INCREASING HIGH SCHOOL STUDENT INTEREST IN SCIENCE: AN ACTION RESEARCH STUDY

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ABSTRACT

An action research study was conducted to determine how to increase student interest in learning science and pursuing a STEM career. The study began by exploring 10th-grade student and teacher perceptions of student interest in science in order to design an instructional strategy for stimulating student interest in learning and pursuing science. Data for this study included responses from 270 students to an on-line science survey and interviews with 11 students and eight science teachers. The action research intervention included two iterations of the STEM Career Project. The first iteration introduced four chemistry classes to the intervention. The researcher used student reflections and a post-project survey to determine if the intervention had influence on the students' interest in pursuing science. The second iteration was completed by three science teachers who had implemented the intervention with their chemistry classes, using student reflections and post-project surveys, as a way to make further procedural refinements and improvements to the intervention and measures. Findings from the exploratory phase of the study suggested students generally had interest in learning science but increasing that interest required including personally relevant applications and laboratory experiences. The intervention included a student-directed learning module in which students investigated three STEM careers and presented information on one of their chosen careers. The STEM Career Project enabled students to explore career possibilities in order to increase their awareness of STEM careers. Findings from the first iteration of the intervention suggested a positive influence on student interest in learning and pursuing science. The second iteration included modifications to the intervention resulting in support for the findings of the first iteration. Results of the second iteration provided modifications that would allow the project to be used for different academic levels. Insights from conducting the action research study provided the researcher with effective

ways to make positive changes in her own teaching praxis and the tools used to improve student awareness of STEM career options.

Keywords: interest, science learning, perceptions, instructional strategies, STEM careers.

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Completing a doctoral degree is a personal journey. It requires dedication, focus, and perseverance. It is hours spent alone in front of a computer with piles of papers surrounding and overwhelming the area you have staked out as that place affectionately known as "dissertation hell." Although much of the journey is spent in solitude pouring over research, methods, data, and finally compiling all of this into one, hopefully coherent, document, it is not travelled alone. It is a journey that requires support, understanding and patience. I could never have done this without my husband, Vinny. I am truly grateful for all his encouragement, and understanding. He was part of the reason I began the journey. With my children grown, and my penchant to be in constant motion, he told me I needed a hobby, it was this or go back to figure skating. I believe I made the right decision. I also need to thank my sons, Luke and Tyler. They kept me going by telling me they knew, without a doubt, I would make it to the finish. Thank you guys, I love you all.

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CHAPTER I: INTRODUCTION

Science is a subject that permeates our lives. Scientific literacy is a vital component of education and important to all citizens as science and technology are ingrained in our everyday lives (Arrison & Olson, 2012; DeBoer, 2000; Osborne, Smith, & Collins, 2003). Additionally, a country's economic prosperity is uniquely tied to its ability to develop a scientifically literate population (Maltese & Tai, 2011; Osborne, Smith, & Collins, 2003). According to the National Center for Science and Engineering Statistics (NCSES), in 2011, foreign students earned 56% of all engineering doctorates, 51% of all computer doctorates and 44% of physics doctorates awarded by U.S. universities. In 2007, China overtook the United States to become the world leader in the number of doctoral degrees awarded in the natural sciences and engineering and in 2010 China conferred nearly 31,000 doctoral degrees compared to nearly 25,000 for the United States (National Science Foundation, 2014). More recently, of the 5.5 million first degrees earned in Science and Technology in 2010, China's share was 24%, the European Union represented 17% and the United States' share was 10% (National Science Foundation, 2014). Science and engineering occupations between 1960 and 2011 grew at an annual rate of 3.3% compared to the 1.5% growth rate for the total workforce and science and engineering skills are no longer limited to occupations with formal science and technology titles (National Science Foundation, 2014). Couple these factors with an aging science and engineering workforce, the answer to combatting the shortfall of science, technology, engineering, and mathematics (STEM) professionals requires that U.S. schools bolster math and science education (Maltese & Tai, 2011; National Science Foundation, 2014). Ultimately, the question still comes down to why U.S. students are not interested in pursuing science.

Exploring student interest in learning science can provide valuable information on ways to effectively structure science education. This action research study relied on surveys, interviews, and a specifically developed instructional intervention to determine if the level of student 'situational' interest in learning science changed as a result of the instructional and learning strategies. Situational interest theories posit that environmental factors such as classroom instructions, tasks, or activities influence the level of student interest (Hidi & Renninger, 2006; Krapp, 2002; Krapp, Hidi, & Renninger, 1992; Schraw, Flowerday, & Lehman, 2001). Interest theory applied to science, or at a broader scale to STEM, can be used as a way to evaluate the classroom instruction, activities, and presentation of materials which impact situational interest (Hidi & Renninger, 2006; Krapp, Hidi, & Renninger, 1992; Pressick-Kilborn, 2015; Schraw, Flowerday, & Lehman, 2001; Swarat, Ortony, & Revelle, 2012). The classroom is the venue through which situational interest in science can be stimulated through the creation of an environment that fosters student interest in the subject. "Focusing on the potential for situational interest inherent in the material and mode of presentation may help teachers promote learning for all students, regardless of their idiosyncratic interests" (Hidi & Harackiewicz, 2000, p.157). Strategies such as problem-based learning or science that is taught through relevant real-world issues have been shown to stimulate student interest in learning science (Faria, Freire, Galvao, Reis, & Baptista, 2012; Feieraband & Eilks, 2010). In addition to using relevant every day examples, enabling students to choose what they study and providing students the opportunity to experience science in their own way is another classroom strategy to increase student interest in science (Seiler, 2011). Providing more hands-on activities that incorporate scientific instrumentation and technology so that students can experience science in the same way scientists carry out research can also stimulate interest in learning science (Swarat, Ortony, & Revelle, 2010).

This action research study used excerpted sections of the 2006 Programme for International Student Assessment (PISA) questionnaire to collect the perceptions of one high school's 10th grade science students' interest in learning science. The PISA 2006 science questionnaire is a validated instrument created by a consortium of international education researchers which targets students aged 15 years 3 months to 16 years two months who are nearing the completion of their compulsory education corresponding to U.S. 10th grade students (OECD, 2006). In 2006 this questionnaire was administered to more than 400,000 students in 57 countries (OECD, 2009). The data from the survey provided this researcher with the student perspective on interest in science, careers and science, learning time, teaching, and learning related to science instruction. Student survey data were used to calculate descriptive statistics in order to provide an overall picture of the student perspective. Semi-structured interviews with a sample of these students provided more detailed and descriptive personal narratives of the students' perceptions of their interest in learning science. As a complement to this qualitative data strand, interviews with 10th-grade science teachers were conducted to determine the teachers' perceptions of student interest in learning science. The semi-structured interviews with teachers described what teachers perceive as student interest in learning science and the changes they would implement to improve the strategies designed to increase student interest in learning science. The responses from both students and teachers were coded for themes in order to shed light on the two perspectives. By investigating and comparing student and teacher perspectives a more comprehensive and holistic picture of the local condition was achieved.

Additionally, an instructional intervention, the STEM Career Project, was employed with the scope of stimulating situational interest in the classroom in order to increase student awareness and interest in learning science and in pursuing science as a potential career. This instructional approach combined two important factors that are essential to the development of interest: (a) an opportunity to gain new knowledge and understanding in an area students have limited knowledge, and (b) a task that affords students a form of personal relevancy (Durik, Hulleman, & Harackiewicz, 2015; Hidi & Renninger, 2006; Krapp, 2005; Schiefele, Krapp, Prenzel, Heiland, & Kasten, 1983; Wigfield & Cambria, 2010; Wigfield & Eccles 2000). Creating an instructional experience for students that is personally relevant and useful for other life goals is just one strategy or approach to deepening interest (Hulleman & Harackiewicz, 2009). Hulleman and Harackiewicz (2009) in their randomized field experiment of 262 high school students found that students exposed to a relevancy intervention, where students had to apply what they were learning to real-life, showed higher levels of interest in science and increased academic performance compared to students in a control group that only summarized what they had learned.

Problem Statement

Science is a subject that develops many of the 21st century skills students will require to compete in our global world such as problem solving, critical thinking, reasoning, creativity, and interpretation and analysis (Jacobs, 2009; Zhao, 2009). Learning science can be an exciting and rewarding educational experience that can inspire and motive students to pursue science as a career. How to increase student interest in science is an area that needs exploring if the United States is to increase the number of individuals entering into the fields of science and engineering. This has become an important national topic because the United States is not producing enough individuals to meet the needs of the science, technology, engineering, and math (STEM) related workforce (National Science Foundation, 2004, 2006). In fact, the scores of United States students on international assessments show they are falling well behind their international counterparts across most grades (National Science Foundation, 2012; Trends in International Mathematics and Science Study, 2011). In 2005, the National Academies, the country's leading advisory group on science and technology, warned that unless the United States improved the quality of math and science education at all levels, it would lose economic ground to foreign competitors ("48th is Not a Good Place," 2010).

Given the importance of science in our society, it is disconcerting that many researchers have observed the problem of students becoming uninterested in and unmotivated to learn science at a young age (Anderman & Maehr, 1994; Hidi & Harackiewicz, 2000; Renninger & Hidi, 2011; Yager & Yager, 1985). Some researchers believe that students come to school with an innate interest in science and that the decrease in interest stems from the way science is taught in schools (Bulunuz & Jarrett, 2015; Mitchell, 1993). Results from the 2011 Trends in International Mathematics and Science (TIMSS) comparing science achievement scores among fourth-grade and eighth-grade students from 35 and 48 countries respectively, show U.S. fourth graders were among the top 10 education systems in science but for eighth-grade students, the U.S. was only among the top 23 performing nations (Trends in International Mathematics and Science Study (TIMSS), 2011). The 2009 Programme for International Student Assessment (PISA), administered by the Organization for Economic Co-operation and Development (OECD), results show 15-year-old students in the United States ranked 17th out of the 34 participating countries in their ability to apply their knowledge of science to real-world situations (National Science Foundation, 2012). This ability has been identified as an important factor in developing interest in STEM fields and careers (Faria, Freire, Galvao, Reis, & Baptista, 2012; Feierabend & Eilks, 2010). In the case study done by Faria et al. (2012) to understand how to promote engagement of students at-risk for dropping out of school science, one teacher working with students used societal problems as the basis for teaching science modules. Feedback collected from the teacher interview, teacher notes, and student questionnaires indicated that student engagement and interest in learning science increased because this type of instruction demonstrated the importance of science in students' daily lives and enabled students to construct personal meaning (Faria et al., 20120. Feierabend and Eilks (2010) participatory action research study, with multiple cases involving 4 teachers and 7 classes of secondary students, used classroom observations, videotaping of pre- and post-learning discussion groups and student questionnaires with Likert response and open-ended questions as a means of data collection. From the data, Feierabend and Eilks (2010) found that when students are allowed to explore the relationship between science and society through curricular modules that require collaborative work and discourse, student engagement and interest in science increase as students come to understand the importance of science in their lives.

Society's increasing dependence on technology requires that all citizens develop a level of scientific literacy in order to make informed decisions (DeBoer, 2000; Osborne, Simon, & Collins, 2003; Swarat, Ortony, & Revelle, 2012). Dr. Quinn, chairman of the National Science Research Council states "Understanding science and engineering is a tool we use in our lives for making decisions . . . All students need an understanding of basic science as deeply and critically as they need to be able to read and do basic arithmetic" (Arrison & Olsen, 2012, p. 9). "Ultimately what we want is a public that finds science interesting and important, who can apply science to their own lives, and who can take part in the conversations regarding science that take place in society" (DeBoer, 2000, p. 598).

Purpose of the Study

The purpose of this research was to understand what makes learning science interesting to students from the perspectives of students and teachers at one suburban high school, determine an applicable instructional learning strategy that supports student interest, and test the effectiveness of the strategy in promoting student interest in learning or pursuing science. In the exploratory phase, Phase I, studying what makes learning science interesting from the perspectives of both students and teachers provided a more balanced picture of the local condition. The two participant groups were equally important to understanding this phenomenon and to improving the classroom teaching and learning environment in order to promote increased student interest in learning science.

Swarat, Ortony, and Revelle (2012), in examining the effects of content topic, activity and goals of learning on student interest in science through student questionnaires with 533 middle school students and a small number of student interviews, found that activities that were hands-on in nature generated the highest level of student interest and that content topic and learning goals contributed little or none to student interest. In the multiple narrative case study of sixty-one 10th-grade biology students done by Raved and Assaraf (2011) students noted that active learning opportunities through experiments, discussions, peer learning, presentations and models contributed to their interest and curiosity as well as to their understanding the material. As Osborne, Simon, and Collins (2003) in their review of the literature on student attitudes toward science state "these research findings raise the question why, despite the recurrent message of the significance of teachers, and teacher styles, on attitudes toward science, so little research has been attempted to understand what makes for effective teaching of science in the eyes of the pupil" (p. 1069). Student input is important to creating a positive learning environment that fosters student interest in science. The interest generated in the classroom, "situational" interest, is a focused attention created by the environmental conditions and is considered a more temporary form of interest; however, it can help promote the development of a longer lasting form of "personal" interest which is more enduring in nature (Hidi, 2006; Hidi & Renninger, 2006; Krapp, 2002, 2005). "Although both types of interest are relevant to educators, only situational interest is manipulable by educators, at least in the short-term encounters" (Bergin, 1999, p.87).

In order to institute effective change to the teaching and learning of science in the classroom at this site, understanding the current situation from a more holistic perspective is required. Many large-scale studies summarize results as generalizable to the larger population. For example, in the reporting of PISA 2012 science achievement data, it was possible to disaggregate the data by state. For the United States the average student score of 497, $SE = 3.8$ fell below the OECD average of 501, $SE = 0.5$; however, Connecticut's average score was 521, $SE = 5.7$ while Florida's score was 485, $SE = 6.4$ (National Center for Education Statistics, 2014). This suggests that generalizability for a country, state, or even a district may not be universally applied. Exploring student interest in learning science and determining the teaching and learning strategy to promote student interest at the local level provided the information from which to draw conclusions and institute effective local improvements in the two action research iterations. The development of the STEM Career Project was based upon the tenets of interest theory that state interest is increased when it affords the opportunity for individuals to acquire new knowledge that is personally relevant. Students at this site have limited knowledge of

STEM careers and therefore the intervention was created to address this deficiency and determine its effectiveness at influencing students' learning of science and pursuing a STEM career. Students explored and investigated three STEM careers that were of interest to them and wrote a reflection of this experience. The reflections and responses to a post-STEM career survey were used to measure the influence of the intervention. Two iterations of the intervention were completed. The first iteration was completed by the researcher. The second iteration was completed by three science teachers at the site. After each cycle, modifications and improvements were completed in order to create a final project that could be implemented further at the site or at other high schools.

The evolution of action research from a form of teacher practice to a viable research methodology has been embraced by both researchers and teachers alike because of its practicality in deriving understanding in real life situations and environments (Carr & Kemmis, 1983; Hendricks, 2013). Research cannot be conducted in a vacuum in which theorists hypothesize potential outcomes. Instead it must involve active participation and be performed in natural settings. "Authentic insights, rather than universal truths, arise out of action research" (Carr & Kemmis, 1983, p. 172). Action research supports the idea that knowing happens through action and knowledge is obtained by doing (Biesta, 2010; Kemmis, 2010). "The world we construct emerges out of the doing-undoing-doing dynamics of what Dewey calls experience" (Biesta, 2010, p. 111). Implementation of the STEM Career Project in Phase II allowed the teacher-researcher to test an empirically-based strategy and its measures in the first iteration, make applicable improvements to the intervention strategy and measures and have other teachers use them in the second iteration. The two iterations provided a means of testing the effectiveness of the intervention in influencing student interest in learning science and in pursuing science as a potential career. The cyclic nature of action research provided an opportunity to improve and refine the intervention in order to create an effective instructional tool for classroom teachers. In addition, the self-reflection associated with action research was used as another data source and provided the teacher-researcher a means of improving teaching praxis to effect positive student outcomes.

Role of Theory

Interest is a unique motivational variable as well as a psychological state that occurs during interactions between individuals and their objects of interest (Dewey, 1913; Hidi & Renninger, 2006; Krapp, 2002, 2005; Schiefele, Krapp, Prenzel, Heiland, & Kasten, 1983). Interest is characterized by increased attention, concentration and affect and therefore plays an important role in learning (Hidi, 2006). Person-Object Interest Theory (POI) and Hidi and Renninger's four-phase model believe cognition and affect contribute to the development and maintenance of interest as individuals move from an initial state of situational interest to a more enduring and developed form of personal or individual interest. Designed as tools for education, the two are grounded in Dewey's (1913) idea that interest develops through a process of "catch" and "hold." A triggering event first "catches" or sparks an individual's attention and as a result leads to further interactions or engagements that "hold" the individual's attention. In terms of education, POI and Hidi and Renninger's 4-phase model believe that creating situational interest in the classroom can promote the development of student interest in the subject by moving from the initial triggered situational interest to a more stabilized situational interest and eventually to the more well-developed individual or personal interest. Knowing a learner's phase of interest development can help educators in developing instructional practices that support, maintain, or further develop student interest levels.

In case study and action research, existing theories or models often function as the framework or blueprint to guide the development of the research (Yin, 2014). In addition theories serve as the theoretical lens or stance by which to: identify interventions; define and interpret constructs; guide and inform research questions and procedures; and analyze data collected (Creswell, 2009; Creswell & Plano-Clark, 2011; Yin, 2014). Person-Object Interest Theory and Hidi and Renninger's 4-phase model of interest development served as the framework or blueprint for this study. In order to increase student interest in science, the level of student interest in the domain of science was first determined. The initial exploration of the local conditions, Phase I, helped identify an instructional and learning strategy that was likely to increase student interest in learning science. Results from excerpts of the PISA student science survey completed by 270 10th-grade students helped to inform the interview questions that were used to elicit the participants' perspectives about student interest in learning science. The student survey data and participant interviews were analyzed using the theoretical framework of POI and the 4-phase model of interest development, as a way to deduce and identify the trends at the site that guided the choice of intervention strategies (Hidi & Renninger, 2006; Krapp, 2002, 2005; Schiefele, Krapp, Prenzel, Heiland, & Kasten, 1983). Understanding how this interest develops within the classroom provided the researcher with the information necessary to implement effective changes in praxis. Creating situational interest in the classroom triggered interest in the teacher-researcher's classroom as evidence demonstrated and helped to move learners into the next phases of interest (Hidi & Harackiewicz, 2000; Hidi & Renninger, 2006; Krapp, 2002, 2005; Silvia, 2005). The first iteration of the action research in Phase II of the study implemented a specifically designed instructional intervention to determine its effectiveness at supporting the development of situational interest as it relates to STEM careers.

The intervention capitalized on the idea that knowledge is required in order to create interest (Hidi & Renninger, 2006; Krapp, 2005). Measurement of the impact of the STEM career project on students' level of interest in learning science or in pursuing science as a career was done through student reflections of the project and post-STEM project survey.

