Dangerous	7

The image of a chemist portrayed on television is comparative to the image of a chemist described in the previous section of this chapter. The most common descriptive of a chemist on television was as a mad scientist. Where only four students directly said mad scientist, other responses eluded to the mad scientist persona, such as evil genius, villain, and disorganized. The mad scientist persona descriptions of how a chemist is portrayed on television has a negative connotation and imply that a chemist uses knowledge for destructive purposes. There is a shared theme within the data that a chemist on television is felonious. One student described a chemist on television as "a criminal trying to make a living". This description matches the main character, Walter White, in *Breaking Bad*, where the chemistry teacher makes drugs to pay for his cancer treatment. One student provided a response that described a chemist as a person who is trying to make new discoveries. The idea of new discovery is founded on the ideas of hope and uncovering the unknown. However, the student response was, "make new discoveries at all cost". The researcher inferred the student's response to mean that the chemist will stop at nothing to make a new discovery, which also has a negative connotation.

Other responses, which correlate to the stereotypical image of a scientist, described a chemist as a nerd and a white male (Mead & Metraux, 1957). The stereotypical image of a scientist that has been derived from 60 years of science education research mimics the stereotypical image of a chemist in this study. As discussed in the previous portion of this study the prevalent construct is that a chemist is a white male and someone who is socially inept or a nerd. There are specific mentions of *Bill Nye the Science Guy* and *Jimmy Neutron* when describing a chemist on television. These characters are both white males who are portrayed as very intelligent and quirky. These characters are examples of television scientists who fit the description of a student's image of a chemist. *Bill Nye* videos are educational tools used in many classrooms as an interesting way to expose students to a topic. All domains of science topics are covered in *Bill Nye* videos including some which are chemistry specific. One student, Joseph, recounts a middle school experience of watching a Bill Nye video, “I would watch *Bill Nye* on Disney channel, and I would see something and would be like, Wow, how does that happen? And here I am now, in chemistry doing it.” Another student, Jessica, while doing her lab states, “I feel like Bill Nye” when she was mixing two chemicals. The students have an association between Bill Nye and the chemistry they do in class. In survey question 5, one student responded with a drawing of Jimmy Neutron and his dog (Figure 4). *Jimmy Neutron* is a show about a boy genius who solves his problems, which range in complexity from the dog eating his homework to alien invasions, using science. The graphic at the beginning of the show in *Jimmy Neutron* is the planetary model of the atom. Since the atom is a fundamental aspect of chemistry content, it is not a surprise that students relate this show to chemistry.

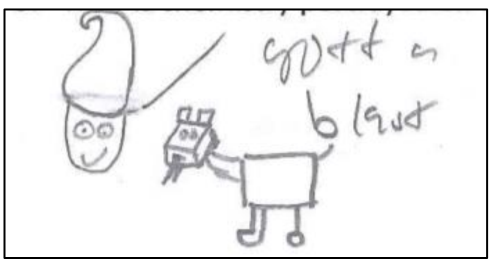

Figure 4. *Student drawing of Jimmy Neutron*

The second category for the responses in survey question 5 was laboratory. Based on the responses in the survey, it is apparent that there is a strong connection between chemical experimentation and chemistry on television. When asked about chemistry portrayed on television, many students described laboratory practices or items used in the laboratory. The most common response, experiments, included statements about mixing chemicals, pouring substances, and doing chemistry. One student described chemistry on television as, "Dealing with chemicals and doing experiments." In some instances, students described the appearance of the chemicals in the experimentation as bubbling liquids or colorful substances. There was also mention of the glassware used in experimentation and the need for the chemist to wear protective gear, like goggles and a lab coat. The notion that chemistry is dangerous and protective wear is needed is a recurring theme among this research.

The last category, chemistry, consists of the remaining responses that did not specifically describe a chemist or experimentation. The most prevalent response in this question was explosions, which was categorized as chemistry and not experimentation due to the variety of contexts in which it was used. The different connotations of the term explosions consisted of explosions as a part of experimentation, as a biproduct of drugs, or explosions as a separate entity. "Blowing stuff up" was a common explosive reference. "Stuff" could refer to anything making "blowing stuff up" a better fit in the chemistry category rather than the experimentation category. When students described chemistry as explosive, this had a negative connotation and has innate destructive characteristics. The second most prominent response was that chemistry is dangerous. In this study, students focus on the inherent danger within chemistry as evident from the association of protective gear as a characteristic of a chemist.

In addition to chemistry being portrayed as dangerous on television, it is also portrayed as a means to criminal activity. In question 5 there were seven responses which stated that chemistry on television involved making drugs. Based on student responses, the idea of chemistry being used to make drugs is from the show *Breaking Bad*. Although this is not the only television show to highlight the use of chemistry in the drug making process, it was the only show referenced when discussing drugs. There were also three instances where a student stated that a chemist was like Walter White, the main character and there are three instances where students' drawings of a chemist were a portrayal of Walter White (Figure 5). Other *Breaking Bad* references included the portrayal of chemistry as making methamphetamine, the drug enterprise that Walter White starts with his former student. In one of the Walter White drawings, the student drew the camper in which he made the methamphetamine.

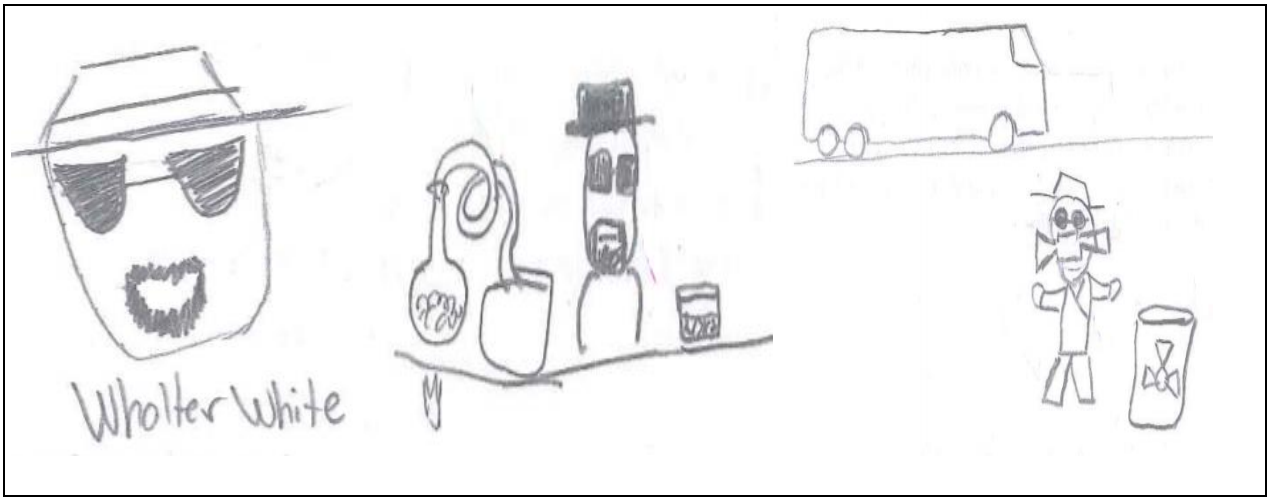

Figure 5. Student drawings of Walter White from Breaking Bad

Some students described chemistry on television as an emotion and not a field of science. One student described chemistry on television as a matchmaker and said there is "chemistry between two love birds like on *Grey's Anatomy*." Six students listed *Grey's Anatomy* as a show that they associate with chemistry. It is unclear if they associate the show with the scientific aspect of chemistry or the emotional connection between two people.

How does your experience in class compare to the chemistry you see on television? In question 6 of the survey, students were asked to compare their chemistry class to the chemistry that they saw on television. Most students described how chemistry class was not like television but there were four students who described how television was the same as chemistry class. The responses are displayed in Table 14. When students described chemistry in the classroom, they differentiated between the chemistry content and the laboratory. Students described the laboratory as safe, surprising, and the most frequent response was that chemistry lab did not involve explosions. In question five of the survey, students described explosions as a representation of chemistry on television. Based on question five and six of the survey, it is the lack of explosions in the classroom that is the key difference between chemistry on television and the classroom. Two students referenced the lack of drug making in the laboratory. The association between drug making and chemistry occurs multiple times in this study. Students characterized the chemistry content as vocabulary/note taking, investigating details, involving math, formulas/equations, and complicated. According to the students, these characteristics are indigenous to the classroom and not portrayed on television. One student described chemistry on television as lacking "measuring, formulas, and math". Multiple students described chemistry in class as "more in depth" and "chemistry is more than just doing experiments". Based on the student responses and interviews, chemistry on television focuses on the laboratory aspect and not on the learning of chemistry content.

Table 14

Survey Response to Question 6: How Does your Experience in the Class Compare to the Chemistry You See on Television?

Response	Frequency of Response
In Class	
Vocabulary/Note taking	2
Investigate details	1
Boring	1
Complicated	5
Involves Math	2
No explosions	13
Safe	3
Organized	2
No drugs	2
Formulas/Equations	1
Same	5
Surprising	1
Television	
Cool	1
Unrealistic	3
Boring	1

There were five students who thought the chemistry in class and on television were the same. Those who specifically referenced television mentioned that the chemistry on television was unrealistic. One student said that chemistry on television was cool which implies that chemistry in the classroom is not cool. Student responses to the differences between classroom chemistry and television chemistry were laden with negative connotations. One student described chemistry in the classroom as “they get to do cool stuff and we burn wet wood.” The student’s comment refers to the flame test lab where students observe changes in flame color when burning wood splints that have been soaked in metallic salt solutions. Another student described chemistry class as “way too complex”.