Research Questions

Developing an interest in an object, subject or domain is demonstrated when participants actively engage in their environment. However, this curiosity or interest in learning can decrease as a student progresses through his formal education, especially as a student moves into the middle grades (Anderman & Maehr, 1994; Hidi & Harackiewicz, 2000; Renninger & Hidi, 2011; Yager & Yager, 1985). This action research study investigates if interest can be stimulated by creating an engaging classroom where students can investigate and learn about scientific phenomena that is meaningful and relevant to them (Carson, Hodgen, & Glaser, 2006; Christidou, 2011; Durik, Hulleman, & Harackiewicz, 2015; Hofstein, Eilks, & Bybee, 2010; Maltese & Tai, 2011; Root-Bernstein & Root-Bernstein, 2013; Rustum, 1990). Seeking out the most effective strategies for developing, maintaining and increasing interest in learning science is an important area of ongoing research.

This action research study examined a potential strategy designed to make learning science more interesting to 10th-grade high school students at one suburban high school. Phase I explored the perceptions of 10th-grade students and their science teachers regarding student interest in learning science. The information collected provided a more representative and balanced picture of the current situation. Specific teaching and learning strategies were used in two iterations in Phase II to determine if an empirically-based strategy creates a better science learning experience for students. The first iteration enabled the researcher-teacher to reflect on her teaching praxis in order to support and increase student interest in learning science. The second iteration was designed to determine if the intervention strategies and supports were useful to three select teachers.

The overarching question for the study: Do theories about interest apply to the learning of science and pursuit of STEM careers in a suburban high school?

The subsumed questions:

Phase I:

1. What are 10th-grade high school students' perceptions of their interest in learning science and pursuing a STEM career? (Quantitative and Qualitative)
2. What are 10th-grade high school science teachers' perceptions of their students' interest in learning science and pursuing a STEM career? (Qualitative)

Phase II:

3. Does the intervention of a STEM Career Project influence student interest in learning science and pursuing a STEM career? (Quantitative and Qualitative)

Significance of the Study

The research provided science administrators and science teachers at this site a comprehensive look at student interest in learning science and a platform from which to develop more effective teaching and learning strategies in the classroom that promote and stimulate interest in science. Exploring the current status of student interest in learning science is the first step in developing and creating a learning environment that engages students in learning science. Creating situational interest in the science classroom enables students to develop a relationship with science that may lead to a more enduring personal interest in the subject, a concept that Dewey (1913) would refer to as "catch and hold," meaning the subject must first capture an individual's attention and then maintain that attention through engagement and learning. Understanding the state of student interest in learning science from the perspective of both teachers and students provides a broader and more balanced representation of the true nature of student interest in learning at this suburban high school. Effective change can only occur from true understanding of the specific environment with its own unique characteristics.

In order to motivate students to pursue science, there must be a change in science education. In *Rising Above the Gathering Storm*, one of the core ideas for the K-12 Science Education practices is that science should "relate to the interests and life experiences of students or be connected to societal or personal concerns that require scientific or technical knowledge" (Arrison & Olsen, 2012, p. 9). There are many unexplored avenues and possibilities to creating a better science experience for students that is relevant to their daily lives. In order to develop future STEM professionals and a scientifically literate society, science education must be engaging, interactive and interesting. Science education must also create student awareness of the various opportunities provided by STEM careers in order for students to consider the possibility of pursuing science in the future. Bringing about change at the local level is just one step to initiating more widespread change in science education. The research for this case study served as an example of how to explore and understand student interest in learning science in order to create and implement an instructional intervention that provides high school students with a positive science learning experience that is personally relevant.

Limitations of the Study

The research was a conducted in one suburban high school. The focus of the study was the10th-grade student population and their 10th-grade science teachers. The results of the research were specific to the educational environment and unique characteristics of this site and as such with a limited sample, the most applicable research design was action research which benefits both local conditions and the researcher-teacher's praxis. In order to capture a representative picture of the case, multiple forms of data collection were used to increase internal generalizability and support valid conclusions (Maxwell, 2012). Access to the site was possible because the researcher is a member of this educational community. Both the emic and etic roles have been disclosed by the researcher-teacher. The researcher is a faculty member and colleague of the teacher participants and a classroom instructor of some of the student participants. Disclosure and awareness of this influence directly impact the credibility and validity of the research because ultimately the trustworthiness of the data is directly tied to the trustworthiness of the researcher (Patton, 1999).

In all forms of data collection, quantitative or qualitative, participation was voluntary. Institutional Review Board approval was obtained to safeguard and protect both participant populations. Due to restrictions on access to students' personally identifiable information identification of factors which might influence student interest or attitudes toward science learning and pursuit of STEM careers was not possible.

Definition of Terms

Four-Phase model of interest: Hidi and Renninger's (2006) model of the four stages of interest development: triggered situational interest; maintained situational interest; emerging individual interest; and well-developed individual interest.

Individual or personal interest: The enduring predisposition to reengage in the content or object-domain of a specific subject (Hidi & Harackiewicz, 2000; Hidi & Renninger, 2006; Hidi, Renninger, & Krapp, 2004; Krapp, 2002).

Interest: Merriam-Webster (n.d.) A feeling of wanting to learn more about something or to be involved in something. A complex construct comprised of cognitive, affective and neurological components (Hidi, 2006; Silvia, 2005; Hidi & Renninger, 2006; Bandura, 1989, 1994; Panksepp, 2005).

NGSS: Next Generation Science Standards. The National Research Council's (NRC) framework that identifies the key scientific ideas and practices that all students should learn by the end of high school (National Research Council, 2015).

OECD: Organization for Economic Co-operation and Development. An international consortium of countries that help governments, worldwide, foster prosperity and fight poverty through economic growth and financial stability (OECD, 2016).

PISA: Programme for International Student Assessment. A triennial international survey that evaluates educational systems worldwide by testing the skills and knowledge of 15-year-old students (OECD, 2016).

POI: Person-Object Interest Theory: The development of interest through a relationship between a person and facts, things or a field of study that is regulated by a cognitive-rational component and an affective or emotional component (Krapp, 2002, 2005; Schiefele, Krapp, Prenzel, Heiland & Kasten, 1983).

Scientific literacy: An individual's scientific knowledge and use of that knowledge to identify questions, to acquire new knowledge, to explain scientific phenomena, and to draw evidence-based conclusions about science-related issues, understanding of the characteristic features of science as a form of human knowledge and enquiry, awareness of how science and technology shape our material, intellectual and cultural environments, and willingness to engage in science-related issues, and with the ideas of science as a reflective citizen (OECD, 2006).

SDT: Self-determination Theory: Deci and Ryan's (2000) theory that there are two types of motivation: intrinsic and extrinsic which can be distinguished based on the reasons or goals that give rise to action.

Situational interest: Focused attention that is stimulated by environmental conditions (Hidi & Harackiewicz, 2000; Hidi & Renninger, 2006; Hidi, Renninger, & Krapp, 2004; Krapp, 2002, 2005).

STEM: Science, Technology, Engineering and Mathematics. An acronym for science, technology, engineering, and mathematics related to education, academic disciplines, fields of study, or career fields (Department of Homeland Security, 2016).

TIMSS: Trends in International Mathematics and Science Study. Conducts regular international comparative assessments of student achievements in mathematics and science every four years (TIMSS & PIRLS, 2016).

CHAPTER II: LITERATURE REVIEW

Science Education in the United States

Until the 1960s, the United States Educational system was the gold standard upon which other countries modeled their educational systems (Jeynes, 2008). Many of the Asian countries fashioned their own systems on the doctrines of the U.S. system. Today, these countries are the top performers in international science comparisons (National Science Foundation, 2014; OECD, 2007; Trends in International Mathematics and Science Study, 2011). However, test scores are not evocative of the entire picture. In fact, before embarking on yet another round of science educational reform based on the East Asian model, the U.S. needs to clearly and objectively examine the principles that are both effective and ineffective (Jeynes, 2008; Zhao, 2005, 2009). America may not be the number one test-taking nation but the U.S. system of education has created positive results in terms of its economy, its citizens, and in fostering creativity (Jeynes, 2008; Zhao, 2005). More importantly it offers every child access to education. Yong Zhao (2009), a professor in the Department of Educational Measurement, Policy and Leadership at the University of Oregon, eloquently states in his book *Catching Up or Leading the Way* "Two paths lie in front of us: one in which we destroy our strengths in order to catch up with others on test scores and one in which we build on our strengths so we can keep the lead in innovation and creativity" (p. 198).

While public concern over science education in the United States continues to make headlines, it is not a new issue. In fact, for nearly 60 years, the United States has been critiquing and scrutinizing science education, creating policy, developing and implementing programs designed to encourage students to pursue the fields of science, technology, engineering, and mathematics and yet the number of students responding to this challenge continues to be low

(Harris & Miller, 2005; National Science Foundation, 2004, 2006; Rudolph, 2014). In 2008, half of the Bachelor's degrees awarded in Japan and China were in science and engineering compared to the United States which awarded one-third of its degrees in science and engineering (National Science Foundation, 2012). Of all undergraduate degrees awarded in the United States, only 4% were in engineering (National Science Foundation, 2012). In the U.S., the latest innovation in science education, the Next Generation Science Standards, is once again hoping to capture the attention of students and set them on the path to achieving scientific literacy and pursuing STEM related careers. The technical and scientific dominance that the United States has maintained since World War II is slipping away. Two of the contributing factors for this are the increased competition for funding and the loss of foreign workers, who make up nearly 17% of the domestic STEM workforce, to the increasing global demand in STEM (Carnevale, Smith, & Melton, 2011; Jahnke, 2015). The decline during the last 60 years has done nothing more than to cement the concern over losing the technological advantage of the last 70 years; the problem remains the same, but how to solve it is still unknown.

Historically, the nation's obsession with science education began with the mechanization of farming in the early 1900s (Gatewood & Obourn, 1963). Millions of adults raised on farms required new skill sets as the nation moved from an agricultural to an industrial based economy. Advancements in farming no longer required the number of laborers and foreman to keep farms running. In order to make this transition, the government enacted the Smith-Hughes Act of 1917 which provided support for the teaching of vocational education in public schools primarily associated with agriculture, trades, commerce, and home economics (Harris & Miller, 2005). The technological revolution in the United States was just beginning and as technology permeated the daily lives of its citizens, scientific literacy for all citizens became an important issue. In the 1930s, advancements in science and technology brought about the obsolescence of many jobs and skills, and with that the idea that science education was also outdated (Gatewood & Obourn, 1963). World War II propelled America into its role as a world power. After World War II, the United States emerged as the most powerful military and economic power in the world. This was partly due to the fact that the U.S. was also the only country that still had a large functioning industrial sector (Rustum, 1990). This dominance was created by several factors: land, labor, capital, entrepreneurship all assisted by a cooperative government and an unequalled educational system (Harris & Miller, 2005).

However, no singular historical event had more of an impact on science education than the Russian launching of Sputnik in October 1957 (Bartholomew, 2005; Gatewood & Obourn, 1963; Harris & Miller, 2005; Rudolph, 2014). The launching of Sputnik challenged that dominance and called into question the quality of science and mathematics education. The outfall was the creation of the National Defense Education Act of 1958, an act referred to as "an educational emergency bill" (Harris & Miller, 2005). What followed was one of the largest reforms to science education that resulted in a flurry of programs, committees, and organizations all focused on improving school science education. It was believed that in order for this educational reform to be successful it should be led by scientists (Gatewood & Obourn, 1963; Harris & Miller, 2005; Rudolph, 2014). The initiative resulted in a curriculum where students practiced science, engaged in more open-ended laboratory experiments, discovered the process of science, and thought like scientists (Duschl, 2008; Gatewood & Obourn, 1963). Met by dauntless challenges from how to restructure courses, provide instructional time to incorporate laboratory work, how to implement these educational changes under the control of fifty states and thousands of local districts, and how to train teachers, the reform still seemed to reestablish the proper course maintaining U.S. global success by creating a pipeline for science careers (Duschl, 2008; Gatewood & Obourn, 1963). While the U.S. continued to lead the world in patents and technological innovations, another educational wake-up call was about to unleash a new wave of educational reforms.

In 1983 the Commission on Educational Excellence released its report, *A Nation at Risk*, by turning attention to the declining test scores of U.S. students compared to their international counterparts. This set off a flurry of change in both K-12 education and teacher education ushering in the era of standardized testing and accountability (Harris & Miller, 2005; Rudolph, 2014). Once again new initiatives were put in place: the National Goals of Science Education in 1989, Benchmarks for Scientific Literacy in 1993, National Science Education Standards in 1996 and, most recently, the Next Generation Science Standards in 2015. The intentions of these reforms have been focused on developing a scientifically literate citizenry and STEM workforce by making science relevant and grounded in everyday applications, practicing the principles of scientific investigation and inquiry, collaborating and discussing data and results, essentially working as a scientist or an engineer in order to solve real-world problems; however, the final outcome is still about test scores (Randolph, 2014; Rustum, 1990). The final outcome is that students are not pursuing science in the numbers required to meet the needs of a growing STEM workforce nor are they equipped to deal with the scientific and technological advancements that have become ingrained in our daily lives. Currently, the traditional STEM workforce, which excludes the field of healthcare, makes up 6.2% of U.S. employment; however with an average growth rate of 17.0% compared to the 9.8% for non-STEM jobs meeting this growth is a challenge (Bureau of Labor Statistics, 2016; Langdon, McKittrick, Beede, Khan, & Doms, 2011). This challenge is further increased by the fact that health care practitioners and technicians, non-STEM occupation categories which contain significant STEM trained individuals, is projected to grow by 25.9% for 2010-2020 (National Science Foundation, 2014). Although the STEM workforce is relatively small it has an enormous impact on the nation's competiveness, economic growth and overall standard of living (Carnevale et al., 2011; Langdon et al., 2011; Maltese & Tai, 2011; Osborne et al., 2003). Science education must change in order to increase interest in learning science.

In 1910, John Dewey addressed the American Association for the Advancement of Science and spoke about how students were not "flocking" to the study of science as was generally predicted based on technological advancements in the latter part of the 19th century. He said that perhaps science was taught too much as an accumulation of knowledge and less as a method of thinking. In looking at the importance of critical thinking as an essential 21st century skill, it is time that education look back to Dewey for guidance in developing a science education experience that can produce the outcomes, not the test scores, that the U.S. has been hoping to achieve for over, not sixty, but one hundred years. "When our schools truly become laboratories of knowledge-making, not mills fitted with information-hoppers, there will no longer be a need to discuss the place of science in education" (Dewey, 1910, p. 127).

Importance of Interest

In order for students to pursue science, interest and motivation are necessary. Interest is an important component for both learning and motivation. Interest is a multifaceted and complex construct comprised of cognitive, affective and neurological components (Hidi, 2006; Silvia, 2005; Hidi & Renninger, 2006; Bandura, 1989, 1994; Panksepp, 2005). Interest is an elusive concept that is often associated with engagement, motivation and attitude (Ryan & Deci, 2000; Wigfield & Cambria, 2010). Interest is defined as a predisposition to reengage particular disciplinary content over time and as a psychological state (Hidi & Renninger, 2006; Hidi, Renninger, & Krapp, 2004; Krapp, Hidi, & Renninger, 1992; Renninger 2009). Interest first caught the attention of educators when Johann Friedrich Herbart (1776-1841) theorized that interest was not only a desirable motivational condition of learning but also an important goal or outcome of education (Krapp & Prenzel, 2011; Ryan & Deci, 2000; Wigfield & Cambria, 2010). It wasn't until John Dewey's work that interest became an important subject of educational learning (Krapp & Prenzel, 2011; Schraw & Lehman, 2001; Wigfield & Cambria, 2010). Dewey (1913) believed that interest operates by a process of "catch and hold" where interest first captures or seizes one's attention by providing intellectual stimulation and then is maintained by finding a deeper meaning or purpose from the standpoint of the individual. According to Dewey (1913), interest cannot be imposed but rather can be fostered by a variety of learning activities that capitalize on student preference and motivation. Dewey (1913) described interest best when he stated that interest was active, objective, personal, emotional, and dynamic because these components together create an individual's interest or form of self-expressive activity. The result is the pursuit of an activity for which the individual sees as having value and worth (Covington, 2000a, 2000b; Dewey, 1913). Interest as a motivational variable "is a psychological state that, in later phases of development, is also a predisposition to reengage content that applies to in-school and out-of-school learning and to young and old alike" (Hidi & Renninger, 2006, p.111). Interest may be viewed as a driving force in successful learning and achievement.

Interest has a variety of definitions based on its application to different fields. It has been defined as a quality, a feeling and as a relationship with an object. The Merriam-Webster dictionary, in defining interest (n.d.) as a noun, lists the following:

1. a feeling of wanting to learn more about something or to be involved in something;

2. a quality that attracts your attention and makes you want to learn more about something or to be involved in something;
3. something (such as a hobby) that a person enjoys learning about or doing.

In looking at these definitions, the cognitive and affective components are easily identifiable but determining the role of each in fueling prolonged engagement or learning with an activity, an object or task, is a complex research problem. Additionally, the neurological component, identified by Panksepp (2005) as "seeking," has been introduced as another important factor in determining how interest develops and is maintained (Hidi, 2006). Panksepp's (2005) neuroscientific evidence suggests that this "seeking" system is designed to actively engage the world and help integrate associated information about the environment through the emergence of cognitive maps, expectancies and habit structures in order to increase the efficiency of behaviors. "Genuine interest is the accompaniment of the identification, through action, of the self with some object or idea, because of the necessity of that object or idea for the maintenance of a self-initiated activity" (Dewey, 1913, p. 14). For this study interest is defined as the relationship or interaction between students and their learning of science.

Theories of Interest

Theories of interest and motivation have developed over the course of many decades and have many overlapping constructs and ideas. Their development is similar to that of a growing tree with its roots intertwined and its branches ever burgeoning to touch upon and connect the various constructs and models that inevitably end as a means to understanding the learning process. Many theories include a duality of factors such as the concept of intrinsic and extrinsic motivation or personal interest and situational interest; however, there are many emergent commonalities rooted in principles dating back to John Dewey and his ideas about creating a successful learning environment. An understanding of these theories and how they developed can help classroom teachers increase student interest in learning. Understanding the learning process and the motivational factors that contribute to student interest, as well as, the external conditions that can affect this function, are critical to inspiring intrinsic student interest and life-long learning.

Eccles and Wigfield (2002) have divided theories of motivation into four main categories based on their unique focus: 1) theories focused on expectancy; 2) theories focused on reasons for engagement; 3) theories integrating expectancy and value constructs; and 4) theories integrating motivation and cognition. Among these categories there are noted similarities and differences that stem from the different intellectual traditions from which these theories have evolved. However, the overlap in categories makes it exceedingly difficult to place a theory exclusively in just one category. Eccles and Wigfield's (2002) category of theories that focus on the reasons for engagement include Deci and Ryan's self-determination theory and two interest theory models, person-object interest theory (POI) and Hidi and Renninger's four-phase model of interest development. These three theories seek to understand the reasons for engaging in an activity or with an object and focus on a duality that describes the development of interest or motivation as being derived from two perspectives, one that is intrinsic in nature and one that is extrinsic.

Self-determination theory (SDT) proposed by Deci and Ryan is based upon the idea that there are two different types of motivation, intrinsic and extrinsic motivation, that compel individuals to act (Ryan & Deci, 2000). Intrinsic motivation refers to doing something because it is personally interesting or enjoyable. Extrinsic motivation is about doing something because of its outcome or end result. The idea of individuals being intrinsically motivated to act is similar to Hull's drive theory which acknowledges that individuals are driven by a phenomenon known as primary motivation which is a composite of physiological or neurological responses or needs and the associated behavior which seeks to satisfy this need (Hull, 1943). Satisfaction of man's needs is also the focus of Maslow's (1943) work where man is described as a "wanting creature" who continues to seek satisfaction by moving through a hierarchy of needs from the most basic human needs to those of self-actualization, thus progressing through a sequence of primary motivations. In self-determination theory the focus of intrinsic motivation is upon the satisfaction of the psychological needs of competence, autonomy and relatedness and less upon the basic needs, but these basic needs are a critical component in the determination of what individuals find inherently interesting (Ryan & Deci, 2000). Intrinsic motivation can be characterized as a state or a trait. The trait-like characteristic is more enduring and characterized by a preference for hard or challenging tasks, learning that is driven by curiosity or interest, and striving for competence and mastery. Learning, being driven by interest, is the most important in maintaining intrinsic motivation.

The other component, extrinsic motivation, is rooted in Skinner's operant theory. Skinner (1953) believed that the environment creates or builds the response or behavior based on rewards and punishments. Operant conditioning improves the efficiency of the behavior even after it ceases to be interesting; however, there is no internal drive associated with repeating the behavior. This type of rote behavior can undermine intrinsic motivation (Covington, 2000a, 2000b; Ryan & Deci, 2000). In self-determination theory, removing the often undermining effects of extrinsic motivation requires moving through a process of internalizing and integrating values that transform into their own so that motivation emanates from within. This process known as Organismic Integration Theory is vitally important if individuals' actions are going to move from an external perceived locus of causality to one that has been fully assimilated to the self (Ryan & Deci, 2000). In terms of classroom learning, creating social contextual conditions that support the basic needs of autonomy, competence and relatedness are necessary for maintaining students' intrinsic motivation as they are exposed to new ideas and skills. Similarly, Bandura's social cognitive theory (1989, 1994) identifies the classroom as the arena in which students develop a growing sense of their own intellectual self-efficacy which affects what they do, how much effort they invest in activities, and how long they persevere in the face of obstacles and failures. Motivation is not completely derived from inner forces nor is it automatically shaped or controlled by the environment (Bandura, 1989). There are many influences that create one's self-efficacy or self-knowledge including direct personal experiences, as well as, vicarious experiences that occur with individuals identified as similar. In processing these experiences, through self-judgment or self-reflective appraisal, one creates a cognitive model of reality that in fact determines and regulates the learning activities that one is most likely to pursue (Bandura, 1989). Individuals develop their own reward and punishment system that affects their behavior and ultimately their interests and pursuits because persistence is ultimately under self- reinforcement control (Bandura, 1974, 1989). The external factors are influential in developing the internal or intrinsic driving force that leads to self-motivation.

Covington (2000a), in describing two motivation theories, achievement goal theory and self-worth theory, discusses the conflicting impact of learning goals and performance goals on motivation and achievement. Learning goals are described as more internal or intrinsic in nature and refer to increasing competency, understanding and appreciation for what is being learned. Performance goals are external in nature and are defined by competition or comparisons to others as a way to improve one's status. Ultimately "the accumulated evidence overwhelmingly favors the goal-theory hypothesis that different reasons for achieving, nominally approach and avoidance, influence the quality of achievement striving via self-regulating mechanisms" (Covington, 2000a, p. 178). Self-determination theory, social cognitive theory, achievement goal theory and self-worth theory are cognitively driven approaches that focus on how individuals reconcile the intrinsic and extrinsic factors that effectively result in the thoughts, evaluations and beliefs that come to define their motivation and achievement (Bandura, 1989, 1994; Covington, 2000a; 2000b; Deci & Ryan, 2000). In this respect they differ from POI and the four-phase model of interest. In fact, SDT, which has many similarities, markedly differs from these two theories in two distinct ways: first, it relies solely on a cognitive framework, believing affect is an outcome and not a mediator of cognition; secondly, it stresses the important influences of goals and rewards on motivation (Deci & Ryan, 2000).

Silvia's (2005) appraisal theory of interest focused on intrinsic motivation and affect. In appraisal theory cognition and affect work in conjunction in a way quite different from other models of either interest or motivation. Silvia (2005) defines interest as an emotion that is associated with curiosity, information-seeking, and intrinsic motivation. Interest is the result of patterns of cognitive evaluations that judge interest by the level of novelty-complexity and coping potential or ability to comprehend (Silvia, 2005; 2008). Judging the level of novelty-complexity can be analogous to triggered situational interest because it is this newness that "catches" interest. Whereas coping potential or ability to understand can be described as similar to the process of developing interest by increasing knowledge and competency which can result in intrinsic motivation or individual interest. Currently this model has focused primarily on evaluations of art or visual triggers and therefore this conceptualization of interest is less applicable to educational practice (Hidi & Renninger, 2011). Silvia (2008) does however make the point that "finding something understandable is the hinge between interest and confusion" which holds true for all applications of interest.

Person-Object Interest Theory and 4-Phase Model of Interest Development

The two leading theories or models that focus on what makes learning interesting are person-object-theory of interest (POI) and Hidi and Renninger's four-phase model of interest development. Both models subscribe to the idea that interest is a unique motivational variable that is both cognitive and affective in nature (Hidi, 2006; Hidi & Renninger, 2006; Krapp, 2002, 2005; Renninger & Hidi, 2011; Schiefele, Krapp, Prenzel, Heiland & Kasten, 1983). There are three important features of the interest construct that distinguish it from other motivational variables: 1) interest is content specific; 2) interest exists in the relationship between the person and content; and 3) interest has both cognitive and affective components (Hidi et al., 2004). Both believe that interest, unlike motivation, is content specific and that it is a relationship between a person and an object such as facts, things, or domains, for example science. Both models maintain that it operates through a dual process of situational and individual interest; and engagement in an activity or with an object results in positive emotional feelings that are integral to the process and not simply an outcome as is indicated in the cognitively driven theories (Hidi & Renninger, 2006; Krapp, 2002, 2005; Schiefele et al., 1983). Both models focus on learning and the role of interest in education.

As of 1983, very little research had focused on the objective relationships between individuals and their engagement with facts, things, and objects in their environment even though the importance of this relationship and its considerable influence on personality development had been recognized (Schiefele et al., 1983). According to Schiefele et al. (1983) the goal was to develop a useful theory of interest within a pedagogical framework so that it could be applied to education. The original name was the educational theory of interest (Schiefele et al. 1983) which later evolved into what is now known as “person-object-interest theory” (POI) (Krapp, 2002, 2005). Schiefele et al. (1983) chose to use an action theoretical framework rather than a behavioral framework for the orientation of their theory. This decision stemmed from the fact that behavioral theories focus on the response to stimulus or object and the conditions under which it occurs. Action theories, however, rely upon cognition or comprehension of the situation and the subsequent choice between alternatives, affect or emotional quality of the experience, and value orientation or the decision to involve oneself with the object of interest based upon the individual’s value structure (Schiefele et al., 1983). The theory set out to create a systematic reconstruction of the course and conditions of an actual action of interest (Schiefele et al., 1983). In this process an individual moves from a state of “minimal interest” or situational interest to one of “ideal interest” or individual or personal interest as he continues to reengage with the object developing a higher level of cognitive complexity that works in conjunction with the emotional attachment that has been created and the value orientation that has been placed on the relationship.

Krapp (2002) describes a three phase model of POI where phase one is the initial occurrence of situational interest (catch) followed by phase two, a stabilized situational interest (hold) and phase three individual interest (see Figure 1). Hidi and Renninger (2006) describe a four-phase model which begins with triggered situational interest (catch), followed by a maintained situational interest, moving to an emerging individual interest, and culminating in a well-developed individual (hold) (see Figure 2). Phase 1, triggered situational interest, refers to a psychological state of interest which results from environmental triggers such as instructional conditions or learning environments, character identification or personal relevance, and intensity

(Hidi & Renninger, 2006). Phase 2, maintained situational interest, is characterized by focused attention, persistence, and reoccurrence to engage. Instructional conditions and learning environments provide meaningful and personally involved activities. Phase 3, emerging individual interest, is characterized by positive feelings, stored knowledge, and stored value (Renninger, 2000). The student begins to develop his own questions about the content but still requires some external support or modeling from others (Hidi et al., 2004; Renninger & Hidi, 2002). An emerging individual interest can enable a person to anticipate subsequent steps in processing work with content (Renninger & Hidi, 2002). Phase 4, well-developed individual interest, enables a person to sustain long-term constructive and creative endeavors and generates more types of and deeper levels of strategies for work with tasks even in the face of frustration (Renninger & Hidi, 2002). Instructional conditions or learning environments can promote the development and the deepening of well-developed personal interest by providing opportunities for interaction and challenges that lead to knowledge (Renninger & Hidi, 2002).

Situational interest is more temporary and is affected by external or extrinsic factors whereas individual interest is more enduring or trait-like and intrinsic in nature. Situational interest has been shown to positively influence cognitive performance, focus attention, enable integration of information with prior knowledge, and enhance levels of learning (Hidi & Renninger, 2006; Schiefele et al., 1983; Schiefele, Krapp, & Winteler, 1988). Individual interest has a positive effect on attention, recognition, and recall, persistence and effort, academic motivation, and levels of learning (Hidi & Renninger, 2006; Schiefele et al., 1983; Schiefele, Krapp, & Winteler, 1988). Hidi and Renninger (2006) believe that individuals move through these phases sequentially; however, without support, any phase can go dormant, regress or recede. POI and the four-phase model stress the importance of cognition, affect, and value orientation in creating a well-developed individual or personal interest. However, POI divides interest into value-related and feeling-related valences, whereas, the four-phase model believes affect and knowledge work together to create value (Hidi & Renninger, 2006; Krapp, 2005). Both models, when applied to student learning, believe that creating an environment that fosters situational interest can lead to the development of the more enduring individual interest which is necessary for an individual to persist in learning. "Focusing on the potential for situational interest inherent in the material and mode of presentation may help teachers promote learning for all students regardless of their idiosyncratic interests" (Hidi & Harackiewicz, 2000, p. 157).

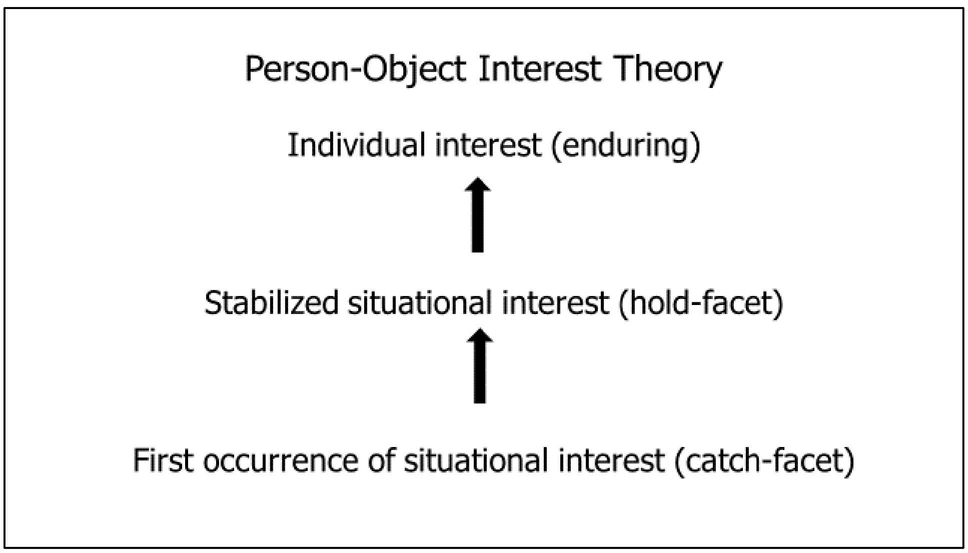

Figure 1. Person-Object Interest Theory phases of development.

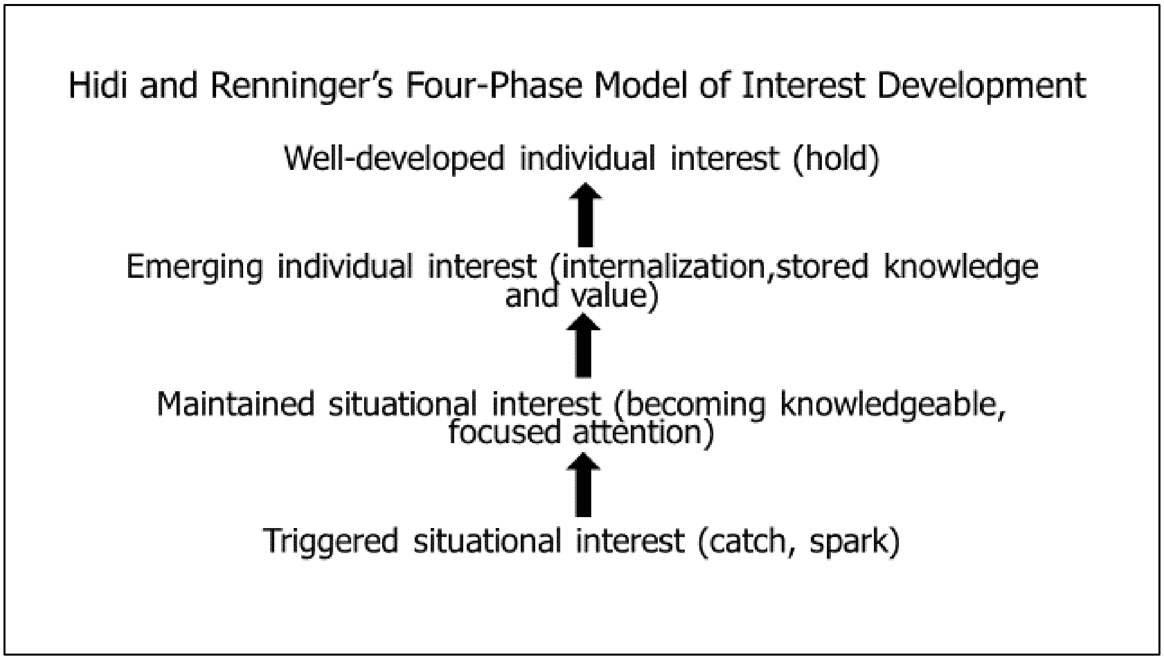

Figure 2. Four-Phase Model of Interest Development and its stages.

Research Studies Focused on Student Interest

In order to develop an interest in learning science, students must cultivate a specific relationship with the domain of science. Potvin and Hasni (2014) reviewed 12 years of educational research on interest, motivation, and attitude toward science and technology and found that the interest construct was most often defined as an association with a domain specific preference or "object of interest." Many interest researchers believe that interest is coordinated with beliefs and reflective awareness which is supported by the fact that interest research uses surveys and interviews as methods of data collection (Renninger, Nieswandt, & Hidi, 2015). Student interest and student interest in science have been primarily evaluated through self-reporting measures such as surveys, using Likert scale responses and open-ended questions. Student and teacher interviews and observations have been included as secondary sources for corroborating information obtained through surveys in some studies. Other factors that characterize interest such as attitude, engagement, or persistence are also included in these measures (Hidi et al., 2004). Hasni and Potvin (2015) created and validated a student questionnaire that simultaneously takes into account 18 components identified as factors that influence interest in order to determine student interest in science and technology for students in grades 5 through 11. The survey used expanded response choices that included six levels of agreement in order to better distinguish any differences.

One of the largest studies of student interest in science was the 2006 Programme for International Student Assessment (PISA). PISA is the primary source for internationally comparative assessment data for students coming to the end of their compulsory education. Administered triennially the study assesses student literacy in the domains of reading, mathematics and science by focusing on how well students can apply the knowledge and skills learned in school to real-life challenges (OECD, 2016). Each test also includes a specific focus on one of the three domains in order to collect more in-depth information. In 2006, the focused domain was science and over 400,000 students from 57 countries participated. In addition to measuring student achievement, the test also included embedded interest items. Students were asked to assess their level of interest in the subjects presented in the questions using a Likert response scale. This unique approach goes well beyond the scope of traditional questionnaires in capturing interest information because it measures interest to a specific context and therefore can unveil students' specialized areas of scientific interest (Dreschel, Carstensen, & Prenzel, 2011). Students were also administered a separate survey to assess their interest in science and support for science. This was defined by PISA as a willingness to engage in science-related issues and to reflect on scientific issues (OECD, 2007). The data generated from this study have been used in further studies to examine individual countries, compare countries, and create new models for understanding the variables that affect student performance and interest (Ainley & Ainley, 2011a; Ainley & Ainley, 2011b; Dreschel, Carstensen, & Prenzel, 2011; Lin, Lawrenz, Lin, & Hong, 2012; Olsen & Lie, 2011). These studies used the constructs and frameworks of POI and the four-phase model of interest to analyze and interpret the PISA data. Ainley and Ainley (2011a; 2011b) using descriptive statistics and correlations between the variables of science knowledge, enjoyment of science, personal value of science, interest in learning science, and socio-economic status as measured by the student questionnaire to formulate how these could be used to predict embedded interest as measured by the instrument assessing science knowledge. The result for the four countries analyzed, United States, Columbia, Sweden, and Estonia, demonstrated that personal relevance and personal meaning are important factors in student enjoyment, interest and engagement with science content and leads to a focused attention to expand their knowledge and understanding of science. In conclusion, the strongest path in the model linked personal value with enjoyment which in turn linked embedded interest through interest in learning science (Ainley & Ainley, 2011b). Lin, Lawrenz, Lin and Hong (2012) analyzed data from Taiwanese students and found that if the goal of education is to increase scientific literacy in the population then more emphasis should be placed on interest and enjoyment in science and less on science competency. Using the 2006 PISA results of the 8,375 Taiwanese students, the researchers developed a theoretical model of engagement and science competency by comparing seven variables as measured through the student questionnaire and the assessment of knowledge. The model was tested through structural equation modeling (SEM) and found that interest and enjoyment were the strongest predictors of future intended interest in science compared to the more cognitive factors of self-efficacy and self-concept (Lin et al., 2012).

In longitudinal studies addressing student interest in science and persistence in the pursuit of science, technology, engineering, and math degrees, researchers noted that understanding the factors that contribute to interest in learning science is necessary to fulfill the growing need of the STEM workforce and to create a scientifically literate society (Logan & Skamp, 2013; Maltese & Tai, 2011). Logan & Skamp (2013) relied upon the components of interest theories to investigate how 14 Australian students' interest in science changes across the four years from upper primary to secondary school year ten. The study focused on the component of situational interest and used a convergent parallel mixed method design to understand the factors that affect interest as seen through student voice. Students' situational interest was measured through interviews and open-ended surveys which occurred each year. Additionally, classroom observations, student work samples, and a researcher diary were used to collect additional information. The conclusion was that simple changes to pedagogical practices in the classroom can promote situational interest that may eventually lead to the more enduring personal interest such as more practical hands-on experimentation, more student-centered investigations, more opportunities to discuss and engage in real-world applications, adequate level of challenge, clear instructions and explanations, and positive classroom environment (Logan & Skamp, 2013). In addition, Renninger (2009), in discussing the case study of an eighth-grade girl's interest in science, noted that an inductive model of interest and identity development in instruction could "usefully inform the design of tasks, exhibits, and activities; instructional conversations; and expectations for learner participation and achievement" (p. 105). This eighth-grade girl was interviewed as part of a short longitudinal study of middle school science where students were asked to describe their classroom learning experiences, self-concept of ability for science, and their work with science tasks. Renninger, Kensey, Stevens, & Lehman (2015) in reviewing the literature on interest development and their own research with middle and high school students concluded that if interest develops or recedes, it is related to whether or not the classroom experience is supportive in actively engaging students in the process of science or simply focused on content mastery of the subject. The classroom environment is the arena in which to trigger, maintain, and hold what is known as situational interest.