Attitudes Towards Chemistry

To understand the students' attitudes and/or beliefs about chemistry the Attitude toward the Subject of Chemistry Inventory Version 2 (ASCI V2) was embedded in the survey. The ASCI (V2) assesses intellectual accessibility and emotional satisfaction (Xu & Lewis, 2011). These two components are the cognitive and affective aspects of attitude. In Table 15, the results for ASCI (V2) are listed. Scores range from 1-7. Numbers below 4 indicate students feel that chemistry is intellectually accessible and emotionally satisfying. Items 1, 2, 3, and 6 addressed the cognitive aspect of intellectual accessibility where 4, 5, 7, and 8 addressed emotional satisfaction. Item 6 has the highest mean score of 4.38 and item 8 has the lowest mean score of 2.75.

Table 15

Descriptive Statistics for the Semantic Differential Questions in the Survey

Item Number	Polar Adjectives		Mean	Minimum	Maximum
1	Easy	Hard	3.91	1	6
2[b]	Simple	Complicated	3.23	1	7
3[b]	Clear	Confusing	3.64	1	7
4	Comfortable	Uncomfortable	3.11	1	6
5	Satisfying	Frustrating	3.54	1	7
6[b]	Not Challenging	Challenging	4.38	1	7
7	Pleasant	Unpleasant	3.29	1	7
8[b]	Organized	Chaotic	2.75	1	7

[b] Item score is reversed for ease of interpretation.

The cognitive process of chemistry based on the students sampled within the study is easy, simple, clear, and challenging. The adjectives *easy*, *simple*, and *clear* demonstrate that students feel that chemistry is intellectually accessible. However, the adjective *challenging*, with the highest mean score of 4.38, does not fit this parameter. Student use of the adjective *challenging* means that students find the content to be cognitively demanding. The adjectives that describe the emotional satisfaction of chemistry are *comfortable*, *satisfying*, *pleasant*, and *organized*. These adjectives demonstrate a positive emotional response to chemistry. Based on the results of the ASCI (V2) there is an overall positive emotional response to chemistry and both a positive and negative cognitive response. Based on the semantic differential results, students enjoy the class but find the content to be difficult.

Synopsis of Research Question 1

Students who take high school chemistry have preconceived notions about chemistry. Students construct a reality of chemistry based on their exposure to chemistry prior to taking chemistry class. Television is one source that exposes students to chemistry. When watching television, students learn incidentally even if the intention is for entertainment and not learning (Whittle, 2003). The portrayal of chemistry on television influences students' reality of chemistry in the classroom. Students' reality that they constructed of chemistry from television is that it is dangerous and explosive. This is due to the portrayal of chemistry on shows like *Breaking Bad*, *Bill Nye the Science Guy*, and *Jimmy Neutron*.

The survey data revealed the students' image of a chemist. The image of a chemist derived from this study is comparable the previous research done on the image of a scientist. Mead and Metraux (1957) and Chambers (1983) reported that the stereotypical image of a scientist is a white male who works in a laboratory and wears a white lab coat. A similar image of a chemist was derived from this study. Students described a chemist as someone who mixes chemicals and works in a lab. The delineation between a chemist and a scientist is the need for chemist to wear protective gear, like a lab coat and goggles. The images that students drew were more frequently ungendered but when a gender was assigned to the chemist it was more frequently a male chemist with more standard images than a female. The characteristics of a chemist depicted by students reflected the image of a chemist portrayed on television. According to the participants of this study, chemists on television are portrayed as evil, mad scientists who work in the laboratory.

Students' attitudes toward chemistry can be broken down into two domains: cognitive and affective. Students find chemistry to be cognitively demanding but emotionally satisfying. Students' attitudes contribute to the overall reality that the students have constructed about chemistry prior to taking the class. Question 1 of this dissertation reveals the perceived realities of chemistry that students' construct prior to taking chemistry. The realities that students' construct influence their expectations of the class. The next portion of this chapter will aim to uncover how students' expectations of chemistry compare to their actual experiences in lab.

How do Students' Expectations of Laboratory Compare to What They do in the Laboratory During High School Chemistry?

Affective Words

To answer the second research question, 10 students were recorded while doing a laboratory experiment. Within 24-48 hours of the lab recording students were interviewed and asked to describe their laboratory experience. The interview consisted of two parts: selection of affective words and a recorded commentary while watching the recorded experiment, allowing students to watch themselves in the laboratory and answer questions about their actions.

The initial stage of the interview consisted of students analyzing 18 affective words as mentioned in chapter 3. The affective words were used to elicit affective experiences during the lab. Prior to the play back of the lab recording, students were asked to first circle any of the words that they feel describe their chemistry class, second put a star next to words that describe chemistry on television, and third cross out any words that they feel do not describe their chemistry class. Figure 6 displays the frequency of the affective words that were circled, starred, or neither.

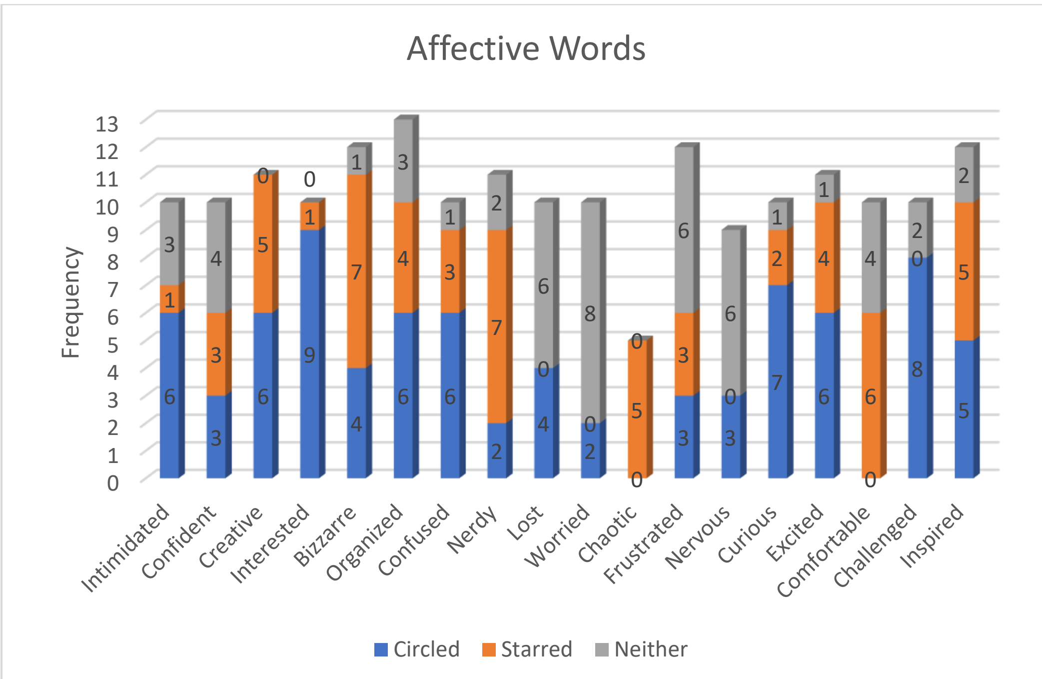

Figure 6. Frequency of affective words. Circled refers to words that described chemistry class, starred words described chemistry on television, and neither refers to words that did not pertain to chemistry class

The mean number of words marked by students was 12, with a minimum of 7 and a maximum of 16. The blue bars in Figure 6 indicate the words that represent students' experience in chemistry class. The orange bars represent how chemistry is displayed on television. The gray bars represent when students neither circled nor starred a word. An average of 6 words were circled per student (maximum of 10 and a minimum of 3) and 5 words were starred by each student (maximum of 8 and a minimum of 3). The diversity of the distribution of words is indicative of the varied experiences that students have in chemistry.

The most frequently circled word was *interested* with 9 of the 10 students selecting it indicating students had an interest in the course and the laboratory. Zaria described the class as "interesting, because the people and the class are pretty interesting, it keeps my focus especially when I'm learning about things that actually make sense." Joseph also described chemistry as interesting: "That's why I chose chemistry because it seemed pretty interesting."

The second most frequently circled word was *challenged*. Many students used the word challenging as an umbrella term for the course. Zaria said, "I circled the word challenging twice because this class is challenging." Mark more specifically described a part of the lab to be challenging. He said, "reading the graduated cylinder was challenging and that is why I circled challenging and frustrated."

There are two words that were not circled at all: *chaotic* and *comfortable* meaning students do not feel comfortable with the content or the laboratory and they see the class as being organized. These results are comparable to 6 of the 10 students selecting *organized*. The words *chaotic* (5) and *comfortable* (6) were not circled but were starred. The most frequent words starred were *nerdy* and *bizarre*. Zaria said, "I put a star next to nerdy because that's the whole stereotype, The Big Bang Theory and Jimmy Neutron, they're all nerds." Joseph considers all chemistry on television to be "Bizarre! That's what they show on television and it's nerdy on television." Based on the starred words, except for *comfortable*, the descriptions of chemistry class mirror the standard images of a chemist as described earlier in this chapter.