Maltese and Tai's (2011) framework for their longitudinal study was based on "the belief that student aspirations are developed from a combination of intrinsic interest and extrinsic experience" (p. 878). This unique longitudinal study spanned from 1988 to 2001 and followed individuals who completed a STEM degree from eighth grade up to twelve years beyond grade 8. Student academic records and questionnaires administered across this timespan were analyzed in order to gain an understanding of how students' experiences in their science and math classes, enrollment, and performance influenced attitudes and future enrollment in STEM courses. From their results, Maltese and Tai (2011) concluded that making the science more personal and relevant through the use of locally or community based science issues and focusing on demonstrating to students the utility of math and science in their lives both now and in the future may pay "greater dividends" in building the STEM workforce. Maltese and Tai (2011) recommend future researchers collect multiple streams of data including classroom observations, focusing on the nature and style of teaching and the activities which engage students, which can help to triangulate between student and teacher surveys regarding pedagogical practices. Although it is difficult to quantify data on the constructs of "engagement" or "interest" in science and math, large-scale efforts are critical to understanding how individuals persist in or leave the STEM pipeline (Maltese & Tai, 2011, p. 901). White (2005) also looked at persistence of interest in STEM using POI. The focus was to understand the conditions for academic persistence in STEM degrees. White's (2005) study, using POI theoretical framework, defined persistence as maintaining a relationship with an object or activity through repeated engagement. Persistence was measured based on duration and frequency of engagements. This study utilized Prenzel's model of individual interest which is characterized by selective persistence (Krapp et al., 1992). The study concluded that interest plays a pivotal role in filling the STEM pipeline.

Studies focusing on situational interest have sought to understand the role of situational interest and its development in order to identify pedagogical strategies to increase student interest in learning. Rotgans and Schmidt (2011), using the framework of interest theories, studied situational interest over the course of a one day problem-based learning event and employed several methods including a 5-point Likert scale student survey, an academic test of prior and new knowledge related to the topic, and observations of achievement-related behaviors to understand the development of situational interest. This unique approach in addressing situational interest in the active-learning environment is the first of its kind (Rotgans & Schmidt, 2011). The participant group were second-year college Business students. The students were given a problem to work on as a group and charged with presenting their findings at the end of the day. The students' situational interest was measured five times over the course of this learning event using a four question survey designed to measure situational interest which was defined as focused attention and the affective reaction triggered by external stimuli. In addition, prior knowledge and acquired knowledge was measured using a pretest/posttest design to determine the role of prior knowledge as it relates to situational interest. Trained observers were also employed to rate students' participation, teamwork, self-directed learning, and presentation skills. The design helped elucidate the process of interest development and found that interest is triggered by presenting students with a puzzling state of affairs and maintained by the various learning activities undertaken to understand the problem. These are characteristics analogous to the concept of developing an active-learning environment (Rotgans & Schmidt, 2011). Measuring knowledge levels provided another level of understanding about the role of interest in cognitive learning.

Swarat, Ortony, and Revelle's (2012) study focused on the role of activity type in understanding student interest in science in the classroom. The five activities tested were classroom discussion, creation of written products, teacher lecture, and designing and conducting scientific investigations with and without instrumentation or technology. Using Hidi and Renninger's (2006) definition of interest as a motivational variable this mixed method study collected data through student questionnaires and interviews. Their findings suggested that activity type accounted for the greatest variance in student interest, whereas content type and learning goals contributed little or none. Classroom activities that are hands-on and actively engage students generated the highest levels of interest (Swarat, Ortony, & Revelle, 2011). This supports both POI and Hidi and Renninger's 4-phase model of interest in that it is the active interaction between the person and the object that determines the level of interest. Abrahams (2009), in his 25 multisite case studies focusing on of whether practical work in science can motivate students, found that what teachers refer to as motivation is better understood as situational interest because motivation or personal interest does not require continuous re-stimulation through hands-on work. However, Abrahams (2009) also found that situational interest generated in the classroom by practical work is unlikely to endure beyond the lesson if students view it only as a preferable alternative to other forms of instruction such as lecturing, reading, or writing.

Dohn’s (2013) case study of 12th-grade students’ was carried out over a 7-week period and included videotaping of the classroom activities, zoo field trip which included classroom instruction and experimentation using life science laboratory equipment, as well as, a guided zoo tour, and interviews with the students and the teacher at intervals throughout the 7-week time period. Dohn (2013) found that stimulating interest is the result of several variables at play simultaneously such as hands-on activities, novelty, surprise, social involvement, and knowledge acquisition. Students found biology more interesting after the zoo trip in week five because they felt the zoo activities were highly meaningful and the students’ positive feelings regarding interest in learning science lasted for at least another two weeks at the conclusion of the study. Further research into the role of students’ affective experience in science learning, both positive and negative, may provide a more complete picture of students’ level of interest in learning science and how to support it (Abrahams, 2009; Dohn, 2013).

Pressick-Kilborn (2015) believes that more interest studies in authentic classroom settings over time can help identify initial interest triggers as well as triggers in interest development over time. Using additional data collection strategies such as researcher field notes, video and audio-recorded classroom episodes, and still photographs, in conjunction with self-reporting surveys, interviews, and student reflections can help uncover the factors that trigger, support, and maintain student interest in the classroom. Capturing the live classroom and observing student reactions can provide a way to identify the factors that contribute to student interest. Pressick-Kilborn (2015) in her case study of one 5th-grade science class, in a girls’ school, purposely selected six students out of the 26 students as focus participants to observe their expressions of interest, or lack thereof, during 2 ten-week science units. This data collection focused on the interactions among teacher actions, collaborative student activities and individual student actions. This additional type of data collection helped reveal the variation in individual student experiences of interest in the same classroom. Pressick-Kilborn (2015) believes that the teacher's pedagogical decisions, the teacher's own interest and responsiveness to learning, and the teacher's ability in helping students connect with the scientific concepts in a way that is personally meaningful and provides a stimulus of wonder are critical elements to developing student interest in learning science. Hands-on activities, opportunities to encounter "the real thing" through field trips and excursions are key to creating potential triggers for the development of student interest in learning science (Dohn, 2013; Pressick-Kilborn, 2015).

Turner, Kackar-Cam, and Trucano's (2015) 3-year intervention study with eight randomly selected middle school math and science teachers measured student interest through classroom observations and student feedback from questionnaires. Each teacher was observed on four separate occasions. Study findings show that students reported higher levels of engagement when the teacher used a more relevant curriculum, encouraged student discussions, and offered more opportunities for students to make connections among ideas and with the world. Changing instructional practices to focus on actively engaging students both cognitively and socially in the practice of science increases student interest in learning. Student feedback and observations indicated that teaching strategies that include raising intriguing questions, providing rationales for activities and the teacher's demonstrated enjoyment of learning are all ways to increase situational interest in the classroom (Turner, Kackar-Cam, & Trucano, 2015).

In Finland, Lavonen, Byman, Juuti, Meisalo, and Uitto (2005) measured student interest in physics using a modified version of the Relevance of Science Education (ROSE FIN) survey. The ROSE FIN survey was designed to uncover the factors that are important in the learning of science and technology in school in order to help teachers and researchers make learning science more interesting. The underlying theoretical framework for the study was grounded in interest theory because "from the viewpoint of physics learning, the critical part of situational interest seems to be how to hold it long enough to lead to motivation to study and the activities of studying" (Lavonen, Byman, Juuti, Meisalo, & Uitto, 2005). Excerpted sections of the ROSE FIN survey were used to understand students' level of interest in the content and context of physics and to see if a gender difference existed. The findings from surveying 3,626 lower-secondary school students indicate that students are more interested in phenomena not grounded in everyday activities but in phenomena not easily explained by school physics such as the twinkling of stars. Additionally, especially for females, interest in physics was most interesting when it related to being human, whereas males were more interested in understanding and use of electrical and mechanical equipment. Although quantitative measurements when derived from surveys may not be able to provide the detailed structure of student interests, according to Osborne et al. (2003), they can provide information about the significance of the phenomena being studied as it relates to students' interests (Lavonen et al., 2005). Further research into how context influences students' situational interest and how it can be held is required, as well as, the effects of specific components of context-based approaches and learning materials (Lavonen, et al., 2005).

Understanding students' interest in learning science is the first step in formulating a plan to create a classroom environment that promotes the development of situational interest. Even though situational interest is often temporary, if fostered it can lead to the emergence of the more enduring individual interest (Hidi, 2006; Hidi & Renninger, 2006; Krapp, 2002, 2005). Situational interest is the precursor to the more enduring individual or personal interest that is described in both POI and the four-phase model of interest development. Knowing a learner's phase of interest development can help educators provide: the appropriate levels of support or scaffolding; feedback to help students develop their own questions; appropriate task challenge; opportunities to ask curiosity questions; and select resources and activities that promote problem-solving and strategy generation (Hidi & Renninger, 2006). In our science and technologically dependent society, all citizens require a degree of scientific literacy (DeBoer, 2000; Osborne, Simon, & Collins, 2003; Swarat et al., 2012). Science is a subject that promotes the development of skills such as problem-solving, critical thinking, reasoning, creativity, analysis and interpretation (Jacobs, 2009; Zhao, 2009). The development of these 21st century skills is necessary in order for students to compete in our global world. Maltese and Tai (2010) in their interviews with 116 science graduate students found that there are many factors that play a role in getting individuals into the science pipeline such as early science interest and enjoyment of the subject and an engaging classroom environment that appeals to a variety of different interests and allows students to feel comfortable asking questions. In addition, Maltese and Tai (2011) in their longitudinal study of 4,700 students in U.S. schools found that the role of the teacher can be influential in turning students on to and off from science by how science is taught in the classroom. Creating interest requires a mix of learning activities that actively engage students to investigate the world around them and think about how to solve math and science problems (Maltese & Tai, 2011). Students reporting greater emphasis on this method of teaching science reported significantly higher levels of interest compared to peers in classrooms where facts and knowledge were emphasized (Maltese & Tai, 2011). What happens in the classroom impacts the academic and career paths students choose to pursue. How to increase student interest in science is an area that still requires exploring.

Instructional Strategies to Increase Student Interest

Osborne, Simon and Collins (2003) believe that while the research identifying the problem of students' lack of interest in science is well-documented, more research into understanding the contextual factors of teaching that stimulate interest, engagement, or situational or extrinsic interest are required. As a result of poor student performance on standardized tests, science reform has looked into teaching strategies such as problem-based learning and inquiry-based teaching approaches. One instructional approach to increasing student interest in science is problem-based learning (PBL) or science taught through socio-scientific issues (Faria, Freire, Galvao, Reis, & Baptista, 2012; Feierabend & Eilks, 2010). This grounding of science in current issues in society is also commonly referred to as science, technology and society (STS). Integral to this approach is the idea that science must be personal and relevant to students' lives in order to be meaningful (Carson, Hodgen, & Glaser, 2006; Christidou, 2011; Hofstein, Eilks, & Bybee, 2010; Maltese & Tai, 2011; Root-Bernstein & Root-Bernstein, 2013; Rustum, 1990). What is important, according to Basu and Barton (2007), is that science education stresses the importance of connecting science as a personal and meaningful experience in order to create sustained interest and student engagement. Potvin and Hasni (2014) in their systematic review of 12 years of research on students' interest, motivation, and attitude toward science noted this idea was repeatedly exhausted throughout the literature and suggests instead that the focus be on why and how science gets distorted when taught in school. Some of the reasons why student interest in science declines as they progress through their education are due to an increased focus on ability as opposed to mastery, a lack of playfulness or the ability to independently investigate or pursue phenomena, and a lack of perceived value or relevancy (Anderman & Maehr, 1994; Bulunuz & Jarrett, 2015; Hidi & Harackiewicz, 2000;

Mitchell, 1993; Renninger & Hidi, 2011; Wigfield & Cambria, 2010; Yager & Yager, 1985). Many schools in the U.S. and worldwide have focused attention on using societal contexts to increase scientific literacy. However, the curriculum materials and instructional practices still emphasize facts, information, and knowledge of disciplines and only secondarily emphasize the practical everyday applications of science (Duschl, 2008; Duschl & Bybee, 2014; Hofstein, Eilks, & Bybee, 2010; Rustum, 1990).

Valente, Fonseca, & Conboy (2011) analyzed PISA 2006 student questionnaire data in order to understand the impact of different instructional approaches on scientific literacy. By disaggregating the data collected for the four clusters of teaching and learning, hands-on activities, interaction, student investigations and applications and models and the assessment score a hierarchical linear model was generated for seven countries including the United States. For all seven countries analyzed science teaching using applications and models had a significant positive impact on student scores while student investigations negatively and significantly impacted all seven countries. Raved and Assaraf’s (2011) interviews with students showed that students who were negative towards studying science could not see its value or find a connection between science in the classroom and their everyday lives. Seiler (2011), using three years of qualitative data collected through participant interviews and observations, found engagement and interest increased when students connected science to their lives, posed questions, had choice in what they studied, and had the freedom to use their own ways of speaking and sense-making. Swarat, Ortony and Revelle (2010) found that among different science activities, students’ interest was highest for those that were hands-on or used scientific instruments or technology than those that were purely cognitive or less physically engaging. Faria, Freire, Galvao, Reis, and Baptista (2012) used the PARSEL (Popularity and Relevance of Science Education and

Scientific Literacy) model in their case study in Portugal. The science modules used in the study were designed through a European project that was tasked with creating innovative science modules to increase student interest in science by demonstrating its' relevancy and involve three specific stages. The first stage begins with the introduction of a societal science problem and the acquisition of the scientific concepts to understand it. Stage two involves students developing and implementing inquiry-based activities to solve the problem. In stage three students reappraise the problem and using the newly acquired information make a decision regarding the problem. In this study teacher data was collected through interviewing and teacher notes while student feedback was collected through a Likert questionnaire. The results indicate that engagement increased when students are allowed to explore the relationships between science and society, participate in activities that are student-centered, and work collaboratively to solve the problem. Using a variety of teaching methods from contests and riddles, movies, presentations and models, tours and discussion, as well as experiments, is important to creating a positive science learning experience that contributes to interest and curiosity in science (Osborne & Collins, 2001; Raved & Assaraf, 2010).

Feierabend and Eilks (2010) also used socio-scientific based lessons to teach science modules and included debate or discourse which generated high levels of motivation and stimulated intense discussion. The multiple case study was conducted in Germany with science teachers and secondary students. Data was collected through questionnaires with Likert and open-ended questions and also used videotaping and observations focusing on the pre and post learning discussions. The responses from students indicated that using this design of debate and discourse instead of the traditional approach of teaching science as a conglomeration of facts, generated high levels of motivation, stimulated intense discussions, and promoted a greater perception of the relevance of science (Feierabend & Eilks, 2010). Lavonen, Byman, Juuti, Meisalo, & Uitto (2005) in their study of interest in physics found from surveying 3,626 student participants that STS approaches were not interesting to all students. This implies that the specificity of the science domain and the topic itself play a role in determining student interest and therefore it is important for teachers to know what content and context interests students (Lavonen, et al., 2005).

Another approach to science reform has been the promotion of inquiry-based science teaching; however, due to its multiple connotations and ambiguity regarding what it looks like in the classroom, educators remain unclear on how to effectively implement it (Campbell, 2006; Colburn, 2008). Campbell's (2006) research with K-12 science teachers found teachers struggling to understand how to implement and assess inquiry in the classroom. The National Science Council in *Guide to Implementing the Next Generation Science Standards* defines instruction in the following way, "we do not mean the information that a teacher delivers to students; rather, we mean the set of activities and experiences that teachers organize in their classroom in order for students to learn what is expected of them" (p.24). Whether it is called inquiry or discovery, the focus is on active learning in a classroom where students are engaged in open-ended, student centered, hands-on activities (Colburn, 2008; Furtak, Seidel, Iverson, & Briggs, 2012; Logan & Skamp, 2012; Parson, Miles, & Peterson, 2011; Smith, Desimone, Zeidner, Dunn, Bhatt, & Rumyantseva, 2007; Wilson, Taylor, Kowalski, & Carlson, 2010). A meta-analysis of experimental and quasi-experimental inquiry-based science teaching by Furtak et al. (2012) found inquiry-based science teaching has a positive effect on the cognitive domain of student learning with a particularly large effect in the epistemic, procedural and social categories. Parsons, Miles and Petersen (2011) in surveying 844 high school students about what helps them to learn science found that class discussions, repetition of ideas, and labs were most helpful. However, students cited teachers more frequently used passive methods rather than active ones. Smith et al. (2007) used NAEP data collected from the 2000 teacher questionnaire in order to see the impact of teacher credentials and participation in professional development on the use of different instructional strategies. Results from the sample of 1,072 science teachers at 593 schools found that teachers needed focused professional development in order to teach an inquiry-oriented curriculum. Wilson et al. (2009), implemented a laboratory-based randomized control study of inquiry-based versus more traditional teaching strategies taught by the same teacher in order to determine the effectiveness of inquiry instruction. This effect was measured using data collected from the 58 student participants that included pretests, posttests and 30-minute interviews at the end of the four weeks. Additionally classroom observations were used to code activities, student engagement, and the level of cognitive demand on students. The researchers found that the inquiry group reached significantly higher achievement across a range of learning goals and this effect was still evident four weeks later. If science education is to move forward, using this approach, a clear definition of inquiry and what it looks like in the classroom is required. This also requires science teacher preparation that focuses on the development of deep content knowledge and pedagogical skills across the K-12 spectrum (Badara, Barkana, Gupta, Ngoh, & Gherasimova, 2015; Brown, Brown, Reardon, & Merrill, 2011; Ejiwale, J., 2013; Pressick-Kilborn, 2015).

The latest approach to improving science education is the National Research Council's (NRC) framework or the Next Generation Science Standards (NGSS). The goal is not that different from other science reform measures but it formalizes and emphasizes the practices that scientists use to solve problems. What has been lacking in science education is the struggle of doing science; the process of how we come to know and why we believe we know have been marginalized (Duschl & Bybee, 2014). Instead it calls for a 5-D framework of component elements or a suite of practices that include: deciding on what and how to measure, observe, and sample; developing or selecting tools and procedures to measure and collect data; documenting and systematically recording results and observations; devising representations for structuring data and patterns of observation; determining if the data is valid and reliable, if new data is required, or a new investigative design or set of measurements is needed (Duschl & Bybee, 2014). The focus is on practicing and learning science as scientists do.

Promoting STEM Learning

How to increase student interest in STEM is a question that certainly requires attention (Christidou, 2011; Logan & Skamp, 2012; Maltese & Tai, 2011; National Science Foundation, 2014; Osborne, Smith, & Collins, 2003). One interesting point is that although the most developed countries spend the most on education, students from developed countries show less interest in science and technology than students from developing countries (Bybee & McCrae, 2011; Ogura, 2009; Potvin & Hasni, 2014). Where, when, and how should this interest be cultivated? According to Krapp and Prenzel (2011), primary school children are interested in all manner of natural phenomena; however, adolescence is the critical phase for the development of science interest since it is a time when students begin to clarify their personal aims and ambitions. In investigating the roots of interest in science from children to Nobel Prize winners, Bulunuz & Jarrett's (2015) have found that interest in science develops at a young age through playful learning experiences and investigating phenomena. Hall, Dickerson, Batts, Kauffmann, and Bosse (2011) in their survey of first-year and senior college engineering students found that for both groups close to half of the respondents reported that the decision to consider a major was made in high school. Maltese and Tai (2010), in their interviews with scientists and science graduate students, found that a high percentage reported being interested in science prior to entering high school or even middle school. Potvin & Hasni (2014) in their review of 12 years of research on student interest, motivation, and attitude regarding science education found that interest is a key factor in making career decisions (Potvin & Hasni, 2014). Although many factors play a role in influencing students' career choices, students need to have the knowledge about these careers and their attributes in order to determine if they are personally interested in a science-related field (Basl, 2011; Hall, et al., 2011).

The first step to increasing the number of students entering STEM fields is to provide students' awareness of those careers (Basl, 2011). Basl (2011) used linear regression modeling and structural equation modeling to analyze the 2006 PISA data for the Czech Republic, Finland, Germany, and Norway to look at the influences that impact student interest in future science education or science as a career. The analysis indicated that the most important influence on student interest in science as a career was the level of awareness of science-related career opportunities (Basl, 2011). A surprising result that was also uncovered was that the influence of the school on future science-related careers was greater than the influence of parents (Basl, 2011). Hall and colleagues (2011) found that the two primary influences on student career decisions are parents and school personnel but they were found to have a limited knowledge of STEM careers especially regarding engineering and information technology. Ohland, Sheppard, Lichtenstein, Eris, Chachra and Layton (2008) in their review of databases of nine institutions of higher learning and a sample of over 300,000 first-time students found that 93% of students enrolled in engineering after 8 semesters entered college with this major. For other college major disciplines 35% to 59% of students enrolled after 8 semesters in the chosen discipline had entered college with this major. In addition, engineering had a high persistence rate of 57% in comparison to other majors (Ohland et al., 2008). Lichtenberger and George-Jackson (2013) investigated the factors that impact the likelihood of students entering STEM fields using data from the American Collegiate Testing (ACT). The data included ACT test scores and a survey called the ACT Student Interest Inventory. Data for all juniors in the state of Illinois, class of 2003, representing a sample size of 27,935 was analyzed. The results indicate that more high school sciences courses taken equated to a greater likelihood of an early STEM interest and those with higher degree aspirations were much more likely to be interested in STEM (Lichtenberger & George-Jackson, 2013). These findings suggest that introduction to these fields at the secondary level is paramount if students are going to enter STEM fields (Hall et al., 2011; Lichtenberger & George-Jackson, 2013; Ohland et al., 2008).

Investments in STEM education have not yielded the expected results. In international comparisons, students in the U.S. continue to fall below the top-performing countries as evidenced by the 2012 PISA results where the U.S. ranked 32 out of the 65 participating countries in science (OECD, 2016). The U.S. also confers the lowest number of engineering degrees compared to other top-performing countries such as China, Taiwan, and Finland (National Science Foundation, 2014). Mahoney (2010) in evaluating a new instrument designed to measure student attitudes toward STEM compared a STEM-based high school to a traditional college preparatory school. A STEM school is one that uses an interdisciplinary or integrated approach to teaching and learning science, technology, engineering and math by focusing on authentic real-world problems and ways to solve them whereas the more traditional college preparatory school treats core subjects separately from one another (Brown et al., 2011; Tsupros, Kohler, & Hallinen, 2009). From the results it was discovered that students attending a STEM-based high school did not exhibit a statistically significant more positive attitude toward STEM than students attending a college-preparatory school (Mahoney, 2010). Other approaches include the short-term immersion programs either in schools or in summer programs. In a summer program at the University of California, 20 Upward Bound minority middle school students' perceptions of science education were measured after students participated in four experiential science learning activities. Pre and post data were collected through written responses, observations, interviews, debriefings and questionnaires. The results indicated that while these experiences were successful in "catching" student interest there was inconclusive evidence to determine if interest was held long term (Jelinek, 1998). However, improving efforts to "catch" student interest in science is essential to motivating students to learn science (Jelinek, 1998).

Azevedo (2015), in his research in long term and short term science programs and activities, noted that sustained engaged participation in science depended upon the environment's ability to provide conditions that enabled individuals to continuously and radically tailor activities to their emergent and long-standing interests. What might appear as off-task activities were in fact the result of an individual branching off into multiple pursuits because of his emerging interest (Azevedo, 2015; Sansone, Thoman, & Fraughton, 2015). Long-term and short-term settings have distinct features and operate under different mandates and schedules so that each affords a different form of interest-driven pursuit; however, all this data taken together create a "thick picture" of what it means to be interested (Azevedo, 2015). Individuals in responding to the need to learn may look from the outside as detouring from the task at hand or in the performance of the task but in reality what is occurring is the process of developing, sustaining, and supporting an emerging interest (Azevedo, 2015; Sansone, et al., 2015).

Flexibility, supportive scaffolding, and offering novelty and relevance to illuminate the connections among ideas is essential if the classroom is going to be an environment that supports interest (Turner et al., 2015). In a 3-year longitudinal study of middle school math and science teachers, it was this type of classroom that students reported increased their interest in the subject over the course of the three years demonstrating that triggering interest is about making connections and showing the relevance of the subject to students (Turner et al., 2015). Taking these same ideas of demonstrated relevancy, novelty, and flexibility and building it into an opportunity to explore STEM careers of personal interest may be a step in the right direction to increasing student interest in STEM-related careers (Archer, DeWitt, & Dillon, 2014; Ting, Leung, Stewart, Smith, Roberts, & Dees, 2012). While most agree that these programs are successful at broadening student views of where science can lead, the impact they have on producing future scientists is still unknown (Archer et al., 2014; Blustein et al., 2013; Ting et al., 2012).

One of the largest STEM programs is Project Lead the Way (PLTW). Founded in 1997 this non-profit organization offers programs in the 50 states and Washington, DC. It offers five distinct programs in 8,000 schools for levels K-12. The approach is to create a seamless K-12 science education that focuses on using problem-based activities, projects, and experiences (PLTW, 2016). High schools that participate in PLTW offer students elective courses focused on principles of engineering. Students elect to participate in PLTW courses as long as they meet the mathematics requirements and the course has available slots. The results of PLTW, according to Tai (2012), in his analysis of over 30 research studies and reports on PLTW, indicate that the program has a positive influence on math and science achievement, positive influence on students' career interests and likelihood of continued education, and interest and motivation in STEM in middle and high schools play a significant role in students' future career choices. Implementing math and science throughout the K-12 curriculum and applying this information as scientists and engineers do to solve real-world problems is the current approach to developing the STEM workforce needed for the United States to retain its position as the global leader in research and development (Tai, 2012; Duschl & Bybee, 2014). Investing in STEM education is investing in the sustainment of the U.S. economy. The current and future need for individuals in STEM-related fields is a wake-up call similar to Sputnik, but this time the stakes are not just scientific dominance but economic survival (Maltese & Tai, 2011; Osborne, Smith, & Collins, 2003). If the United States is going to continue to be successful in the global economy, STEM has to be a priority. According to projections from the U.S. government, 1 million additional STEM graduates will be needed by 2022 to meet the projected workforce (Handelsman & Smith, 2016). It is expected there will be 2.4 million job vacancies for STEM workers between 2008 and 2018 for both new and replacement positions (Carnevale et al., 2011). Over the past 10 years, growth in STEM jobs is 3 times as fast as in non-STEM positions with a growth rate of 17.0% for 2008-2018 compared to 9.8% for non-STEM occupations (Langdon et al., 2011). Xue and Larson (2015) in their comprehensive study examining the controversy over whether there is truly a STEM crisis concluded that shortages and surpluses do exist in certain STEM job segments. However, Xue and Larson (2015) stated that as the U.S. relies further on technology for economic development and prosperity, the vitality of the STEM workforce will continue to be a concern. The implementation of more STEM career programs and interventions, and their integration into science lessons and classrooms, may go far to creating the much needed next generation of STEM professionals (Archer et al., 2014; Blustein et al., 2013; Ting et al., 2012).

Research Questions

The formulation of the study's research questions began by first identifying interest as an important motivational variable in student learning (Hidi, 2006; Hidi & Renninger, 2006; Krapp, 2002, 2005; Schiefele et al., 1983). As John Dewey (1913) clearly identified interest operates through a process of "catching" the attention or interest of an individual and then "holding" or maintaining that interest through active participation in engaging and meaningful activities. POI and the 4-Phase Model of Interest Development were designed as tools for education and build off of Dewey's idea by further describing this process as a relationship between an individual and a specific object or domain that can progress from one of curiosity into a highly developed individual interest. How to move learners to this developed state is an area that still requires further investigation (Hasni & Potvin, 2015; Hidi & Renninger, 2006; Rotgans & Schmidt, 2009). For educators it is important to create an engaging classroom environment that can spark, support and maintain interest but in order to do so it is important to understand students' areas and context of interest in science learning, as well as, their preferred methods of instruction (Hidi & Harackiewicz, 2000; Osborne & Collins, 2001; Raved & Assaraf, 2010; Valente, Fonesca, & Conboy, 2011).

Phase I of this study explored the perceptions of students and teachers regarding student interest in learning science. The findings of researchers analyzing and examining the data from the PISA 2006 student questionnaire provided insights into how the relationships of important variables such as interest and enjoyment work to foster future interest in learning science (Ainley & Ainley, 2011a; Ainley & Ainley, 2011b; Lin et al., 2012). Further examination into the patterns and relationships identified in this research and their applicability to other countries can inform those educators about how to increase student engagement in science as culture and science education itself can be very different from country to country (Ainley & Ainley, 2011a; Lin et al., 2012). The PISA 2006 Student Questionnaire was used as one of the vehicles for the collection of student data because it is a validated instrument designed by an international consortium of science educators and captures the student perspective on the learning of science by measuring such variables as interest in science, enjoyment of science, science self-concept and motivation to learn science. The instrument's theoretical framework is grounded in the concepts of POI and the 4-phase model (OECD, 2007; Krapp & Prenzel, 2011). In addition it provided a way to collect information on the methods of teaching and learning that occur in the classroom which impact how students perceive the learning of science as well as future interest in science. If more students are to enter STEM fields then interest in learning science is essential.

How science is taught may in fact be the reason why students choose not to pursue science (Duschl, 2008; Duschl & Bybee, 2014; Hofstein, Eilks, & Bybee, 2010; Rustum, 1990; Potvin & Hasni, 2014). Students and educators have their own perceptions about how to make the classroom more engaging and conducive to learning science. Identifying the instructional methods and strategies is one of the first steps to increasing student interest in learning science. As many researchers have noted, creating situational interest in the classroom is the first step in the process leading to the development of the more enduring individual or personal interest (Dohn, 2013; Hidi & Harackiewicz, 2000; Hidi & Renninger, 2006; Rotgans & Schmidt, 2011; Skamp & Logan, 2013).

The PISA survey also measures student awareness of STEM careers. If students are to pursue these careers they must first know about the requirements and variety of opportunities available (Basl, 2011; Hall et al., 2011). Phase II of the study was the implementation of the

STEM career intervention. The intervention capitalized on two important aspects in the development of interest, the opportunity to gain new knowledge and personal relevancy (Durik et al., 2015; Hulleman & Harackiewicz, 2009; Maltese & Tai, 2011; Renninger & Hidi, 2002). In the first iteration the researcher-teacher's students researched STEM careers in which they had an interest and explored the specific requirements of these careers. Students created an electronic slideshow of their information and presented one of their careers to the class. Data collection was done through student reflections of the project and a Post-STEM career survey. The researcher used this information to make improvements and modifications to the intervention for the second implementation. The second iteration was completed by three 10th-grade science teachers teaching different academic levels of chemistry. Teacher feedback was used to make further modifications to the intervention and provided a means of assessing the ability of the STEM Career Project to influence students' interest in learning or pursuing science. As growth in STEM careers far outpaces other fields, it is important for students to be aware of the possibilities of a science-related careers (Bureau of Labor Statistics, 2016; Carnevale et al., 2011; Langdon et al., 2011).

In a society with an ever-growing dependency on science and technology it is important to prepare all students with a degree of scientific literacy to understand the world around them. Exploring how to create a more engaging environment by conducting a needs assessment using survey data and the individual information of students and teachers collected through interviews provided a more holistic picture and greater depth of information regarding individuals' experiences in the learning and teaching of science. Through this sequential action research process of exploration and intervention it was possible to make effective improvements in the local condition and my own praxis in order to promote and increase student interest in learning science.

The overarching question: Do theories about interest apply to the learning of science and pursuit of STEM careers in a suburban high school?

The subsumed questions:

Phase I:

1. What are 10th-grade high school students' perceptions of their interest in learning science and pursuing a STEM career? (Quantitative and Qualitative)
2. What are 10th-grade high school science teachers' perceptions of their students' interest in learning science and pursuing a STEM career? (Qualitative)

Phase II:

3. Does the intervention of a STEM Career Project influence student interest in learning science and pursuing a STEM career? (Quantitative and Qualitative)

Summary

How to develop interest in learning science is a complex problem that requires further investigation into the factors or variables that influence its development, the classroom strategies and instructional practices that trigger and sustain it, an understanding of how emerging interests develop and shift to become more self-generating, and how to identify the stages or phases of interest in order to identify individual needs. POI and the 4-phase model of interest development were used as the basis for understanding how the relationship between students and their interest in learning science develops. In addition identifying effective strategies that create a classroom environment that encourages this development can help to increase the number of students that pursue both the learning of science and pursue a science-related career. Since effective change can only be accomplished by first uncovering the current level of student interest at the site, a needs assessment was necessary. This information was gathered through the PISA student questionnaire and led to the discovery that although students are interested in science and value science as important to society, students do not have the level of personal connection to science that would perhaps lead them to consider pursuing science or a STEM-related career.

The problem of students not pursuing science has been well defined, identified, and debated for nearly 60 years. If the United States is going to create the STEM workforce it needs in order to maintain its economic and technological dominance then how science education is delivered needs to change. Research clearly identifies relevancy to everyday life and societal problems as key areas of focus to create a more interesting science learning experience. Interest in science must be triggered if it is to ever exist. Learning science must begin at an early age where exploration and play can plant the seeds for future interest in learning science and in pursuing science as a career. Learning science can be fun, rewarding, and challenging if presented and experienced in the right way. All students, not just future scientists, deserve a science education that prepares them for the challenges of living in a world of ever-evolving science and technology.

CHAPTER III: METHODOLOGY

The purpose of this research study was to investigate student interest in learning science and pursuing STEM careers in order to make effective changes at the local level through the implementation of a STEM Career Project that focused on creating student awareness of science-related careers. The research questions that guided the study provided the framework that led to the choice of methods used to collect this data.

Research Questions

The overarching research question for the study: Do theories about interest apply to the learning of science and pursuit of STEM careers in a suburban high school?

The subsumed questions:

Phase I:

1. What are 10th-grade high school students' perceptions of their interest in learning science and pursuing a STEM career? (Quantitative and Qualitative)
2. What are 10th-grade high school teachers' perceptions of their students' interest in learning science and pursuing a STEM career? (Qualitative)

Phase II:

3. Does the intervention of a STEM Career Project influence student interest in learning science and pursuing a STEM career? (Quantitative and Qualitative)

Research Design

Action research is a form of inquiry that enables educators to explore, understand, and reflect upon their environment and praxis in order to improve teaching and learning in the classroom. It is research by practitioners for practitioners that can provide valuable insights into how to improve the quality of education locally. In this climate of accountability, action research provides a method of self-monitoring as means of justifying practices and as a workable approach to improvement through action and self-reflection (Carr & Kemmis, 1983). This form of research provides a way to critically assess the local condition, create a an action plan to address the situation, evaluate the plan's effectiveness, reflect upon the outcome, and repeat the cycle in order to develop effective measures that improve the learning environment and teacher praxis.

This action research study sought to understand how to increase student interest in learning science. It was designed to describe how certain instructional and associated learning strategies support the development of students' situational interest. The study was conducted from the perspectives of 10th-grade science students and 10th-grade science teachers at one suburban high school. The research design used a sequential multiphase approach (see Figure 3, p. 66). Phase I took an exploratory approach to ascertain students' perceptions about learning science and choosing a science-related career through a Student Science Survey. Interviews with eleven 10th-grade students in different course levels and eight 10th-grade science teachers were conducted to further understand the perceptions of student interest in learning science at the site. Phase I began with the administration of the Student Science Survey using selected questions from the PISA 2006 Student Questionnaire. The PISA questionnaire was selected as the vehicle for data collection because it was designed to specifically address students aged 15-to-16 years of age corresponding to U.S. 10th-grade high school students. The questionnaire uses the interest construct as defined in both POI and the 4-phase model of interest development as the specific relationship between an individual and the domain of interest which in this case is science. The questionnaire was created by an international consortium of educational experts and has been validated and field tested. The quantitative data collected from the survey helped in the development of the interview questions for both participant groups by enabling the researcher to probe deeper into understanding the condition of student interest in learning or pursuing science at this site (Creswell & Plano-Clark, 2011; Collins, 2010; Onwuegbuzie & Collins, 2007; Teddlie & Tashakkori, 2009). Student interview questions delved further into students' learning experiences by uncovering information about 1) the types of teaching and learning that they find increase their interest in science, 2) their favorite science teacher, 3) their ideas for increasing interest in science learning, 4) their views on science, and 5) their views on science as a potential career. Teacher interviews addressed the current teaching and learning that occurs in the classroom, how teachers can increase student interest in learning science, and how to encourage students to enter STEM fields. Phase I served as a needs assessment in order to identify the current situation of teaching and learning in the classroom at the site in order to make effective changes that increase student interest in learning science and pursuing science as a career. Data collected in Phase I and from the pilot study indicated that students are not informed about science-related careers and are unaware of the variety and possibilities that these careers can offer. The STEM Career Project intervention was created to provide students the opportunity to explore STEM careers. Phase II used action research to test the effectiveness of this specifically designed STEM Career Project to determine its success in influencing students' interests in pursuing science. Phase II was completed in two iterations. The first iteration was implemented by the researcher with four 10th-grade chemistry classes. The second iteration was carried out by three 10th-grade science teachers teaching different academic levels of chemistry. Data sources used in the first iteration were student reflections, a post-STEM Career Project survey, and project evaluation using a specifically formulated rubric. This information, as well as, the teacher/researcher reflection was used to make improvements and modifications to the project for the next action research cycle, Iteration 2. The teachers' experiences with the project were documented through interviews and their insights and recommendations will be used to further refine the STEM Career Project. The second iteration created multiple cases of the intervention providing evidence to support the ability of the project to influence student interest in pursuing a STEM career and feedback for further procedural refinements. Using multiple cases also served to increase the validity and credibility of the intervention (Yin, 2014).