Laboratory Recordings

The students' recordings occurred within two different chemistry classes and took place during the Chemical Reactions unit. The laboratory experiments that were recorded were the Endothermic and Exothermic Lab and the Indicators of Chemical Reactions lab (Appendices E & F). In the Endothermic Lab, students had four stations where they observed temperature changes as a result of chemical reactions. The four chemical reactions included: adding solid magnesium to hydrochloric acid, mixing solid barium hydroxide and ammonium chloride, mixing solid potassium iodide and water, and adding sodium pellets to water. The reactions between magnesium with hydrochloric acid and sodium pellets with water are exothermic reactions that produce heat. The mixture of barium hydroxide with ammonium chloride and water with potassium iodide are endothermic reactions that have a decrease in temperature. In the Indicators of Reactions Lab, there were four stations and a demonstration. The five stations represented the five types of chemical reactions that students learn about in the content standards. Station one consisted of adding zinc metal to a copper chloride solution. In this reaction, students observe the single replacement reaction between copper and zinc. Students observe a color change in the solid zinc from black to a reddish brown and temperature change where the test tube is warm to the touch. Station two was an example of a synthesis reaction between magnesium and oxygen. The students burned a piece of magnesium using the Bunsen burner. When the magnesium burns it produces a bright yellow light. Station three was the decomposition of hydrogen peroxide. This reaction, commonly referred to as elephant's toothpaste, produces a foam that grows in size and gives off heat. It is extremely exothermic, and students can observe the change in temperature through the production of steam. The last station was an example of the double displacement reaction between potassium iodide and lead nitrate.

At this station students mixed two clear liquids that combine and form a bright yellow solid. Finally, the demonstration included the combustion of methane. The combustion reaction produces fire and due to the inherent danger, it was performed by the teacher.

After the students performed the lab experiments, the video recordings were transcribed and coded using an open coding system. From the open coding, six themes emerged: self-efficacy, risk, attitude in the lab, preconceived expectations, image of a chemist, and relevance. Table 16 lists the emerging themes and the frequency of codes within that theme. Figure 7 displays the frequency of codes separated by lab experiment. The results in Figure 7 will be discussed within each theme in the following sections. The remainder of the chapter will discuss the emerging themes and aim to answer the second research question: How do students' expectations of laboratory compare to what they do in the laboratory during high school chemistry?

Table 16

List of themes and the frequency of codes within each theme.

Themes	**Code Frequency**
Preconceived Expectations	34
Attitudes in the Lab	42
Self- efficacy	42
Image of a chemist	14
Relevance	13
Risk	54

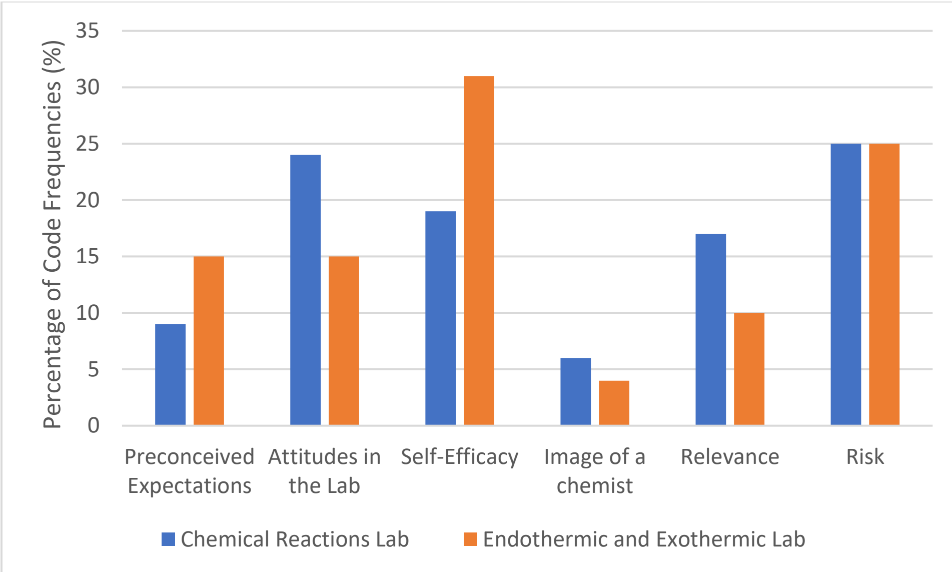

Figure 7. Comparison of code frequency between the Endothermic and Exothermic lab and the Chemical Reactions lab

Preconceived Expectations. Students who take high school chemistry have preconceived expectations as to what experiments they will get to do. It is during those experiments that students get to actualize the results. There were 34 instances where students discussed their preconceived expectations. Students who performed the Endothermic and exothermic lab (15 %) had a higher percentage of instances where they exhibited preconceived expectations than students who performed the Chemical Reactions lab (9 %). The students' expectations varied from expecting the results of the reactions to observing unexpected results. Often students were surprised by unexpected results of the chemical reactions. Comments like "I didn't know that was going to happen" or "That's crazy" were phrases heard throughout the recordings. Frank describes the double displacement reaction between potassium iodide and lead nitrate, where he mixed two clear liquids and obtained a yellow product. He said, "As soon as the solution turned yellow, that's what really surprised me." When Leslie recounts the burning of magnesium, she explains, "I thought it was just going to be the orange fire, the regular one, but it was way brighter." David thought that the decomposition of hydrogen peroxide exceeded his expectation. When asked why, David said, "to see chemicals combining and make steam, it's just cool to see reactions like this." When the results were different from what students expected, students' reactions were coupled with positive feelings of excitement or curiosity. There were times when students commented that the lab was just as they expected. Some students had seen the results of the reactions via Snapchat and thus they were not surprised. Jessica saw the decomposition of hydrogen peroxide via Snapchat and describes, "I thought it was going to be like when you put two chemicals together and just spreads and is big and foamy, so I expected that." When the reaction occurred just as the students expected, there was a lack of wonder and enthusiasm. Student attitude will be discussed further in the next section.

Attitudes in the Lab. While performing the laboratory experiments students expressed varying attitudes of dissatisfaction (21%), excitement (26%), caution (19%), nervousness (11%), and comfortability (26%). Students' attitudes in lab were often affiliated with the affective domain of attitude. The diverse nature of the students and the differences in their experiences lends to the diversity of their attitudes in the laboratory. Students who performed the Chemical reactions lab had a higher percentage (24%) of codes pertaining to attitudes then students who performed the Endothermic and Exothermic lab (15%). The predominant attitude in the Chemical Reactions lab was excited and cautious, where comfortable was the predominant attitude for students who performed the Endothermic and Exothermic. The difference in attitude could be due to the difference in procedure and outcome between the two experiments. The Chemical Reactions lab had more vivacious experiments that aligned with students 'expectations. The Endothermic and Exothermic lab only focused on temperature change.

As mentioned previously, students have preconceived expectations as to what will occur in the lab. Often a student's attitude is associated with the outcome of the lab experiment. Students were disappointed when the outcome of an experiment did not match their expectation of what would occur. When students burned the strip of magnesium in the flame of the Bunsen burner, four students expressed disappointment in the short-lived flame. Emily described the experiment as, "I expected it to last a little longer." David said, "I thought it would be brighter." Many students were disappointed in the single displacement experiment where zinc was added to copper (II) nitrate. There was a color change and a slight temperature change. The results were not vibrant or volatile, so students were disappointed. Emily described this reaction as "the least exciting". Jessica explains her disappointment in this reaction when asked if she was impressed with the chemical reaction, "Yes, but not as much as the one before. The one before was crazy. This one is more like observing what's going on." Jessica's dissatisfaction stems from the less obvious results of color change and temperature change produced in this reaction. Students completed the lab stations in different orders. This station was described as the least interesting reactions by every student recorded. It did not matter if this lab station was their first station, where there was no other reaction to compare the results to, or their last station. There were two instances where students thought nothing was happening in the reaction due to the minimal evidence of a chemical change. Throughout the recordings, students' excitement increased when the results of the experiment were grander.

In the double displacement reaction between potassium iodide and lead nitrate, Jessica expressed feelings of excitement. While talking to her lab partners, she describes the experiment, "It's clear and then it's a bright yellow liquid and then turns into a solid. Look. There it goes. That's so cool." When Emily mixed the chemicals together she proclaimed, "Whoa! That was amazing. Chemistry amazes me." Another experiment that students were excited about in the lab was the decomposition of hydrogen peroxide. Emily describes why she was excited for this reaction, "I was kind of excited because I saw the videos of this one. I think I've seen it on Pinterest and stuff like that." Emily was in the last block class of the day and had heard about this experiment from her peers in earlier classes. Jessica saw a group of peers perform this experiment prior to her turn and was excited for this station. "It was really cool. We were all excited to do it," said Jessica.

Sometimes students paired words together to better describe their affective experience. Meghan pairs the feelings of being excited and terrified together to describe her experience in the lab. Meghan explains:

> *I see the labs as exciting as well as terrifying. That's one thing I really focus on. I don't want anything to go wrong in the lab. Since we're so close, I feel like I'm going to turn around or do something or it's going to fall on me.*

In Meghan's class the lab area is smaller than in other chemistry classrooms at her school. The proximity that Meghan and her classmates are in created feelings of fear that are coupled with her excitement to do the lab. Other students expressed feelings of apprehension in the lab. Joseph describes his feelings of concern during his interview. When asked if he enjoys mixing chemicals during the lab he explained:

> *I mix them sometimes but then, when I feel a little bit nervous about it, I will ask someone else to mix them. Sometimes when we mix, if we put something on the fire, I'll be nervous to turn on the fire because I don't know what might happen or something will catch on fire.*

Jessica also mentioned that fire makes her nervous. She describes using the Bunsen burner in the lab, "I let other people light it because it makes me nervous to put a heat on it and I don't really know how to work it." Mark was also nervous about the Bunsen burner. He said, "I was really worried. I was scared of the fire. I don't like fire." When Emily was lighting the Bunsen burner she was nervous and scared. During the laboratory recording, as she lit the Bunsen burner, she proclaimed "I don't know what to do. My God, I'm scared, I thought, I thought I was about to…" Though she had lit a Bunsen burner in a previous lab she was still anxious.

The prevailing emotion in the lab is one of unsureness and unease with 45% of students recorded expressing that they were nervous or cautious. However, some students expressed feelings of comfort. In the lab recordings it was evident that the student who felt comfortable in the laboratory oversaw mixing the chemicals. In James' lab group, he was the one mixing the chemicals. He explains why he was comfortable:

> *There's things that I'm excited about and curious. Sometimes people will get excited and they want to mix the chemicals. Chemistry is fun, so they'll want to do it and they'll just only mix the chemicals, so usually I would like to mix them.*

Emily said she "is not nervous" to use chemicals. Emily showed great fear with fire but extreme comfort with chemicals. In Joseph's lab group, he was the individual who mixed the chemicals. Joseph said, "I like to be the one in charge and mix the chemicals." It was apparent in the videos that students wanted the student who was the most comfortable in the lab group to conduct the experiment, while uncomfortable students were spectators.

Self-efficacy. Self-efficacy is an important aspect of student success in the chemistry laboratory. Self-efficacy is the students' expectation of what he or she can accomplish in a given situation (Nieswandt, 2007). In the lab recordings there were 42 instances where students' expressed discernments about themselves regarding their performance during the lab. Students who performed the Endothermic and Exothermic lab had a higher percentage (31%) of instances of self-efficacy than those who performed the Chemical Reactions lab (19%). In both labs, students were concerned about making mistakes and often needed confirmation from peers when doing the experiment. When Mark was burning a piece of magnesium in the flame of a Bunsen burner and his magnesium caught on fire, he began to frantically look around the room. He said, "At that point I thought I messed something up." In another portion of the lab Mark describes how he felt when mixing potassium iodide and hydrogen peroxide. "My hands were shaking because I thought I had actually messed up." During the same experiment Frank mixed the chemicals and then asked the other lab group "Is this normal? Is that normal?" When James added hydrochloric acid to a piece of magnesium ribbon, his group was not getting the same temperature as the groups around him. His reaction was, "Oh, my God. No, we should add a little bit more." In these three different experiments the students all exhibited concerns about making a mistake in the lab. Reasons for concern could stem from fear of failed experiments that could earn negative marks on their grades or cause harm to others.

Another example of self-efficacy in the laboratory is the students' need to confirm their procedure with peers. In all the laboratory experiments that were recorded, the students were provided with directions that outlined the procedure. However, the students frequently needed confirmation from another group or their partner regarding the procedure. When Joseph and his lab partner were adding hydrochloric acid to magnesium ribbon, they argued over the procedure.

Joseph: Keep adding. All right check the time. Keep adding it, man.

Partner: You're sure I have to add this?

Joseph: What you're doing, dude?

The directions provided to the students said: Add 3 droppers full of hydrochloric acid to the beaker. Even with the directions the students needed clarification. During the interview with Joseph, he confirmed that he often needs clarification and confirmation while in the lab.

Interviewer: Were you ever worried that you're not going to do the right thing?

Joseph: Sometimes. That's why I ask some of my friends before doing the lab. "Are you sure with what's--?"

Interviewer: You need a confirmation?

Joseph: Yes, also if I see my partner messing up, I'll tell him. Like right now, after that, he almost put I think water in the same beaker, I think, or something. I was like, "No, we're supposed to put it in the beaker, and that's not a beaker." It was acid I think, or vinegar. He was going to put the vinegar in there. I don't know what he was doing.

Similarly, in James' lab he thought he did the experiment incorrectly because he was comparing his results to another group. During his interview he explained why he thought he made an error in the experiment.

James: I don't think we put enough pellets in there though because ours didn't fizz as much as other groups did. We put about 12 in. It didn't fizz as much.

Interviewer: It didn't give you the reaction you thought it was going to get?

James: No, because we looked over at someone else and it had more fizz.

Interviewer: Did you think you did something wrong?

*James**:** Probably. Probably didn't mix it enough or something. I probably didn't crush the pellets enough or something.*

James did the experiment correctly and yielded the appropriate results. Due to his lack of self-efficacy, he believed that his experiment was incorrect because his peers' experiments looked different than his. Other students sought confirmation from their teacher. In both labs the students were instructed to dispose of their chemicals in a waste container provided on each table. Students, like David still needed confirmation as to where to dispose of the chemicals; "What do we do when there is extra in there? Ms. Holcomb?" In the laboratory recordings, students demonstrated a lack of self-efficacy when conducting the experiments. Students often relied on peers for validation of the procedure to ensure they were performing it correctly.

Image of a Chemist. In the laboratory experiments, there were 14 instances where students referred to themselves as a scientist or chemist. When Jessica performed the reaction between potassium iodide and lead nitrate, she proclaimed, "Oh, my God. We're chemists. You see that. It turned yellow. It was clear then it turned yellow. That's crazy." She was referring to the yellow product, lead iodide. When asked why she felt like a chemist, she explains:

I felt like a chemist because it reminds me back in the old days where they had this whole lab filled with containers and stuff and they got two chemicals that look totally different and they put it into one and just made something. It was exciting.

When Leslie did the decomposition of hydrogen peroxide she described herself as a mad scientist. She recounts, "it's very pretty. It got bigger, it's hot, it's foamy. It's… I feel like a mad scientist." The idea that mixing chemicals to produce different colors and steam made her feel like a mad scientist. These instances of students referring to themselves as a chemist is reflective of the image of chemist described earlier in this chapter. The students were performing labs that they felt were representative of the reality of chemistry that students constructed prior to taking the course.

Relevance. The goal of a laboratory experiment is for the students to experience the chemistry they are learning about in class. Depending on when the laboratory experiment falls in the curriculum sequence, the lab can serve as an introduction, exploration, or confirmatory. For this study, the lab served as a confirmation of the content learned in class which was identifying different types of reactions. The students were to perform four different chemical reactions and categorize them based on the system they were given in class. Upon analysis of the video and student interviews, it was noted that many students did not connect the laboratory to the content. There were 10 instances during the interviews where students stated that they did not realize there was a connection to the content that was learned in class. One example of the content-lab disconnect was during the double displacement reaction in the chemical reaction lab. Students were asked during the interview if they were able to connect the experience of mixing two clear solutions and forming a yellow solid product to the content of a double displacement reaction. David replied, “It did not occur to me.” Frank’s response was, “I thought it was cooler than anything else.” During the interviews, students often commented that they were just doing the lab and not thinking about what type of reaction was occurring.

Though students were not making connections to the chemistry content, they were relating the chemical reactions and the products to things that were familiar to them. Students made connections between chemistry and food, as well as chemistry and television. It was easier for them to make connections to things familiar to them than it was to connect to the chemistry content. There were many instances where students compared the product of the reaction to food.

James refers to the sodium pellets as mints and tells his partner that she should eat them. Jessica describes the yellow lead iodide as “spoiled milk” and the foam from the decomposition reaction as “Jell-O”. Leslie remarks to her partners that the foam “looks like inside a cake. Don't eat it though.” Food is a common, relatable topic for students and as such is used by students as a descriptor.

Students made other connections between the chemicals and other household items. Joseph compared the smell of ammonia to hair dye. Joseph exclaims, “Oh, guys, it smells like hair dye.” Jessica describes the foam in the decomposition reaction as a “sponge”. Emily said that the yellow product from the double displacement reaction turned to “clay”. The students were using common items to make a connection to the unfamiliar chemistry.

Another connection that students make in the lab is to chemistry they have seen on television. There were five references to Bill Nye in the lab recordings all from different students. When David was asked about the decomposition of hydrogen peroxide he refers to it as elephant toothpaste. David explains, “I've seen Bill Nye and other people doing elephant toothpaste thing.” This reaction was not referred to as elephant toothpaste in any of the lab directions or class. Jessica was asked how it made her feel when she poured chemicals? She responded, “I feel like Bill Nye. I remember watching Bill Nye videos in seventh grade.” Joseph was asked if the lab experiments reminded him of anything he had seen on television. “I would watch *Bill Nye* on Disney channel, and I would see something like that. I would just be like, ‘Wow, how does that happen?’ Here I am now in chemistry doing it”, said Joseph.

Not all television references were about Bill Nye. In the interview with Emily, she was asked how the lab in the recording compared to labs that were done previously in the course. Emily explains, “I think these were more like the kind of experiments you see on TV. These are more of the reactive ones, while the other one was like the M&M lab, where we used them to represent something else and stuff like that." She believes that the reactions with color changes and steam are more like chemistry on television than the labs where candy was used to model abstract concepts.

Risk. In a laboratory setting there is an inherent risk when using chemicals, fire, or glassware. In a high school setting there is a risk present, but the chemicals used have minimal risk due to the naivety and immaturity of the students. A recurring theme within the lab recordings was students' awareness of the risk. Students were both cautious and scared to use chemicals or they were excited and wanted to try their own experimentation. There were many references to explosions within the experiments. These references were both hopeful and hesitant. Either students wanted an explosion to occur or the students thought the reaction may cause an explosion, and they were scared to complete the reaction. In both laboratory experiments there was an equal percentage (25%) of instances where students referenced a risk within the experiment.