Person-object interest theory (POI) and Hidi and Renninger's 4-phase model served to define the construct of interest, phases of interest, and as a contextual guide to provide a broad explanation of student interest in science. In addition it served as a model to interpret and examine the factors that affect the development of student interest for this case study. Theory provides a blueprint for the research design and guides the decisions in determining the data collected and the strategies for analysis (Creswell & Plano-Clark, 2011; Yin, 2014). Interest is the development of a relationship with a specific object, activity or domain of learning that engages an individual cognitively and affectively driving the individual to continuously reengage with the object, activity, or in this research, science learning (Dewey, 1913; Krapp, 2002, 2005; Hidi & Renninger, 2006; Schiefele et al., 1983; Silvia, 2005, 2008). How interest develops within each individual is deeply personal and is impacted by both internal (individual interest) and external factors (situational interest) (Hidi et al., 2004; Hidi & Renninger, 2006; Krapp, 2002; Renninger & Hidi, 2002). In order to create a learning experience that can work to cultivate the relationship between students and their learning and pursuing of science, it was necessary to capture student perceptions and the perceptions of their teachers as both play roles in developing the components of situational and individual interest (Hidi & Renninger, 2006; Turner, Kackar-Cam, & Trucano, 2015). The survey provided an overall snapshot of student interest in learning and pursuing science but the student and teacher interviews provided a deeper and more descriptive layer of knowledge concerning how to improve and increase interest in order to create a more enduring relationship between students and their interest in learning science. The STEM Career intervention was guided by the principles of POI and the 4-phase model of interest development that state interest develops through the acquisition of new knowledge that is personally relevant (Durik, Hulleman, & Harackiewicz, 2015; Hidi & Renninger, 2006; Hulleman & Harackiewicz, 2009; Krapp, 2005; Schiefele et al., 1983). In this project students explored STEM careers that were of interest to them thereby acquiring new knowledge that is personally relevant.

In order to institute effective change, understanding of the current situation was necessary. This case study provided a depth of understanding of student interest in science in order to create a classroom environment that stimulates situational interest and is specific to the local conditions. The design of the study incorporated two phases and several methods for the purpose of providing a depth of knowledge and information regarding how to make learning science more interesting for students. Using a multi-step design provided a stronger array of evidence than could be accomplished by a single method alone and afforded a better opportunity to assess the "goodness" of the data (Teddlie & Tashakkori, 2009; Yin, 2014). This research provided specific and applicable information from which to draw conclusions and institute effective local improvements. It also provided information for the improvement of teacher praxis. The rationale for using multiple forms of quantitative and qualitative data was to provide significant enhancement in order to maximize the interpretation of the findings (Leech & Onwuegbuzie, 2007, 2010).

Research Design

Phase I: Exploratory	**Data Collection**	**Data Source**
Quantitative Data Collection	Implementation of Student Science Survey (N=270)	Validated and tested instrument. Excerpted from PISA 2006 Student Science Questionnaire. Specific for Grade 10 students.
Quantitative Data Analysis	Descriptive Statistics	Demographic data. Interest Data. Provides information for question development of qualitative strand and development of instructional intervention.
Case Selection (Students)	Nested sample from larger convenience sample of Grade 10 students. Development of semi-structured interview questions.	Cases (N=11)
Case Selection (Teachers)	Convenience and purposeful sample of Grade 10 teachers.	Cases (N=8)
Qualitative Data Collection	Individual in-depth one-on-one interviews. Interviews are audiotaped and transcribed.	Text data from transcriptions.
Qualitative Data Analysis	Coding for themes. Cross case analysis.	Codes and themes. Cross case thematic matrix.
Phase II: Action Research-Iteration 1		
Qualitative and Quantitative Data Collection Instructional Intervention-Implementation of STEM Career Project as a method to create classroom situational interest.	Convenience and purposeful selection. Researcher's students (sample from larger Grade 10 student population). (N=76)	STEM Career Project. Student reflections of project. Student data from post-STEM survey. Researcher reflection.
Qualitative Data Analysis	Coding for themes.	Codes and themes to identify influence of instructional learning strategy (situational interest) on student interest in learning or pursuing science.
Iteration 2: Action Research		
STEM Career Project 2nd Cycle. Intervention implemented by three 10th Grade teachers.	Student reflections and post-STEM surveys. Teacher A (N=63); Teacher B (N=88); Teacher C (N=36).	Feedback from teachers addressed implementation and influence of intervention on student interest in learning or pursuing science.

Figure 3. An overview of the study design including Phases I and II, data collection/measures, and data sources.

Procedures

Role of the researcher. The role of the researcher in this study was both emic and etic. In Phase I, the exploratory phase, the researcher takes an etic stance with regard to the Student Science Survey and an emic role while co-constructing knowledge with the perceptions of the students and teachers as a result of analyzing the interviews. Being a colleague of the teacher interviewees provided an insider perspective, and because of the relationships, helped to elicit honest and candid answers during the interviews. It can also introduce bias due to familiarity thereby impacting the etic nature in interpreting data. These relationships which provided entry to the research site also created ethical issues which were addressed and acknowledged as part of the researcher's role (Creswell, 2009). "In qualitative studies, the researcher is the instrument of the research and the research relationships are the means by which the research gets done" (Maxwell, 2012, p. 91). In Phase II action research, the duality of the emic and etic stances also existed. In Iteration 1, the emic relationships between the researcher-teacher and students needed to be acknowledged since they can influence the data interpretations of the data where the researcher strives to maintain the etic perspective. Again, in Iteration 2 of the action research phase, the researcher must be honest in identifying herself as a faculty member and colleague of the teacher participant group.

An important component of any research investigation is the knowledge and background of the researcher. As a former scientist and current science teacher, my own personal experiences have shaped my viewpoint and provided the impetus for the study (see Table 1, p. 68). I have constructed my own lens through which I observe the world and therefore can inject assumptions into the research as a result of my actions and experiences (Crotty, 1998). Trained in the positivist or post-positivist mindset and maintaining a degree of objectivity by following consistent procedural protocols helps to increase credibility and validity. From my experience as a science teacher, the pragmatic approach to finding a "what works" solution by taking action is what creates a learning environment that accommodates different perspectives. Knowledge and understanding are created from the perceptions of many groups and are necessary in order to take effective action to improve the local condition; however, even then there still remains an underlying mechanism that might never be uncovered. Finding a workable solution starts with understanding the phenomenon in order to formulate an effective action plan. No singular philosophy can adequately address the knowledge, values, or beliefs of the researcher; "each of these selves comes into play in the research setting and consequently has a distinctive voice" (Guba & Lincoln, 2005, p. 210). Having intimate knowledge of the site provided another level of understanding and level of trust that provided participants an environment in which to be honest and forthcoming.

Table 1

Researcher's Worldview Matrix

Researcher's Worldview	**Postpositivism**	**Constructivism**	**Pragmatism**
Ontology : Reality or what exists.	There is an absolute reality that can be best defined through scientific means and empirical evidence.	Each individual creates their own reality through the knowledge they acquire and their experiences interacting in the world.	Each stakeholder's unique perspective has been shaped by their experiences, knowledge and actions. Biesta (2010) refers to it as a "theory of knowing" or a "theory of experimental learning" because knowledge can only be obtained through action.
Epistemology: How knowledge is constructed.	Knowledge is constructed by proving or disproving theories. There exists an absolute truth. Phase I: Survey is administered to a larger sample and participant identity is unknown.	Knowledge is co-created by the perceptions of many. Phase I: Exploration of student interest in learning science through student and teacher interviews to foster greater understanding of the local conditions.	Knowledge is created through doing. It is defined by what works in the situation at that moment in time. Phase I: Triangulation of data strands to corroborate information and provide a more detailed and descriptive understanding of learning strategies that increase situational interest in learning science in order to construct an effective intervention.

Researcher's Worldview	Postpositivism	Constructivism	Pragmatism
Axiology: Values and their role in research.	Researcher remains objective and maintains an etic view. Value-free or despite being an insider at the site, as both teacher and colleague. Phase I: Survey is anonymous to prevent bias. (Academic and scientific training of researcher.)	Researcher is emic and etic. Researcher works closely with participants and therefore must acknowledge this role and its influence in the research process. Values and perspectives of researcher and participants influence all aspects of research in Phase I and Phase II.	Researcher is emic and etic seeking to improve local conditions. Researcher implements actions to produce an outcome. Phase II Action Research: Understanding gained from Phase I has helped to create the intervention and the actions required for Phase II. Practice generated in Iteration 1 is reflected upon in order to improve actions in Iteration 2. Etic perspective is maintained through use of evaluative rubric and post-STEM survey. Emic perspective evident in coding of student reflections and researcher/student interactions. Iteration 2, researcher-teacher's emic relationships but researcher maintains overall etic perspective.
Methodology: The processes used in research.	Scientific method. Quantitative methods. Phase I: Student Science Survey administered to 10th-grade student population. Information from descriptive statistics to further inform Phase I and Phase II.	Qualitative methods to create theory that is grounded in the data. Analysis uncovers themes, patterns and rich description of the phenomenon. Phase I: Exploration or needs assessment of student interest in learning science. Descriptive statistics data used to corroborate qualitative strands.	Multiple methods approach to find the best possible solution to the problem. Phase II: STEM Career intervention uses action research, and a reiterative process to measure the outcome of the actions.

Bounding the Case. The focus of this action research study was to understand how to increase student interest in learning science and pursuing STEM careers by 1) ascertaining student and teacher perceptions of student interest in learning science, 2) determining theory-embedded strategies to increase student interest in learning science, and 3) implementing an intervention to test its effectiveness in increasing student interest in pursuing science. The site of the study was the science department at a large suburban high school with a total student population of approximately 2,800 students in grades nine through twelve. The sequencing of science courses, for the majority of students in this school, ensures that most 10th-grade students are enrolled in one of three levels of chemistry: practical, regular and honors. The school also has one class of ESL Chemistry for non-native English speakers which is comprised of all grades. There is also a small portion of students who are enrolled in 10th-grade biology as a result of an alternative sequence offering.

The student participants in this study were 10th-grade science students. The number of students in the 10th-grade class was approximately 600 students. The eight teacher participants were 10th-grade science teachers teaching different levels of chemistry and biology at the site. These teachers were selected because they teach at least two classes of 10th-grade students. The years of teaching experience range from the most novice at six years to the most experienced with 40 years of teaching science. The research specifically targeted 10th-grade students because the researcher is a 10th-grade science teacher at the site. The action research approach enabled the researcher to reflect upon her praxis and improve upon her teaching. The timeframe for the study was approximately 11 months for the collection of all data sources.

Phase I of the study began with an invitation to the entire 10th-grade student population (approximately 600 students) to participate in an anonymous Student Science Survey. The survey used excerpted sections from the PISA 2006 Student Questionnaire that focused on interest in science, enjoyment of science, science self-concept, methods of teaching and learning, and science-related careers. The PISA 2006 Student Questionnaire is a validated instrument designed by a consortium of international science educators and targets student 15-to-16 years of age, the age of 10th-grade students (OECD, 2006, 2009). The reason for the anonymity of the respondents was due to district restrictions regarding data that is considered personably identifiable information. The survey was created using Google forms because the research site uses Google as its software platform. Using the site's platform provided easy access for the students volunteering to participate in the survey and helped to maintain confidentiality by keeping the survey within the site's network. After administration of the survey, interviews with a selected sample of eleven 10th-grade students who had completed the survey were conducted. Students who had completed the survey and were taking different academic levels of 10th-grade science were selected in order to capture a range of perspectives representative of the grade. Interviews with eight 10th-grade science teachers completed the data collection for Phase I.

In Phase II of the study, the first iteration of the STEM Career Project was completed by the researcher with seventy-six 10th-grade students. The STEM Career Project was a student-directed intervention that enabled students to explore and investigate STEM careers that they would be interested in pursuing. Students created an electronic slideshow presenting information about the career that included educational requirements or training, job responsibilities and daily activities, companies that employ the career, and projected growth for the career and salary range. Students shared one of these careers in an oral presentation in their science class. To measure the effectiveness of the intervention on student learning of science and pursuit of a STEM career, student reflections and a post-project survey were used. At the end of the first iteration, the researcher's reflections were used to improve and refine the intervention. In the second iteration, feedback from interviews with the teachers administering the second cycle of the STEM Career Project was used to make further refinements to the project in order to produce a final intervention package that can be used by science teachers in other schools and districts similar to the one in which the study was conducted. The results of the study are not generalizable outside of the district in which it was conducted because of the unique characteristics of the site and the small sample size. The intervention itself could be implemented in other districts; however, the results may be different.

The sampling for this study was purposeful because it focuses on 10th-grade students and 10th-grade science teachers. These teachers have direct contact with the students in the study and are teaching colleagues with whom I have an established productive relationship (Maxwell, 2012). As I am a science faculty member at the site and a teacher of the 10th-grade student population, these samples are also convenience samples.

Research study Phase I. Many large-scale studies summarize results as generalizable to the population but, as evidenced by varying differences among states in the PISA 2012 data, generalizability may not be representative of smaller populations such as school districts (National Center for Education Statistics, 2014). For example, in the reporting of PISA 2012 student achievement data, it was possible to disaggregate this data by state and, while the United States average student score of 497, *SE*=3.8 fell below the OECD average of 501, *SE*=0.5, Connecticut's average score was 521, *SE*= 5.7 (National Center for Education Statistics, 2014). This demonstrates that generalizability for a country, state or even district may not be universally applied. In order to obtain a broad understanding and overview of the current condition of student interest in learning science or pursuing science at this specific site, the sequential design began with the administration of excerpted sections from the 2006 PISA Student Science Questionnaire.

Excerpted sections of the PISA Student Questionnaire from 2006 were administered to a large convenience sample of tenth grade students, approximately 600 students. The data collected were analyzed using descriptive statistics in order to provide an overall picture of the perceptions of the 10th-grade student population regarding their views on science, interest in learning science, teaching and learning of science in the classroom, and pursuing a science-related career. These data helped structure the interview questions for the qualitative portion of Phase I of the study by providing a basis from which to create more targeted interview questions. The qualitative data came from interviews with two distinct samples, students and teachers, making it a multilevel design (Onwuegbuzie & Leech, 2007; Teddlie & Tashakkori, 2009). The student sample for this phase represented a nested sample because the smaller sample is a subset of the participants from the larger sample of survey participants (Onwuegbuzie & Collins, 2007; Onwuegbuzie & Leech, 2007).

Triangulation was used to compare the quantitative and qualitative data collected from the student samples and to compare the perspectives of teachers and students to determine if there was convergence, differences, or some combination of the two (Creswell, 2009). Triangulation of perspectives or multiple viewpoints is a key issue for social research and a way to provide a methodological framework to construct meaning (Flick, Garms-Homolova, Herrmann, Kuck, & Rohnsch, 2012; Torrance, 2012). In essence the quantitative data formed the canvas upon which to paint the descriptive narrative details provided by the qualitative data. Both strands support one another in a synergistic relationship that demonstrates equal importance. Put simply, “Rather than mixing because there is something intrinsic or distinctive about quantitative data or qualitative data, we mix so as to integrate the two fundamental ways of thinking about social phenomena” (Fielding, 2012, p. 126).

Data collection.

The choice of PISA. The Programme for International Student Assessment (PISA) is an international comparative educational survey sponsored by the Organization for Economic Co-operation and Development (OECD). The significance of PISA is that it is the primary source for internationally comparative science data of students coming to the end of their compulsory education, 15-to-16 year-old students. It is designed to assess the extent to which students can apply their knowledge to real-world situations. PISA is unique because the test is not directly linked to school curriculum but rather is developed as an international collaboration designed to measure students' mastery of processes and understanding and application of knowledge, not content itself. The test is created by PISA participants and international contractors. These individuals include international experts in the specific assessment domains and technical experts in areas such as sampling, test and questionnaire item development, translation, and statistical analysis (Turner, 2009). The questions are reviewed by participants and contractors and checked for cultural bias. Only unanimously approved questions are used. Field testing is done in all participating countries. PISA was launched in 1997, and in 2000, the first test was administered. Since then, it has been repeated in three-year cycles. The intent of the international comparison is to improve education policies and outcomes. The data have become increasingly useful as a tool to assess the impact of educational quality on incomes and economic growth and to explain differences in achievements across nations (Ainley & Ainley, 2011; Bybee & McCrae, 2011; Krapp & Prenzel, 2011).

In 2006, the PISA science assessment of scientific literacy also included a student questionnaire to collect data on students' attitudes and engagement with science as it relates to: self-belief as science learners; support for scientific inquiry; interest in science; and responsibility toward resources and the environment (OECD, 2006; Ogura, 2009). The questionnaire uses a 4-point Likert response scale to capture data for several indices. Among the items are questions designed to determine student interest in science, enjoyment in learning science, instrumental motivation to learn, future-oriented science motivation, science self-efficacy, science self-concept, and four constructs associated with science learning and teaching. These constructs provided a means of uncovering student perceptions of their learning of science and pursuit of a science-related career answering the research question, “What are 10th-grade high students’ perceptions of their interest in learning science and pursuing a STEM career?” where interest is defined as the relationship between a person, the student, and an object or domain which in this case is science. In addition it provided a way to collect information, from the student perspective, about the instructional strategies that students find support the development and maintenance of interest in the classroom.

The choice of the PISA student questionnaire for data collection was based on the fact that it is a validated instrument developed by experts and targets the specific student sample population in this study 15-to-16-year old students. The validity of the instrument has been well established. In 2006, the test, including the survey, was administered internationally to 400,000 students in 57 countries. The test was administered across a minimum of 150 participating schools within each country with a sample size of at least 4,500 students per country. Participating countries must have the technical expertise necessary to administer this international assessment and must be able to meet the full costs of participation. In order to be eligible, participants must join two years before the survey takes place.

In developing the questionnaire, PISA used an Item Response Theory (IRT) scaling method and a weighted mean-square statistic item fit to calibrate and evaluate items in order to improve measurement accuracy and reliability (OECD, 2009). For each item parameter, 500 students were randomly selected within each of the 57 OECD country samples from which a randomly selected final calibration sample of 15,000 students’ data was used (OECD, 2009). Once the international item parameter was estimated from the calibration sample, a weighted likelihood estimation (WLE) was then used to develop student scores. The WLEs were then transformed into an international metric with an OECD average of zero and standard deviation of one (OECD, 2009). Confirmatory factor analysis (CFA) using the international calibration sample was performed to test the validity of the theoretical model and latent correlations between the constructs (OECD, 2009). Confirmatory factor analysis is used to explain the maximum amount of common variance in a correlation matrix using the smallest number of explanatory constructs or latent variables which represent cluster variables that correlate highly with one another (Field, 2013). The international nature of the test required cross-country validation of the constructs from which an OECD average was generated. For interest in and enjoyment of science the latent correlation was 0.75 at a significance level of $p < .05$ demonstrating a strong relationship between the constructs. In addition, scale reliabilities, which evaluate the degree to which different test items that probe the same construct produce similar results (Field, 2013), were calculated creating an OECD average which resulted in a Cronbach's alpha of 0.83 for interest in science and 0.92 for enjoyment of science learning therefore demonstrating a strong association for the questions addressing those constructs (OECD, 2009). Additionally the OECD average latent correlation between motivation to learn science and future-oriented science motivation was 0.72, with Cronbach alpha scale reliabilities of 0.88 and 0.90 respectively.