Within the laboratory experiments, there were a variety of chemicals used and fire sources. In both lab settings, students were made aware of the dangers associated with the chemicals and fire. The purpose of lab safety is to inform students of potential harm and hazards so that they can avoid injuring themselves or others. In every lab video recording collected in this study, there is an instance where a student emphasizes the lab safety and cautions another student about the potential for harm. David tells his partner, "Don't lean over it. You are not supposed to touch it." Emily warns her partner, "Don't look directly at the flame." Frank also warns his partner about the fire, "Don't look at it bro. Don't look at it because it is really bright." Another concern with the fire is that the students might burn themselves. Zaria warns Mark, “Don’t burn yourself.” Students are aware of the inherent dangers and at times overemphasize the safety precautions. The overemphasis could be due to the lack of familiarity with using chemicals and fire or their expectations from experiments as seen in television programs.

In addition to overemphasizing the lab safety, students expressed fears that they had while doing the lab. When Joseph did a reaction that began to bubble he expressed concern, He explains,

> *I thought it was going to go above the beaker and spill out, and then we would have to clean it up. Thankfully, it didn't. Sometimes, I get nervous when our teacher would tell us that these will burn us or this, we do get nervous. If we're careful, we're going to be all right.*

When Meghan was conducting the lab with hydrochloric acid, she was concerned about getting a chemical burn. She was asked if she felt the container to see if there was a temperature change. She explains:

> *No. I didn't do it because first, I was too scared. We did one with hydrochloric acid and it erodes things. I was like, "Oh my God, if I touch it, I'm going to die." I didn't want to--. I don’t normally feel this way with chemicals, but this is an acid.”*

Fire, as well as the use of chemicals, makes students nervous and apprehensive. Mark described his fear of fire, “The fire. I don't like fire.” As previously mentioned when students are not comfortable in the lab, they often defer to other students who are more comfortable with the lab task. Joseph was also scared of fire. He explains:

> *If we put something on the fire, I'll be nervous to turn on the fire because I don't know what might happen, so I say that you (his partner) turn on the fire-- I feel like with this one would be a gas leak.*

When asked what would happen if the gas leaked, Joseph explained there could be an explosion. The idea of explosions in chemistry lab was a reoccurring topic in the lab recordings. There were 15 mentions of explosions. Some students referred to explosions as “fireworks,” “combustion,” and “things blowing up.” Some students were nervous that the reaction might explode. James asked his partner during the lab, “what if it blows up?” Other students were hopeful for an explosion, for example Frank said, “I hope that this combustion was actually a combustion.” When Joseph added the sodium pellets he expected a fire. He tells his partner, “I expect to see a ton of fire, fizzy reactions, and gas, production and stuff like that. We put 12 in there. It took a minute to get the reaction that we wanted.” It should be noted that the directions for the sodium pellets said 3-5 pellets should be added. Joseph’s group took it upon themselves to alter the experiments for grander results.

Provoking other students to engage in risky behavior or disregarding safety warnings was another type of risk that occurred throughout the lab. During the experiment when the students burned magnesium, they were told to not look directly at the flame because it could damage their vision. During her interview, Emily said that she looked directly at the flame. When David was burning the magnesium, his partner told him to “put the flame by his hair.” David was then chastised by his partner for not doing it. Frank is also encouraged by his partner to engage in harmful activities during the lab. Frank’s partner encourages him to drink the lead iodide solution. During the decomposition reaction students wanted to touch the foam product even though they were told it was very hot and a skin irritant. Emily explains her reaction to the foam, “I remember that you said if we touched it, we would get burned, so I didn't touch it, but I did want to feel around it to see." Frank also wanted to touch the foam and he did. He explains his reasoning, "I know it's poisonous but it's fine. It's way worth it." There are times when the students' curiosity outweighs they inherent risk.

Synopsis of Research Question 2

This portion of the chapter presented the development of findings from the laboratory recordings to determine how students' laboratory expectations compare to the laboratory experiments in their high school chemistry class. The affective word analysis revealed that students were interested and curious about the chemistry laboratory. When students were performing the laboratory, students expressed satisfaction and dissatisfaction with the results of the laboratory. Based on preconceived expectations, students often wanted grander results and as a result were disappointed when this was not achieved. Students expressed varying attitudes in the lab from disappointed, excited, and reservations about chemicals.

Where many students were comfortable in the lab there were many students who were apprehensive to use the chemicals. In the lab recordings, students acknowledged the inherent dangers associated with the chemicals used in the lab. Students were often overcautious about the dangers and at times scared to use the chemicals. There were other instances where students were inciting their own experiments and disregarding the associated dangers.

Students had varying lab experiences but the behaviors and attitudes within the experiments were similar and reoccurring. In Chapter 5, further discussion of the implications of students' expectations of lab will be discussed further.

Chapter 5: Conclusions, Implications, and Future Work

This chapter presents the overall conclusions for the findings presented in Chapter 4 in the context of the theoretical frameworks discussed in Chapter 2. Implications of this research are presented for both secondary chemistry instruction and science education research. The chapter concludes with future work based on the results from this dissertation.

Conclusions

The goals of this research were to answer the two research questions: (1) What are the realities of chemistry that students construct while watching television? and (2) How do students' expectations of laboratory compare to what they do in the laboratory during high school chemistry? These goals were met through a qualitative research protocol using a survey instrument, laboratory recordings, and interviews.

The survey instrument was used to elicit students' realities of chemistry as it relates to television. This research is framed by the theoretical underpinnings of constructivism and reception theory. Constructivism is when individuals seek understanding of the world that they live in and develop subjective meaning through experiences, and these meanings are directed towards an object (Creswell, 2013; Moustakas, 1994). Prior to chemistry class, students are exposed to chemistry representations on television and while watching chemistry portrayed on television, students are incidentally learning about chemistry. When students watch television, they construct meaning and formulate ideas about the world around them. According to reception theorist, television shows have no inherent meaning, only the meaning derived by the viewer (Staiger, 2008). When television shows are produced there is a message that is created by the producer. Viewers watch the shows and decode the message intended by the producer. Once a television show is viewed by the viewer, the producer can no longer control the context to which the viewer perceives the intended message (Heinz, 2018). There are instances when viewers decode the message outside of the boundaries set forth by the producer, and this leads to misunderstandings of the media (Heinz, 2018). The experience of watching television and how meaning is created through that experience, influenced students' expectations of chemistry class (Morley, 2005). Students expressed a discontinuity in the chemistry on television and chemistry in the classroom.

Realities of Chemistry

The realities of chemistry revealed from the survey reflect the students' preconceived ideas about chemistry and a chemist. Students' attitudes about chemistry leaned toward being cognitively difficult but emotionally enjoyable. Students described chemistry as explosive, dangerous, and mixing chemicals. These characteristics of chemistry class are reflective of the shows that depict chemistry. Students referred to *Breaking Bad*, *Jimmy Neutron*, and *Bill Nye the Science Guy* as shows that portray chemistry. Many students made references to the show *Breaking Bad* within the survey. However, there was no mention of *Breaking* Bad during the video recordings. Evidence of the impact of these television shows on students' perception of chemistry emerged in the student drawings of a chemist, laboratory recordings, and descriptions of chemistry.

The image of a chemist uncovered in this study was comparable to the stereotypical image of a scientist found by Mead and Metraux (1957). In previous research, the stereotypical image of a scientist was a male. The predominant image of a chemist in this study was also a male, but there were frequent drawings that included a female chemist. Students differentiated between a chemist and a scientist by describing a chemist as someone who wore a lab coat and protective wear. This suggests that when many students are forming an image of a scientist that, in general they identify any scientist with a chemist.

This study is significant because it uncovered the image of a chemist, where previous research focused on scientists. The results from this study mirror results from research sixty years ago. Meaning that even though the science curriculum has evolved students' perceptions have remained unchanged. Students still hold a stereotypical view of a chemist and this is due to society's portrayal of chemists on and off the television. Students had strong connections to chemistry on television and chemistry in the classroom which influenced their attitude towards chemistry. Educators need to be aware of students' attitude toward chemistry, so that learning opportunities can be created to address the students' perceptions.

Expectations in Chemistry Laboratory

Science education is transitioning to nationally adopted standards, *NGSS*, which provide clear expectations as to what students should be able to do within a chemistry classroom. These standards provide emphasis on laboratory experiences through science and engineering practices and provide students with more realistic science experiences. It is important for teachers to understand students' attitudes towards the lab experiences since recent standards revisions place a larger emphasis on lab skills. This study focused on the cognitive and affective learning experiences of students in a high school chemistry classroom.

Students had varying attitudes towards the laboratory experience, both cognitively and affectively. Affective responses to the laboratory experience varied from cautious and scared to excited and wanting more. Students who were cautious often exhibited signs of low self-efficacy or were intimidated by the dangers associated with the chemicals used. Students had preconceived expectations of what the results of the laboratory should look like. Students often wanted grander results and were disappointed when their expectations of dramatic reactions were not observed. The range of emotions from the students impacted how they performed and carried out the lab. When students discussed their lab experiences they discussed their emotions in the lab and not the content. Students' observed attitudes in the laboratory were different than the attitudes expressed in the survey about chemistry in general.

The variety of affective responses in the laboratory could be due to the students' varied levels of laboratory experience. Often chemistry is the first laboratory science that students take in high school. This is the first time that students work with chemicals and fire. The inherent danger associated with chemicals and fire can be intimidating for novice students. Additionally, if a student's only exposure to chemistry is through television then that student may have unrealistic views of what the chemistry laboratory entails. The lack of familiarity can influence the students' attitude towards chemistry and the laboratory experience.

Incidental Findings

As mentioned before, students had little content connection between the laboratory experiment and the content learned in class. Often the first mention of the relationship of the lab and the content occurred during the interview. Similar results were observed by Galloway and Bretz (2016). Though students were able to complete the lab task, many could not identify the type of reaction that they were performing. The purpose of the lab was to provide the students with the hands-on experience with different reactions that they learned about in lecture, but students did not make the connection between content learned and the laboratory activity. They were more interested in the results of the reactions.

Limitations

There are limitations to this study that emerged from methodological decisions made during the study. First, the students were interviewed at different points in the semester due to their completion of the lab at different times. Therefore, students' lab experience varied based on the time in the semester when the interview occurred. Students who were interviewed later in the semester had more lab experiences on which to reflect than students who were interviewed earlier. The second limitation is that the study is representative of one sample population. Consequently, the results are not generalizable to all high school chemistry laboratory experiences, but the reader is encouraged to determine similarities in context to which comparable results may be uncovered.

Implications

Secondary Chemistry Instruction

Students' realities of chemistry can impact their expectations. In this study, it was found that students' expectations influenced their experience. Students come into the class with varying expectations based on differing life experiences. Instructors of the course should be aware of the varying expectations that students bring to the class. The instructors' awareness of students' expectations will allow the instructor to meet the cognitive and affective needs of the students. Instructors could assess students' attitude in laboratory through an easy assessment like the affective words. Additionally, the laboratory recordings serve as an alternative method to explore students' affective experiences in the laboratory. The video recordings and affective words can provide insight into students' prior knowledge and self-efficacy. The lack of self-efficacy in students within this study shows that students need scaffolded lab experiences and more exposure to lab. More exposure in lab provides students with more opportunity to familiarize and improve lab skills. Based on the lab recordings, the students were not making cognitive connections to the lab and the content of the course. There should be check points throughout the lab experience where students can stop and process the information in the lab. Checkpoints can be done through informal questioning from the instructor or questions provided to the student. Additionally, if students have more frequent exposure to labs, students will have more real-life science experiences and lessen the influence of incidental learning from television. Also, more laboratory exposure will improve students' scientific literacy and Nature of Science and enable students to differentiate between Hollywood and classroom chemistry.

To debunk the stereotypical view of a chemist, chemistry teachers can use applications like *Skype a Scientist* for students to interact with chemists that do not fit the stereotypical image. Additionally, chemistry teachers can reach out to chemists in their area and ask them to present to their class. When students are provided opportunities to interact with chemists, in addition to their teacher they get a clearer picture of chemistry outside of the classroom. Students can also see that anyone can be a chemist, not just a male in a white lab coat.

Science Education Research

Previous science education research focused on revealing the image of a scientist. Studies by Mead and Metraux (1957) and Chambers (1983) focused on a scientist in general. This study focused specifically on chemistry. This interview protocol and the student recordings of the lab provide insight into the students' lived experiences in high school chemistry laboratory. Galloway (2015) performed similar research at the collegiate level regarding laboratory expectations in chemistry courses. At the high school level, there has been research studies that address students' attitudes in high school chemistry laboratory, but these studies did not have the students record themselves and then watch the recording for insight into the student's interpretation of the lab. Additionally, this study focused on chemistry specifically, but the protocol can be used in other science domains. Understanding the students' attitudes in the lab and their expectations can help grow the laboratory practices in all science domains.

Future Work

The laboratory recordings provided insight into the affective experiences of students in the lab during one laboratory experiment. Future research could investigate the affective experience of students throughout a semester. The research could evaluate students' changes in affect in the lab as the course continues. In this study, different instrumentation was used to assess students' attitude towards chemistry. It was found that there is a difference in attitude towards chemistry class and chemistry lab. Further analysis of these results could be insightful to chemistry educators.

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Appendix A- Kennesaw State IRB Approval

Study 17-356: How Does Media Impact Students' Perceptions of Chemistry?

irb@kennesaw.edu

to me

2/15/2017

Sarah Holcomb

RE: Your application dated 2/14/2017, Study #17-356: How does media impact students' perceptions of chemistry?

Dear Ms. Holcomb:

Your application for the new study listed above has been administratively reviewed. This study qualifies as exempt from continuing review under DHHS (OHRP) Title 45 CFR Part 46.101(b)(2) - educational tests, surveys, interviews, public observations. The consent procedures described in your application are in effect. You are free to conduct your study.

NOTE: All surveys, recruitment flyers/emails, and consent forms must include the IRB study number noted above, prominently displayed on the first page of all materials.

Please note that all proposed revisions to an exempt study require IRB review prior to implementation to ensure that the study continues to fall within an exempted category of research. A copy of revised documents with a description of planned changes should be submitted to irb@kennesaw.edu for review and approval by the IRB.

Thank you for keeping the board informed of your activities. Contact the IRB at irb@kennesaw.edu or at (470) 578-2268 if you have any questions or require further information.

Sincerely,

Christine Ziegler, Ph.D.
KSU Institutional Review Board Chair and Director

cc: klinenenb@kennesaw.edu

Appendix B- Cobb County IRB Approval

COBB COUNTY
SCHOOL DISTRICT

One Team, One Goal: Student Success

514 Glover Street
Marietta, GA 30060
Telephone: (770) 426-3300
www.cobbk12.org

April 18, 2017

Ms. Sarah B. Holcomb
5802 Fairwood Walk NW
Acworth, GA 30101

Dear Ms. Holcomb:

Your research project titled, **How does media influence on student perceptions of chemistry?** has been approved. Listed below are the schools where approval to conduct the research is complete. Please work with the school administrator to schedule administration of instruments or conduct interviews.

School

McEachern High School

Should modifications or changes in research procedures become necessary during the research project, changes must be submitted in writing to the department of Accountability, Research & Grants prior to implementation. At the conclusion of your research project, you are expected to submit a copy of your results to this office. Results cannot reference the Cobb County School District or any District schools or departments.

Research files are not considered complete until results are received. If you have any questions regarding the process, contact our office at 770-426-3450.

Sincerely,

Cindy Nichols
Grants & Research Manager
Accountability, Research & Grants

nf

Appendix C- Parental Consent and Assent

PARENTAL CONSENT FORM

Title of Research Study: How does television influence students' perceptions of chemistry? Study #17-356

Researcher's Contact Information:

Sarah Holcomb	Kimberly Cortes
770-222-3410 ext. 716	(470) 578-6278
sbluetse@students.kennesaw.edu	kilinenb@kennesaw.edu

Your child is being invited to take part in a research study conducted by Sarah Holcomb of Kennesaw State University. Before you decide to allow your child to participate in this study, you should read this form and ask questions if you do not understand.

Description of Project

The purpose of the study is to investigate how media influences and shapes a student's attitude towards chemistry. This study is important because a student's attitude can have an impact on their ability to learn the topic and pursuit of careers related to that topic. This study will involve obtaining and addressing student's perceptions of chemistry as it relates to media.

Explanation of Procedures

If your child decides to participate in this study they will be required to complete a survey that includes questions and prompts for drawing as it pertains to their perception of chemistry. An interview may be needed to clarify student's survey responses. Students whom are interviewed will be asked to record themselves while conducting a lab experiment. The survey should take no more than thirty minutes. The interview, if needed, will take no longer than fifteen minutes and will be held outside of school hours. The laboratory experiment will be a part of the planned curriculum and will last about thirty minutes.

Risks or Discomforts

There are no known risks or discomforts associated with this study.

Benefits

The benefit of the study is that through the in-class activity students can investigate the realities of chemistry and professions in the field of chemistry. All students in the course will participate in this class activity as it pertains to the curriculum. Additionally, there is benefit to chemistry educators that they may learn more about student perspectives which can influence how information is conveyed to the students.

Confidentiality

The results of this participation will be confidential. All records will be securely maintained and only used within the scope of this study.

Parental Consent to Participate

I give my consent for my child, ____, to participate in

(please print student's name)

the research project described above. I understand that this participation is voluntary and that I may withdraw my consent at any time without penalty. I also understand that my child may withdraw his/her assent at any time without penalty.

Signature ____
Parent Date

Signature____
Principal Date

Signature____
Classroom Teacher(researcher) Date

____

PLEASE SIGN BOTH COPIES OF THIS FORM, KEEP ONE AND RETURN THE OTHER TO THE INVESTIGATOR

Research at Kennesaw State University that involves human participants is carried out under the oversight of an Institutional Review Board. Address questions or problems regarding these activities to the Institutional Review Board, Kennesaw State University, 585 Cobb Avenue, KH3403, Kennesaw, GA 30144-5591, (470) 578-2268.

Child Assent to Participate

My name is Sarah Holcomb. I am inviting you to be in a research study about television's impact on students' views of chemistry. Your parent has given permission for you to be in this study, but you get to make the final choice. It is up to you whether you participate.

If you decide to be in the study, I will ask you to complete a survey that includes questions and prompts to draw pictures of your perceptions of chemistry, and interview, and possibly be recorded doing a lab. Regardless if you agree to participate in the study this topic will be discussed in class accompanied with an in-class activity. There is no known risk to participating in this study. The benefit of this study is that you will gain knowledge of chemistry professions and the realities of chemistry. Additionally, there is benefit to chemistry educators that they may learn more about student perspectives which can influence how teachers teach chemistry.

You do not have to answer any question you do not want to answer or do anything that you do not want to do. Everything you say and do will be private, and your parents will not be told what you say or do while you are taking part in the study. When I tell other people what I learned in the study, I will not tell them your name or the name of anyone else who took part in the research study.