For science career preparation and student information on science careers, the OECD latent correlation from CFA was 0.45 showing only a moderate correlation; however, scale reliability data showed a Cronbach alpha of 0.79 and 0.77 (OECD, 2009). For science learning and teaching, the scale reliabilities for the four items measuring the frequency with which students engaged in each type of activity, interaction or interactive teaching and learning in the form of student explanations, discussions or debates, hands-on activities, student investigation, and focus on models or applications, Cronbach alphas were consistent ranging from 0.74 to 0.76 (OECD, 2009). In terms of latent correlations between these variables, the values ranged from 0.55 to 0.74 demonstrating the positive correlations among them with the highest correlation being found between interaction or interactive learning and student investigation, as well as between hands-on activity and student investigation (OECD, 2009).

Pilot study. The final selection of categories and questions from the PISA student science questionnaire was based on a preliminary pilot study of 56 Grade 10 students in June 2015. The pilot was used to identify the questionnaire items that best address the research questions, to determine the appropriate length and time for survey administration, and to identify any logistical problems that might arise in initiating an on-line format. For the pilot, the PISA student science questionnaire was used in its entirety as written and constructed using Google forms software. Students were provided with a link to the survey. The students for the pilot were the researcher's 10th-grade Honors and Regular Chemistry students. Participation was voluntary. The pilot data were collected electronically through the use of Google forms. The results were analyzed through Google forms using descriptive statistics to ascertain the percentage breakdowns of student responses to the questions in order to gather information about student interest in learning science, future interest in learning or pursuing science, and teaching and learning of science.

The results of the pilot study indicated that the number of questions needed to be streamlined in order to shorten the time of survey completion and to narrow the focus to the information required to answer the research questions. The electronic format was found to be easily accessible by respondents. It also provided ready access to data collection, viewing, and analysis for the researcher. The information required to answer the research questions was identified in the sections: your views on science which included questions pertaining to interest in learning science, enjoyment of science, science self-efficacy, general value and personal value of science, and sources from which students learn science; careers and science which included questions about science career preparation, science career information, and future motivation to learn science; learning time which compared time spent studying science compared with other academic subjects; and teaching and learning science which asks students to indicate how much classroom time is spent on specific learning activities, and also asks questions pertaining to motivation to learn science, and science self-concept.

Quantitative data collection. The questions designed to measure: student interest in science; enjoyment in learning science; instrumental motivation to learn; future-oriented science motivation; science self-efficacy; science self-concept; and four constructs associated with science learning and teaching, were excerpted from the PISA student questionnaire and used as the basis of the quantitative data collection instrument for the study. The questions were excerpted in their entirety by category from the 2006 PISA student science questionnaire. The categories are: Your Views on Science, Careers and Science, Learning Time, and Teaching and Learning Science. Permission to use the questionnaire was granted by the OECD (see Appendix A).

The Student Science Survey (see Appendix B) being used in the research was created using Google Forms so that data could be collected on-line. The survey was anonymous in order to comply with the site's district guidelines so no personally identifiable information is associated with any student participant (see Appendix C). A parent letter (see Appendix D) describing the research study and the information being collected was emailed to all parents of 10th-grade students at the site. It included a link to the survey and the on-line opt-out form for parents who did not want their child to participate (see Appendix E). Opt-out data was electronically recorded. The parent window for opting out was two weeks. After the two week timeline, all 10th-grade students at the site were emailed a link to the on-line survey. Assent was documented through the survey. The data was collected electronically and stored on a computer in a password protected format that is only accessible to the researcher.

Qualitative data collection. The qualitative data for Phase I are from audiotaped interviews with two categories of participants, 10th-grade students and 10th-grade teachers. The multilevel sampling design related two units or levels of analysis, students and teachers, to provide a more comprehensive understanding of the site (Creswell, 2009; Leech & Onwuegbuzie, 2010; Teddlie & Tashakkori, 2009). The student interview questions were designed specifically to address the question of student interest in science and the factors or experiences that have influenced the student's interest in science including aspects of learning science that are interesting, classroom situations that are interesting, how a science classroom should be conducted to be interesting, and a narrative about their favorite science teacher. These data provided additional detailed information on the student perspective of interest in learning science. In order to address student interest or knowledge of science careers, the two main interview questions focused on whether or not the student would consider a career in a STEM field and the reasons behind this decision, and how the student views STEM individuals and what they do in their jobs. These data helped to answer the research question, *What are 10th-grade high school students' perceptions of their interest in learning science and pursuing a STEM career?* Capturing the experiences and stories of these individuals provided a deeper level of understanding (Creswell, 2009; Creswell & Plano-Clark, 2011; Maxwell, 2012; Teddlie & Tashakkori, 2009). Student interview questions were piloted with two 11th-grade students to check for clarity of understanding and as a discussion format to uncover any other questions that would be relevant to obtaining the necessary information to answer the research questions.

The purpose of the interviews was to explore individual student perspectives in order to provide more detailed information about student interest in learning science. Interest in this study was defined by POI and Hidi and Renninger's four phase model of interest development: interest is the relationship between the individual and the object of interest, science. Uncovering how each individual student participant's relationship with science develops from their views on science to their experiences in the classroom sheds light on how to create an environment in which this relationship can thrive. Developing situational interest in the classroom can stimulate, support, maintain, and further cultivate this relationship so that it develops into the more internalized and enduring personal interest. The 28 interview questions were a mixture of semi-structured and open-ended questions addressing interest in learning science, views on the types of science teaching that make science interesting, views on teaching methods that maintain, support and increase student interest in learning science, and STEM careers (see Appendix F). The development of the interview questions was driven by the information elicited from the pilot study and survey data and were based on constructs demonstrated in the literature as indictors of interest (Hidi & Harackawicz, 2000; Hidi & Renninger, 2006; Hidi et al, 2004; Krapp 2002, 2005; Schiefele et al., 1983; Silvia, 2005, 2008). These constructs included interest as it relates to learning about and engaging in science, enjoyment of science, value of science, and future motivation to engage or pursue science. Parental permission and student assent for student interviewees was obtained and documented (see Appendix G).

Teacher interview questions were designed to capture the teacher perspective on student interest in learning science as seen in the classroom. Written consent for the interviews was obtained and documented (see Appendix H). The eight semi-structured interview questions addressed teacher perceptions of student interest in learning science, the instructional and teaching practices they use in supporting student interest in learning science, changes they would implement to increase student interest in learning science, and why students are not pursuing STEM careers (see Appendix I). Teacher questions focused on their understanding of: level of student interest in learning science and key indicators of interest; teaching approaches and strategies that stimulate interest and indicators used to assess the effectiveness; implemented changes to increase student interest in learning science; and what high school teachers can do to encourage students to pursue STEM careers. These questions were intended to provide insights into the science teaching classroom at the site and the impact that it has on stimulating, maintaining, and supporting student interest in learning science. The interview questions were driven by constructs in the literature and data collected from the initial pilot study. Interest is characterized by engagement and the willingness to continue to engage in a subject such as science (Krapp, 2002, 2005; Schiefele et al., 1983). However for interest to thrive it must be supported in an environment that demonstrates the importance of science and helps students to make a more personal connection to their learning of science (Hidi & Renninger, 2006).

Overall, questions included in the interviews with teachers were meant to reveal teachers' perceptions about student interest in science and were formulated on the principle that situational interest created in the classroom can trigger, support and increase interest thereby moving a learner through the phases of interest development (Hidi & Harackiewicz, 2000; Hidi & Renninger, 2006; Krapp, 2002, 2005; Mitchell, 1993; Silvia, 2005).

Sampling criteria. The sampling for the Student Science Survey was both a purposive and convenience sample of 10th-grade students at the site. All 10th-grade students were invited to participate in the survey. In order to adequately capture and represent the perceptions of 10th-grade students a large sample of this population was surveyed. Collecting information from a larger sample increased the validity of the study and helped to avoid the crises of representation and legitimation (Onwuegbuzie & Collins, 2007). For the student interviews, a nested sample of 11 students from the larger sample of 10th-graders completing the Student Science Survey was used (Onwuegbuzie & Collins, 2007; Onwuegbuzie & Leech, 2007). This ensured that the views of the student interviewees had also been captured as part of the survey data since the purpose was to corroborate the two data strands (Creswell & Plano-Clark, 2011; Teddlie & Tashakkori, 2009). The qualitative data gained in the interviews supported the quantitative data in that it provided a more detailed picture of student interest in learning science. In addition, the 11 students represented the different academic levels of courses offered to 10th-grade students, Practical Chemistry, Regular Chemistry, and Honors Chemistry. The students selected came from different 10th-grade science teachers' classes. Due to district restrictions no potentially personal descriptors were used such as socio-economic status, ethnicity, or levels of parent education, all of which may contribute to bias toward science and STEM. The sequential nature of the research design recommended using at least seven participants in order to integrate the inferences between the quantitative data derived from the survey and the qualitative data from the interviews (Onwuegbuzie & Collins, 2007). Students expressing an interest or willingness to be interviewed were selected for this sample and therefore the bias associated with this type of convenience sampling must be acknowledged (Teddlie & Tashakkori, 2009).

Eight 10th-grade science teachers who were the instructors of the student participants were selected for the teacher interviews. The teacher selection was purposive in that they are Grade 10 science teachers with different levels of experience and represent individuals teaching the different levels of 10th-grade science. It was also a convenience sample as these individuals are my colleagues.

All interview data were recorded using a digital recorder and stored on the recorder until the digital file was transferred to the researcher's password protected private laptop. The researcher transcribed the data, verbatim, into a Word document. Pseudonyms were used for all interviewees, both students and teachers, to ensure privacy and confidentiality. The original digital recordings were deleted from the digital recorder after verbatim transcriptions were finished and reviewed by interviewees as a form of member checking to ensure the accuracy of the responses. Transcriptions will be stored off campus in a locked file cabinet for a period of three years following the conclusion of the study. After that time all transcriptions will be shredded.

Research study Phase II. The action research approach taken in Phase II used an instructional intervention, the STEM Career Project, which was designed to promote situational interest and determine its influence on student interest in science and the pursuit of a STEM career. The project was designed as a student-directed learning module in which students researched STEM careers of interest to them. The STEM Career Project was introduced through a specifically designed lesson plan that began with a class discussion of "what is a STEM career" and video clips of individuals in STEM careers. The individuals in the video clips described how they became interested in their fields of study and chosen careers. Students were given a written handout of the project requirements, grading rubric, and selected websites to begin their research. Class time was devoted to the initial research in order to assist students and monitor progress. The research was completed outside of school and each student created an electronic slideshow of three careers of interest to them. Students presented one of the three careers to the class. In addition, after project completion, the students wrote a reflection of the experience and completed a post-project survey. The reflection provided an opportunity for students to describe the experience in their own words and enabled them to identify changes in their perceptions (Dunlap, 2006). This instructional intervention combined two important factors that are essential to the development of interest: an opportunity to gain new knowledge and understanding in an area of which they have limited knowledge, and a task that affords students a form of personal relevancy (Durik, Hulleman, & Harackiewicz, 2015; Hidi & Renninger, 2006; Krapp, 2005; Schiefele et al., 1983; Wigfield & Cambria, 2010; Wigfield & Eccles, 2000). One approach to deepening interest is creating an instructional experience for students that is personally relevant and useful for other activities or life goals (Hulleman & Harackiewicz, 2009). Additionally, the reflection gave students a voice allowing them to describe in their own words the perceptual changes they experienced and accomplishments they achieved during the learning experience (Dunlap, 2006). The survey provided a quantitative snapshot of the student responses to the project and its effectiveness in meeting its objective of increasing student awareness and interest in pursuing science.

As a classroom chemistry teacher, it is important to find teaching methods that create a classroom environment that stimulates interest in topic being studied. The STEM Career Project was created as a result of the information gained through the initial pilot of the student survey, the Student Science Survey administered in Phase I, and my experience as a classroom teacher. Using this information effectively to create a successful learning experience means reflecting upon the next course of action (Norton, 2009). Action research is a personal journey of self-study that enables an individual to improve their practice and in doing so gain valuable knowledge and insight into the local conditions (Hendricks, 2013). The spiraling cycle of reflect, act, evaluate and reflect provides a unique opportunity to engage in an ongoing process that can lead to greater understanding of the local situation.

Reflecting upon what one believes about the scholarship of teaching and learning is an important part of defining what you believe about teaching; is it an art, a science, or a bit of both? In any event, “Theoretical reflection is needed to produce qualitatively different insights about teaching and learning which can provide teachers with conceptual tools to establish new links between what they know and what they do” (Norton, 2009, p. 46). Creating an engaging classroom environment and positive science learning experiences is critical to increasing student interest in science (Basu & Barton, 2007; Osborne & Collins, 2001; Raved & Assaraf, 2010).

The first implementation of the intervention provided data to assess the impact of the project on student awareness of STEM careers and interest in further pursuing science. The experience helped to refine, revise, and improve the STEM Career project. The next cycle of implementation was carried out by other 10th-grade teachers to see how the revised intervention worked for these teachers in their classrooms. Feedback from the teachers was used for further refinement in order to develop an intervention that can be used by other teachers at the site or in other schools. The iterative nature of this action research phase provided a way to gain valuable knowledge and authentic insights into the local condition (Carr & Kemmis, 1983; Hendricks, 2013).

STEM career project. The impetus for the creation of the STEM Career Project came from the information gained in both the pilot study and the Student Science Survey. Students do not have an awareness of STEM careers nor the variety of opportunities afforded by these fields. This intervention was modeled from examples found in the literature and from my own teaching experience. Two specific examples that helped in determining the components for the required career criteria and the methods of data collection were the Project Lead the Way career journal (Project Lead the Way, 2016) and the ASPIRES project developed in the United Kingdom (Archer & Dillon, 2014). These two interventions were used during the school year and not as separate enrichment programs outside of school. The STEM Career Project was also delivered during the school year and was included as part of the chemistry course. Although the STEM Career Project was not a requirement of the school curriculum, it did however support the research site's school philosophy and objective to connect science to real-life. This project had the ability to demonstrate the relevancy of what students are learning and how these concepts are used and applied in careers. The researcher-teacher has the flexibility to include enrichment activities and interventions in the classroom in order to promote student awareness to the role of science in everyday life and across the many disciplines of science.

The STEM Career Project was completed with my four chemistry classes comprised of seventy-six 10th-grade students. This sample of students was purposive in that it is only 10th-grade students who participated. It was also a convenience sample since these are my current chemistry students. It is the researcher's belief, that although the initial Student Science Survey administered in Phase I is anonymous, a majority of these students will have completed it. The intervention was implemented as part of the normal classroom activities; however, parental permission and student assent was obtained in writing (see Appendix J). The consent form included a letter to parents explaining the STEM Career Project and how the collected data will be used in the research study (see Appendix K).

POI and the 4-Phase Model of Interest Development were used as the underlying theoretical framework for the design of the intervention. Creating situational interest in the classroom can trigger interest and help move learners into the next phases such as maintained or stabilized situational interest (Hidi & Harackiewicz, 2000; Hidi & Renninger, 2006; Krapp, 2002, 2005; Silvia, 2005). The intervention supported the idea that knowledge is required in order to create interest (Hidi & Renninger, 2006; Krapp, 2005). Determination of the impact of the intervention on students' level of interest in science or science careers was done using student reflections of the project and the post-STEM project survey. The project was designed as a student-directed learning module focused on the exploration of potential STEM careers that are of interest to the student capitalizing on personal relevancy and demonstrating the role of science in the workforce.

The STEM Career Project was introduced as outlined in the teacher lesson plan (see Appendix L). The first step in the intervention was the defining of a STEM career. Students were asked to identify careers they believe fall into the STEM category and to name as many as possible. This helped to determine student knowledge in this area and developed a definition of what constitutes a STEM career as this definition has, in some cases, been expanded to include the fields of social science and psychology (Brown et al., 2011; Lichtenberger & George-Jackson, 2013). Therefore, it was important to specify the careers to be classified as STEM careers for the purpose of the intervention. To further introduce and engage students in the topic, video clips of STEM professionals discussing how they became interested in STEM fields was shown. The video clips included Nobel prize-winning scientists, engineers, and students just completing their graduate degrees. The variety of the careers shown was designed to appeal to a wide range of interests. The selection of young STEM professionals was included in order to connect students to peers closer to their own age, those who represent their near future selves.

A thorough explanation of the requirements and expectations of the project was detailed in the student handout (see Appendix M). During the lesson the researcher-teacher also discussed with students how to write a reflection. The students have been writing reflections as part of the school-required sophomore research project that every 10th-grade student must complete to graduate high school. A discussion of reflection writing helped to identify student knowledge of this form of writing and reinforced the purpose of the reflection for the project. The graded components of the intervention included the final electronic document and the oral presentation of one of the three careers. Students completed the project and then wrote a reflection of their experience. The reflection questions focused on the intervention's influence on student interest in pursuing science and any personal meaning derived as a result of the experience. The reflections were not included in determining the students' scores on their projects. The decision to not include the reflections as part of the project grade was based on the researcher's belief that reflections are designed to express and elicit honest feedback. Students submitted their reflections electronically and their identities were unknown.

Students were given class time to begin their research which was approximately 2 hours of time. As of the 2015-2016 school year, all students at the site have been issued their own Chromebooks or laptops allowing students to perform electronic searches and in-class research. The student handout provided some initial websites for the students to begin exploring STEM careers. By providing class time, individual questions and clarifications were able to be addressed. It also provided the researcher with an opportunity to observe student engagement in the project and note any immediate changes that may be required. One class block of 58 minutes was devoted to the introduction of the project and initial research time. Thirty to 58 minutes of a second instructional block was used at the discretion of the researcher to clarify any further questions or assist student with their searches. Students also used time outside of class to complete the project by the assigned due date. The project timeline was approximately 2 weeks from initial inception to the oral presentations. The project was graded using the developed grading rubric (see Appendix N). A post-project questionnaire was also used to ascertain the effectiveness of the intervention (see Appendix O) and provided the researcher with immediate feedback. In addition, as the primary researcher, a reflective journal of the experience was maintained and used to provide information for future refinements.

For the teachers completing the second iteration, more details were required in the lesson plan and were added from the information gained in the first cycle. Based on student questions and feedback from the first iteration, clarifications about the required elements and electronic format were necessary. Additionally, the inclusion of how to write a reflection was deemed necessary to remind students about this form of writing. The second iteration of the STEM Career Project was implemented by three10th-grade teachers and their feedback provided data for further refinement. Teachers received introductory training by the researcher in order to introduce and explain all the components of the intervention. The training allowed for clarification of any questions regarding the implementation of the project. Teacher feedback was collected through interviews after the teacher had completed the project (see Appendix P). The purpose of the teacher feedback was to help further refine the intervention in order to provide a learning experience that creates situational interest in learning or pursuing science and provides students and teachers with a well-orchestrated project that is both meaningful and relevant.

Data analysis

Research study Phase I.