If anything in the study worries you or makes you uncomfortable, let me know and you can stop. No one will be upset with you if you change your mind and decide not to participate. You are free to ask questions at any time and you can talk to your parent any time you want. If you want to be in the study, sign and print your name on the line below:

____

Child's Name and Signature, Date

Check which of the following applies *(completed by person administering the assent.)*

- ☐ Child is capable of reading and understanding the assent form and has signed above as documentation of assent to take part in this study.

- ☐ Child is not capable of reading the assent form, but the information was verbally explained to him/her. The child signed above as documentation of assent to take part in this study.

____

Signature of Person Obtaining Assent, Date

Appendix D- Survey Instrument

Chemistry in Media Perception Survey

Section 1: Demographic Questions
Directions: Answer the questions in Section 1 to the best of your ability.

1.What is your current grade level? Circle one
9th 10th 11th 12th

2. How many total science courses have you taken in High School? Circle one

0 1 2 3 4+

3. Are you currently in a chemistry course? If yes, what level chemistry course?

4. What is your race? Check all that apply

White____ Hispanic or Latino____ Black or African American____

Native American or American Indian____ Asian / Pacific Islander____
Other_________

5. Gender: Check one
M _______ F_________ Prefer not to say____________

6. Age: Check one __13 ___14 ___15 ___16 ___17 ___18

Section 2: Survey Questions

Part A
A list of opposing words appears below. Rate how well these words describe your feelings about chemistry. Think carefully and try not to include your feelings toward chemistry teachers or chemistry courses. For each line, choose a position between the two words that describes exactly how you feel. **Circle** the number on this sheet. The middle position is if you are undecided or have no feelings related to the terms on that line.

1) easy |__1__|__2__|__3__|__4__|__5__|__6__|__7__| hard
middle
2) complicated |__1__|__2__|__3__|__4__|__5__|__6__|__7__| simple

3)	confusing	|__1__|__2__|__3__|__4__|__5__|__6__|__7__|	clear
		middle	
4)	Comfortable	|__1__|__2__|__3__|__4__|__5__|__6__|__7__|	uncomfortable
5)	satisfying	|__1__|__2__|__3__|__4__|__5__|__6__|__7__|	frustrating
6)	challenging	|__1__|__2__|__3__|__4__|__5__|__6__|__7__|	not challenging
7)	pleasant	|__1__|__2__|__3__|__4__|__5__|__6__|__7__|	unpleasant
		middle	
8)	chaotic	|__1__|__2__|__3__|__4__|__5__|__6__|__7__|	organized

Part B
Directions: please complete the following questions to reflect your opinions as accurately as possible. Some questions will ask you to draw a picture of chemistry related concepts.

1. What does a chemist do?

2. What does a chemist look like?

3. In what ways does a chemist look different from a scientist?

4. Draw a chemist doing science.

5. Do you think chemistry is portrayed accurately in the media? If so how is it portrayed? Explain your answer.

6. How does your experience in this class compare to the chemistry you see in the media (TV, movie, comics, and cartoons)?

7. Fill in the table below with examples of specific types of shows that you associate with chemistry and have impacted your expectations of this class.

Media Source	Examples of media that you associate with chemistry
Sit com	
Cartoons	
Drama	
Other	

Appendix E- Endothermic and Exothermic Laboratory

Name____ Date______________

Is it Exothermic or Endothermic?

Purpose

To study changes in temperature associated with chemical reactions, and to learn to identify processes as endothermic or exothermic based on the temperature changes.

Experiment 1

Materials: Mg(s), HCl(aq),

Procedure

1. Add about 3 dropperful of HCl to the test-tube.
2. Add the magnesium ribbon to the test-tube.
3. Describe if the reaction became colder or warmer.

Observations:

____
____
____
____
____

Experiment 2

Materials: barium hydroxide and ammonium chloride

Procedure

1. Put clean beaker on an electronic balance.
2. Press "zero" to make the mass of on the balance zero.
3. Add about 3grams of BaOH to the beaker.
4. Add about 1 gram of NH_4Cl.
5. Mix the mixture with a glass stir rod.
6. Describe if the reaction became colder or warmer.

Observations:

____
____
____
____
____

Experiment 3

Materials: potassium iodide and water

Procedure

1. Using a graduated cylinder, pour 25 mL of water into a beaker.
2. Using a weight boat and an electron balance, measure 4g of potassium iodide.
3. Add the potassium iodide to the beaker of water.
4. Stir the solution
5. Describe if the reaction became colder or warmer.

Observations:

____
____
____
____
____

Experiment 4

Materials: Sodium hydroxide pellets and water

Procedure

1. Using a scoopula, scoop about 3-5 pellets of sodium hydroxide and place it into a beaker.
2. Add about 50mL of water.
3. Stir it with a glass rod until it dissolves completely.
4. Describe if the reaction became colder or warmer.

Observations:

____
____
____
____
____

Appendix F- Chemical Reactions Lab

Types of Chemical Reactions Name ________________________

Station 1 Single Replacement

1. Collect a test tube and sample of zinc.
2. Fill the test tube with the copper (II) sulfate solution (Only half of the test tube).
3. Write and balance the equation for this reaction.

   zinc + copper (II) sulfate yields copper + zinc sulfate

4. Add a piece of zinc to the copper (II) sulfate.
5. Let the test tube sit for 2 minutes and record observations **during** the reaction on the line.

____

____

____

6. How could you tell a chemical reaction occurred?

____

____

CLEAN OUT THE TEST TUBE WHEN YOU ARE FINISHED!!

Station 2 Synthesis

1. Obtain a piece of magnesium from your lab station.
2. Set up your Bunsen burner. The burner will serve as oxygen for the reaction.
3. Write and Balance the equation for this reaction.
4. magnesium + oxygen → magnesium oxide

4. Use crucible tongs to hold the magnesium in the Bunsen burner flame. Do not stare at this reaction.
5. Record observations **during** the reaction on the line.

____

____

6. Describe the appearance of the magnesium at the end of the experiment.

____

____

CLEAN UP YOUR AREA WHEN YOU ARE FINISHED!!

Station 3 Decomposition

Safety

The reaction is exothermic, producing a fair amount of heat, so do not lean over the graduated cylinder when the solutions are mixed.

Procedure

1. Make sure you have on goggles. Please do this lab over the bin at the station.
2. Pour 20 mL of 30% hydrogen peroxide solution (H_2O_2) into the beaker.
3. Write and balance the equation for this reaction.
4. dihydrogen dioxide $\rightarrow$ water + oxygen
5. Squirt in a little dishwashing detergent and swirl it around.
6. You can place 2 drops of food coloring along the wall of the cylinder to make the foam resemble striped toothpaste.
7. Add 20 mL of potassium iodide solution. This is a catalyst for the reaction. It is not used up in the reaction and its formula is **written above the arrow**. Do not lean over the cylinder when you do this, as the reaction is very vigorous and you may get splashed or possibly burned by steam. **DO NOT TOUCH THE PRODUCT!!!!!**
8. Observe and record your observations below.

____

____

____

CLEAN OUT THE BIN AND BEAKER WHEN YOU ARE FINISHED!!

Station 4 Double Displacement

1. Write and balance the equation: lead (II) nitrate + potassium iodide →lead (II) iodide + potassium nitrate

2. Place 10 mL of the aqueous lead (II) nitrate solution into a graduated cylinder.

3. Add 10 mL of the aqueous potassium iodide solution to another graduated cylinder.

4. Simultaneously pour the contents of both graduated cylinders into the beaker.

5. Write down your observations below.

Before the reaction:

____

____

After the reactions:

____

____

Write the Net Ionic equation for the reaction:

You cannot pour this down the drain. Put the product in the appropriate waste container.

Station 5 Combustion DEMO ONLY

1. Write and balance the equation: for the combustion of CH_4 (methane).

Observations

____

____

2. What evidence was present that a chemical reaction occurred?

____

____

Appendix G- Interview Guides

Interview Protocol for Survey Instrument:

What images have you seen on television that make you think about chemistry?

How did this experience relate to your expectations of chemistry?

What types of experiments do you think we will do in chemistry? Why do you think this?

What TV shows do you currently watch?

Are you aware of science present in the television show?

What feelings are generated during this process?

Does TV or movies have anything to do with your perception of chemistry?

Can you explain your drawing to me?

Interview Protocol for Laboratory recordings:

What were your thoughts while performing this experiment?

What were your feelings while performing this experiment?

Did this lab meet your expectations of chemistry?

Is this lab like chemistry you have watched on television? How?

Appendix H- Example of Transcripts

<u>Meghan's Video Recording</u>

Meghan: That's working.

Teacher: It's working now. All right let's put this back on here.

Teacher: Straighten the camera.

Meghan: Is it straight now?

Teacher: There you go.

Meghan: Okay, thank you. It's chilling on my forehead right now. Excuse me, sorry, excuse me. All right, now it is 20, so the initial temperature is 22. That was just the acetic acid alone? In 4? What is that?

Meghan: That is the 4?

Student 3: It's done. Now we got to draw the chart. Wait, loses heat, because it loses heat, Julian.

Teacher: All right guys, start cleaning up your stations please, start cleaning up your stations, please. Everything can go down to the sink

Student 3: But we're going to cut up birds and the bees.

Teacher: Guys, do not move stations yet, I'll tell you to do so. Okay? All right, is everybody done? On this set when you're everybody done? All right, so let's go. We're going clockwise. Guys, I need your eyes over here. We're going clockwise, so this group right here you guys will go to that station, that station over there you guys will come here. You guys over there, you guys will come here. You guys over there, you come here, and you guys over here move over there.

Student 4: We're going over here?

Teacher: Yes, clockwise.

Meghan: So we'd be right here, right?

Student 3: Yes.

Meghan: Okay.

Student 3: They're not done yet, we got to wait. Jose, watch your language.

Meghan: Is it off again?

Student 3: No, it's on. Let me see it.

Meghan: It's blinking. The screen turns on.

Meghan: Do you want to go over there?

Student 3: Let's go over there.

Meghan: Yes, let's just go over. That's the final temp, right? That's a negative?

Student 3: Point.

Meghan: No, I'm talking about right there. No, no, no, I'm talking about right there. No, I'm talking about the dash is that a negative sign?

Meghan: Oh, okay. Thank you. No, it kind of wasn't it was just a dash. That could be interpreted as a negative.

Student 3: Look, look.

Meghan: We're not the best at the dark. Placebo. What is that?

Student 3: Exo-.

Meghan: Oh, exothermic.

Student 3: Look, you keep judging my handwriting.

Meghan: Exothermic temperature, oh wait, it's exothermic because it loses heat. Oh Jesus

Student 3: So what happens if I stick my hands under there?

Meghan: Your hands are going to burn, voluntary amputation.

Student 3: Should I do it? You said, "Do it."

Meghan: Don't.

Meghan: All right. Let's take the temperature.

Meghan: Oh, be careful, the strip is right here. 21.3?

Student 3: This is the strip?

Meghan: Yes.

Student 4: Yes.

Student 3: Doesn't heat up at all.

Meghan: Guys that's the initial temperature is 21.3 degrees Celsius.

Meghan: Oh, gosh.

Meghan: Mr. Estime?

Student 3: Mr. Estime, the strip here, it's down to 21.

Meghan: [laughs]

Student 3: Look at the temperature rise, it's crazy.

Meghan: That’s the end of that.

Teacher: What are you doing?

Student 3: Nothing.

Teacher: All right guys, you have about 4 minutes left.

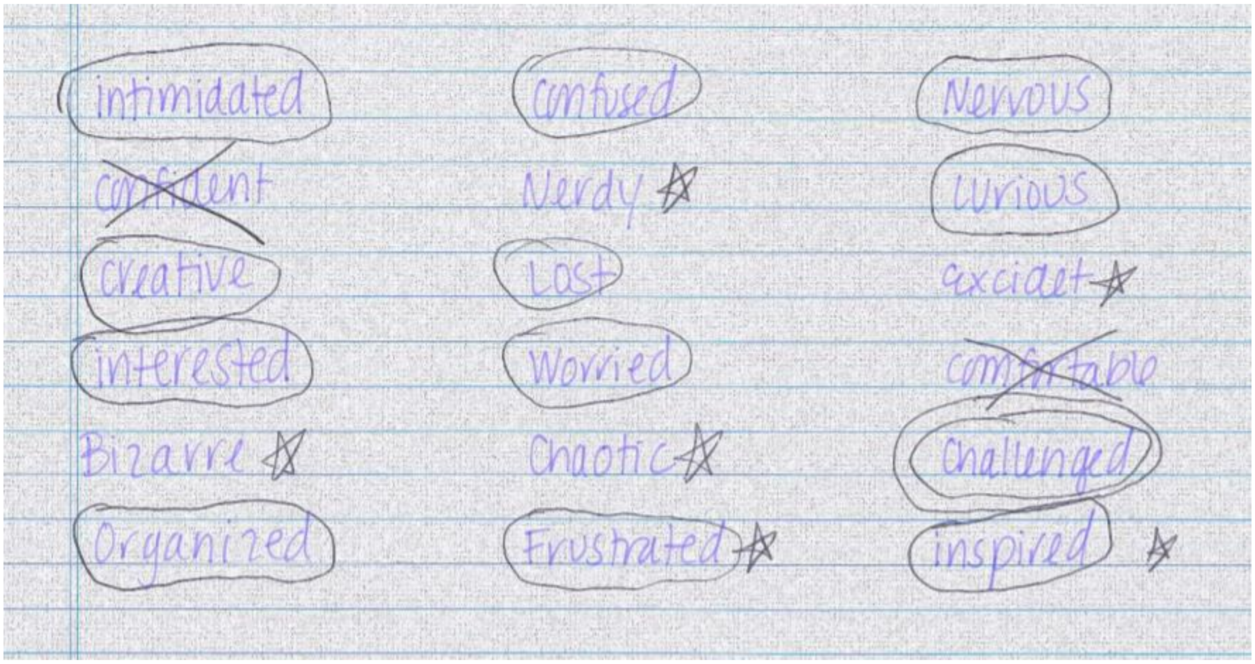
Student 3: It finally stopped, oh shoot, it still going. 44.8 that's the highest it went because it went back up, .9, .5, it's still going up. You want us to just write the 45.5 degrees Celsius?

Meghan: Yes, because it still going.

Student 3: Still going, and then slow.

Meghan: Yes, okay.

Appendix I- Students Sample of Affective Words



Appendix J- Qualitative Codebook

A. Qualitative Codebook: First Cycle

Code	**Description**	**Number of Code References**
Acid	Student mentions acid in a dangerous context	1
Added more chemical for bigger results	Student alters the experiment in hopes to get a grander result.	5
Bill Nye	Student reference Bill Nye during their lab	5
Cautions other students	A student warns another student about the possible harms in the experiment.	8
Comfortable	student is comfortable using the chemicals in the lab	3
Concerned about making mistake	Students show concern about making a mistake in the lab.	25
Confirmation of procedure from other groups	Verifies the procedure with another lab group	7
Confusing	Students mentions they are confused about the procedure or results	2
Dangerous	Student thinks the results of the experiment or the procedure is dangerous.	14
Did not follow directions	Student disregarded the directions.	2
Unexpected Results	The results of the lab were different than what the students expected.	22
Disappointed	The students were disappointed or underwhelmed with the results.	9
Excited	The student is excited with the results from the procedure.	11
Expected results	The lab happened just as the student expected.	2
Experiments like on TV	The student mentions that they saw this experiment on television.	2
Explosion	The mention of fire or explosion.	15
Feel like a chemist	The student mentions that they feel like a chemist	5
Fun	Student mentions that chemistry is fun.	1

Messed up experiment	The students did not follow directions and their reaction did not work.	2
Mystery	Student refers to chemistry as a mystery	10
Nervous	The student mentions that they are nervous during the lab.	11
Lab not related to content	The students do not see the connection of the lab to class content.	2
Glassware	Student makes a connection between glassware and chemistry.	11
Proposes other experiments	Student is hypothesizing other experiments to do with the chemicals.	1
Real chemist	Student refers to themselves as a real chemist during their lab.	1
Relate chemistry to common things	During the lab the student compares the product in the lab to something that they know from everyday life.	3
Relates chemical to food	During the lab the student relates the chemicals/product to a food item.	7
Relating to content	Student references the classroom content to the lab.	1
Risky behavior	Student is not following safety protocol.	6
Scientist	Student refers to themselves as a scientist.	2
Scared	Student was scared or apprehensive to use the chemicals	2
Smell chemical	Student smells the chemicals	2
Snapchat	Student puts their experiment on Snapchat	1
Stressed	Student expresses feelings of stress about the lab while being interviewed.	1
Technology is more scientific	Student mentions that technology makes them feel more scientific.	2
Thought reaction wasn't happening	Student thought reaction did not occur	3
Unsure	During the interview student said that they were unsure of their expectations for the lab.	6

Wants instantaneous	During the lab if it did not happen instantaneous they thought the reaction wasn't going to happen.	1

B. Qualitative Codebook: Second Cycle Code Categories

Name	Description	Number of Code References	Original Codes within the category
Risk within the experiment	Reference to the risk within the experiment	44	Acids, cautions other students, dangerous, explosion, risky behavior
Attitude towards chemicals	Perspective on using any type of chemicals in the lab	13	Comfortable, Scared, Cautions other students
Doing it right	General concern about doing the procedure correctly to yield correct results.	42	Concerned about making mistakes, confirmation of procedure, confused, nervous, stressed, unsure
Alternative Experiments	Does not follow the directions or propose an alternative experiment	10	Added more chemical for bigger results, did not follow directions, messed up experiment, proposes other experiments
Relevance	Relating to real-world or anything outside of chemistry class	5	Experiments on TV, relating chemicals to food
No connection between class and lab	Does not see how this relates to the content learned in class. Sees lab as a separate portion of chemistry.	2	Lab not related to content
Excitement or enjoyment	Student expresses joy and excitement while doing the experiment or when the reaction is over.	12	Excited and fun
Dissatisfied	Not satisfied with the results of the reaction within the laboratory	10	Disappointed, wanting instantaneous

Chemist	Reference to a chemist or a scientist.	14	Scientist, real chemist, feel like a chemist, Bill Nye
Television	Mentions experiments that students have seen on television or mentions television scientists	7	Bill Nye, experiments like on TV
Expectations of the lab	Student mentions expectations of results	24	Expected results, unexpected results
Mystery	Reference to chemistry, lab, or science as a mystery.	10	mystery

C. Themes

Themes	**Code Category**
Self Efficacy	Doing it Right
Risk	Risk within experiment, alternative experiments
Attitudes in the Lab	Dissatisfied, Excitement, attitude toward chemicals
Preconceived Expectations	Expected results, unexpected results, mystery
Image of a chemist	Chemist
Relevance	Television, relevance