Quantitative data analysis. Descriptive statistics were used to quantify the student responses collected from the Student Science Survey. The data provided information to address the research question: *What are 10th-grade high school students' perceptions of their interest in* *learning science and pursuing a STEM career?* in order to determine the student perspective regarding their interest in learning science, identify the teaching and learning strategies they find supportive of their interest in learning science and the student perspective on pursuit of a STEM career. These data captured the 10th-grade student perspective of the local condition. The Google Forms software was used to calculate the percentages of student responses to the survey as it was the means of data collection for the survey. The survey data provided an overall representative picture of 10th-grade student perceptions as they relate to their interest in learning science. The Google Forms software includes statistical analysis software options allowing the researcher to readily analyze the data. The survey's descriptive statistics were used to capture information from 44.0% of the entire 10th-grade student population at the site in order to increase the validity and credibility of the study. The information gained helped to hone the questions for the interviews that were conducted in the qualitative data collection phase. The survey data was tabulated and graphically represented using the statistics provided by the Google Forms software. The collected data were summarized as percentages of student responses to the survey questions. For the ordinal data collected from the survey, the non-parametric chi square goodness-of-fit test was performed at the significance level of .05 to determine if the sample data was consistent with a hypothesized distribution. The hypotheses were:

H_0: For each survey question, the frequency of responses are equal among all categories. This is the null hypothesis which was assumed true and tested at a .05 significance level.

H_a: For each survey question, the frequency of responses are not equal among all categories. This is the alternative hypothesis. IBM SPSS Statistics 24 software was used to perform these statistical analyses.

Qualitative data analysis. The transcribed interview data were manually coded line-by-line using an open coding or initial coding strategy and employed In Vivo coding as a way to capture the essence and meanings of the participants (Maxwell, 2012; Saldana, 2016). Each transcript was individually coded in the first cycle. The second cycle coding process used pattern coding in order to identity emergent themes from each participant group (Saldana, 2016). By using a constant comparative process codes representing similar patterns, concepts, and themes can be merged (Creswell, 2009; Leech & Onwuegbuzie, 2007; Saldana, 2016). Student transcripts were coded and themed before beginning the coding of the teacher transcripts. Using this strategy helped to limit the influence of one data set upon the other (Saldana, 2016). The responses for students and teachers were organized in tables by themes and summarized in a narrative discussing these themes. The identified themes generated from the data provided information to address the research questions regarding10th-grade student perceptions of their interest in learning and pursuing a STEM career and 10th-grade high school science teacher perceptions of student interest in learning science and pursuing a STEM career. The information generated from the questions provided insight into the influences and the classroom experiences that impact student interest in science. As POI and the 4-phase model of interest development provided the underlying framework of the study, determining the influences and experiences which contribute to the development of situational interest can help to create a better learning and move learners into a more developed phase of interest. Themes generated by responses to questions associated with views and interest in STEM careers provided evidence supporting the implementation of the STEM Career Project in Phase II of the research study. The student generated qualitative data helped to corroborate the quantitative data collected from the larger student sample and provided a more in-depth and detailed understanding of the student perspective, a form of significance enhancement (Leech & Onwuegbuzie, 2007). A cross-case comparison of the themes generated in the student and teacher interviews provided a better understanding of how these two perceptions view the current state of student interest in learning at this site in order to help create a learning environment that better promotes student interest in learning science. A cross-thematic matrix was created from these data.

Triangulation. The data from the quantitative and qualitative strands were compared to determine if there was convergence, difference, or some combination of the two (Creswell, 2009). The initial quantitative strand provided a database of information from which to refine and generate interview questions for both students and teachers and support the reasons for implementing the STEM Career Project. In Phase I, the purpose of mixing the student quantitative and student qualitative data strands was to corroborate the data collected from the larger representative sample with the individual student interviews in order to provide a more detailed, descriptive understanding of the student perspective. In this study, triangulation was a form of comparative analysis (Patton, 1999). In addition, the teacher and student perspectives and subsequent themes generated by the data provided a way to understand how the two populations view interest in learning science and the teaching and learning strategies that support interest in science. The views from these two distinct groups are critical to understanding the situation as these are the individuals who create and experience science learning in the high school classroom. The data were summarized in a narrative highlighting the commonalities, differences, and pertinent information provided by both teachers and students. By highlighting the overall consistency in the patterns generated and providing reasonable explanations for differences can significantly increase the credibility of the study's findings (Patton, 1999).

Research study Phase II.

STEM career project. The written student reflections generated in the STEM Career project were coded using the multiple strategies of open or initial coding, In Vivo coding, and provisional coding. The reason for this approach was that, to answer the research question, *Does the intervention of a STEM Career Project influence student interest in learning science and pursuing a STEM career?*, using the theoretical framework that interest is the willingness to continue to engage in the activity of learning science, predetermined codes were necessary. Concepts related specifically to interest in learning science, further pursuing of science, or pursuing STEM or science-related careers can answer this question and therefore provisional coding was the preferred method. However, using an open or initial coding strategy as well did not limit the analysis but instead opened it up to understanding any changes that may have resulted from the intervention. Using multiple coding strategies was necessary in order to identify all possible changes that may have occurred as a result of the project and therefore helped capture even subtle changes that are meaningful in trying to understand student interest in science (Saldana, 2016). Each reflection was read thoroughly to identify changes related to interest in pursuing science. Additionally, any emerging codes or concepts related to other changes as a result of the intervention were identified. Using the In Vivo coding strategy, notable text and phrases associated with these changes was highlighted. After generating a list of common themes, the data were re-analyzed using a comparative approach to synthesize it to the most commonly reoccurring codes. The themes generated from these written reflections were organized in a table and were summarized and discussed in a narrative format. These data helped to determine if student interest in pursuing science was influenced by the implementation of this instructional strategy designed to create situational interest. A post-project questionnaire was used as a quantitative method to collect student data regarding their views of the STEM project and its impact on future science learning and career aspirations. The questionnaire provided immediate feedback to gauge the effectiveness of the intervention. The researcher's reflective journal provided information and data for procedural revisions and refinements for the next intervention cycle. Teacher feedback from the second iteration was used for further improvements and refinements resulting in a finalized version of the STEM Career Project intervention.

Data Merging

In this research study, Phase I and Phase II worked synergistically to create a picture of student interest in learning science at this site and to identify strategies to increase the level of student interest in learning and pursuing science. The resultant information provided a way to develop a practical course of action on how to make learning science more interesting for students. The exploration into student interest in Phase I provided the current status of the situation as represented in the quantitative data by a larger sample of students and incorporated the more personal, narrative qualitative data from the student and teacher interviews. Combining and weaving these strands together created a more in-depth, balanced and accurate picture of student interest.

The STEM Career project was a direct outgrowth of the data collected in the survey in keeping with the underlying theoretical framework of the study that interest in learning science is a relationship that can develop if interest is first caught and then held or maintained. For students, the classroom is the venue through which situational interest in science can be promoted. However, creating this interest is dependent upon the teaching and learning strategies and approaches employed. The STEM Career Project used two important factors in creating interest: the acquisition of new knowledge, and personal relevancy. Testing the effectiveness of these strategies in influencing student interest in learning science and future interest in learning science enabled the researcher to complete the cycle from exploration to praxis. Employing the assistance of fellow colleagues in Iteration 2 truly embodies the collaborative nature of action research with the intent purpose of identifying how the intervention works in the classroom and how to make it successful for different academic levels of students and different teachers. Phase II of the research was both a personal and practical journey in discovering how to increase student interest in science. Improving the classroom environment by identifying what strategies can be used to increase student interest is fundamental to increasing the number of students entering STEM fields. The data from the two phases of the research study worked together in order to uncover the complexities and issues at the heart of the story. It is not so much about the stage at which integration occurs but more about the gradual process of providing clarity to a complex issue (Fielding, 2012; Guba & Lincoln, 2005).

Credibility, Validity, and Reliability

Credibility and validity are principles upon which the researcher is evaluated because the research cannot be taken seriously unless it is shown that the researcher behaved ethically, followed protocol, and represented and interpreted the results with honesty and integrity. Whitemore, Chase, and Mandle’s four primary criteria are credibility, authenticity, criticality, and integrity and they are the standards that are most universally applicable to research (Creswell, 2007). The strategies used to achieve these principles may be different depending on the type of study being carried out but they are still the standards against which research will be judged.

In this research study the researcher's role was both emic and etic. The emic perspective can limit the study but it also provides access to the site. However, one element of the researcher's role is to work through any ethical issues that arise from this relationship (Creswell, 2009). I am not an outsider looking in, but an insider looking deeper. In this regard, my scientific background, teaching experience, and knowledge of the site increase credibility. Intellectual rigor and professional integrity combine to create the thread that runs through my credibility (Patton, 1999).

Research study Phase I. Phase I of the study was an exploration in understanding student interest in learning science in order to improve the experiences of students in the classroom. In trying to uncover an objective representation of the phenomenon at this site and increase the validity of the study, the perspectives of the individuals responsible for the instructional learning experience, the teachers, and the experiences of the students in this learning environment are necessary. In order to adequately explore this issue, both quantitative and qualitative data strands were used because the purpose of mixing was to achieve a deeper understanding (Leech & Onwuegbuzie, 2010; Teddlie & Tashakkori, 2009; Yin, 2014). The two data strands from which the researcher collected information on the student perceptions of their interest in learning science and the selected sampling criteria for the quantitative student data and qualitative student data were used in order to increase the internal generalizability of the study (Maxwell, 2012). Using this form of data triangulation provided the researcher with the ability to adequately understand the variation in student interest in their learning of science by revealing complementary aspects of the same phenomenon (Maxwell, 2012; Patton, 1999).

For the quantitative strand, using a validated instrument developed by a consortium of international experts that has been administered to a large sample and has undergone the tests of content validity, predicative or concurrent validity, and construct validity increased the credibility and reliability of the quantitative results obtained in this research study (Creswell, 2009, 2012). Sections relating to each of the constructs were excerpted in entirety to preserve the validity of the instrument. By providing anonymity to the survey participants, it was hoped that accuracy and truthfulness in the responses increased the credibility and validity of the data collected. In order to target the selected population, only data collected from students classified as Grade 10 was included. All 10th-grade students were invited to participate in order to generate a sample size that is representative of this population and ensures that the conclusions drawn from the survey data adequately represent the perceptions of Grade 10 students at this site (Creswell, 2012; Creswell & Plano-Clark, 2011; Maxwell, 2012). Achieving representativeness through sampling is important so that it does not negatively impact internal generalizability and ultimately validity (Maxwell, 2012). In the collection and analysis of this data, the researcher retained an etic position because of the anonymity of the respondents and the objectivity required in the analysis of quantifying the data.

In the collection of the qualitative data in Phase I, the researcher was obligated to provide sufficient details in the collection and analysis of data to demonstrate credibility and validity (Patton, 1999). As a faculty member and colleague of the teacher interviewees, it was important to acknowledge this relationship as both researcher bias and reactivity can be primary threats to the validity of the study. Reactivity or “reflexivity” as it applies to interviews can have a positive influence but the important point is to be aware of this effect and not deny the potential influence (Maxwell, 2012; Yin, 2014). This awareness, as well as clarification of the researcher’s own bias, increases the validity and credibility (Creswell, 2009; Maxwell, 2012; Yin, 2014). Having spent a prolonged time at the site, 15 years, I have intimate knowledge of its workings providing an insider perspective which can influence aspects of the study from data collection to final conclusions. However, it is this same insider perspective that has provided the inspiration for the research study in the hope of improving my own praxis and in effecting positive change in the site's science program. Maintaining neutrality or impartiality is difficult because "value-free" interpretative research is impossible (Maxwell, 2012; Patton, 1999).

All teacher interviews were conducted by the researcher following the established interview protocol. Of the total 11 student interviewees, nine student interviews were conducted by the researcher following the established protocol. In order to increase the validity and credibility of the data, these students were not current or former students of the researcher. Two of the 11 students in this phase of the study were current students of the researcher and therefore were interviewed by another individual in order to eliminate any potential bias and any threats to the validity of the data collected. The interviewer received training from the researcher and followed the same established protocol. In order to increase validity, member-checking was used as a tool to confirm the accuracy of the findings (Creswell, 2009; Creswell & Plano-Clark, 2011). Students and teachers reviewed their transcribed interviews in order to confirm the accuracy of their responses. Triangulation of the two participant groups, students and teachers, provided a more accurate representation, explanation, and interpretation of student interest in learning science thereby increasing the validity and credibility of the study (Maxwell, 2012).

Research study Phase II. Action research is a journey of discovery and self-exploration that is often initiated for deeply personal reasons. Hendricks (2013) points out that the origin of the research topic is an integral part of the research methodology. The study of chemistry in the 10th-grade fueled my interest in learning science and in pursuing chemistry as a career. In teaching 10th-grade chemistry, I am committed to seeking new strategies and instructional practices that will increase my own students' interest in learning science and my own praxis. These two personal experiences have joined together in creating this research study. As Mertler (2006) believes an action research topic should be inspired by a personal interest and the positive experiences associated with that interest.

The research journey began with Phase I, an exploration into student interest in learning science and, in Phase II, moved into how to effectively craft and implement a STEM Career Project that will increase students' interest in pursuing science. The researcher's role in this phase moved along the participant-observer continuum (Mertler, 2006). In Iteration 1 of the STEM Career Project the researcher was a full participant. This emic role as the teacher/researcher conducting the intervention with my own students provided a way to experience the intervention and reflect upon its impact. It also created an opportunity to make improvements and refinements. This personal connection to the research and participants necessitated full disclosure and honesty, and required that the researcher abide by the principles of beneficence, honesty, and importance (Mertler, 2006; Norton, 2009). As Norton (2009) points out it is important in pedagogical research that the researcher be aware of the undue influence or coercion that might occur as a result of the teacher-student relationship. By acknowledging these ethical issues, formalizing the consent process, maintaining the privacy and confidentiality of the participants, and demonstrating the benefits and contribution of the research to improving the educational experience of students, the researcher increases the credibility and validity of the research (Mertler, 2006; Norton, 2009).

In order to establish credibility and increase validity in this action research phase, multiple forms of data were used including artifacts, such as student projects, teacher lesson plans, teacher reflective journal or field notes, inquiry data from the student reflections, student post-STEM survey, and interviews with teachers implementing Iteration 2. In action research, triangulation using multiple forms of data helps to establish credibility and in doing so increases the validity of the findings (Hendricks, 2013). However, at the core of action research is reflective inquiry which serves to improve praxis, improve understanding of the practice, and improve the situation (Hendricks, 2013; Mertler, 2006). Documenting the changes that arise through the reflective process and the reasons for these changes helped to maintain both credibility and validity. While the methodology, methods, data collection, and data analyses are grounded in theory and scientific principles, the story of the research goes beyond this to describe the journey that results in a personal epiphany. The researcher's narrative of the process "does not attempt to create an illusion of an objective reality that has simply been observed and reported; instead it includes in the text the explicit reminders of its status as a construction, and of the process of that construction" (Winter, 2002, p. 150).

In Iteration 2, the researcher's role moved across the participant-observer continuum shifting from full participant to observer, taking on an etic perspective in this collaborative stage. The knowledge and personal experience gained by the researcher-participant in Iteration 1 was used to improve and refine the intervention for the teachers implementing the next cycle. In this stage the researcher worked with the teachers/colleagues to orchestrate the implementation of the intervention but maintained a more objective perspective. The use of collaborative teachers in implementing the next iteration provided an opportunity to demonstrate the consistency or dependability of the findings, as well as its applicability or transferability to other individuals, and increased the validity of the research outcomes. The replication by other teachers created multiple cases. Using multiple cases is one way to strengthen or broaden what Yin (2014) calls analytic generalization, and increase the study's credibility and validity. In this way any researcher bias, motivation, or interest that could impact the findings is reduced and helps to increase the trustworthiness or validity through confirmability and neutrality showing that the results are an accurate representation of what has transpired (Hendricks, 2013). Using multiple analysts (the researcher and participating colleagues) to assess and critique the effectiveness of the intervention is a form of dialogic validity which helps to ensure that the research processes and outcomes are aligned and that the findings make sense to others (Hendricks, 2013). Using this form of peer debriefing incorporates the viewpoints of other individuals in order to critically assess the intervention and findings which can help highlight any researcher biases that may affect the interpretation of the results. The feedback provided by the teachers in Iteration 2 helped to further refine the intervention in order to formulate a final product that could be used in other high schools.

The collaborative nature of this action research study required that the voices of the stakeholders involved be heard. This is what Kemmis (2010) refers to as the third understanding or situated self-understanding. It is the individual and collective self-understanding that is uniquely grounded in the setting in which individuals struggle to seek understanding. An accurate representation of the research and its findings can only be accomplished if it includes the voices and perspectives of the individuals intimately involved. In this study student voice was documented through the written student reflections and survey data. The teacher interviews provided another voice in critically assessing the intervention and providing another lens through which to interpret the data. Using this form of democratic validity further increased the reliability, credibility and validity of the research (Hendricks, 2013).

Catalytic validity, or the process of researcher transformation, which is at the heart of action research truly defines the ethical nature of the researcher. Documenting the Phase II research through deep reflection was important to improving the intervention, but more importantly the researcher's ability to provide a teaching and learning experience that engages students in increasing their knowledge and interest in learning science. Deep reflection helps to make the researcher's thinking explicit and provides the context through which to tell the story (Hendricks, 2013; Norton, 2009). It is also the critical self-journey that provides an opportunity for professional growth and improved praxis.

Summary

In order to address the question, *Do theories about interest apply to the learning of science and pursuit of STEM careers in a suburban high school?* a two phase action research study was designed that explored student interest in learning and pursuing science in order to create an intervention that was focused on the needs of the site. Phase I used student survey data and student and teacher interviews to capture the perspectives of both in order to create a more accurate picture of student interest in learning and pursuing science. Phase II was completed in two iterations in order to test the effectiveness of the intervention in influencing student interest in learning and pursuing science. The two cycles created multiple cases in order to increase the validity and credibility of the intervention and provided two opportunities to make procedural refinements and improvements. The rich descriptive data generated in the two phases provided credibility to the study, an opportunity for the researcher to determine the state of student interest in learning science and pursuing STEM careers at the site, and a platform from which to make effective changes in the classroom.

In any research undertaking the most important element in terms of credibility and reliability is the integrity of the researcher because the trustworthiness of the data is intimately and directly tied to the trustworthiness of the researcher (Patton, 1999). In reporting and interpreting the data, the words and voice of the researcher are linked to the quality, credibility, and validity of the research because these constitute the trail of breadcrumbs left behind to show the path of inquiry (Graue, 2006). Ultimately, it is the researcher's ethical responsibility to document the journey and allow the data to tell the story.

CHAPTER IV: RESULTS

Understanding student interest in learning science is an important first step to creating an engaging science learning environment where students have the opportunity to explore, engage, and understand the role of science in their world. Exploring the perceptions of both students and teachers is important in order to develop the types of instructional strategies that spark, support, and inspire interest in learning science and in pursuing science in the future. In order to increase the numbers of students entering into STEM fields, their science educational experience must be engaging and positive.

Pilot Study Trends

The pilot study provided an opportunity to narrow the focus of the research study by enabling the researcher to pinpoint the survey questions that helped to answer the research study's questions and identify the focus of the intervention. Using the PISA questionnaire in its entirety, data were collected from 56 tenth grade students. The data were summarized as percentages of students answering each questions using the 4-point Likert-scale responses. The trends that emerged from the pilot indicate that students value science and believe it is important but half of the students responded that learning science is not easy and felt it was more important to do well in English and mathematics. School is the main source of student learning about science topics. Students indicated that not enough class time is spent on practical experiments, designing their own experiments, and testing out their own ideas. Student responses also indicated that students do not have enough choice about the investigations that are carried out in the classroom and there is not enough time spent on class debates. Most students in this pilot, over 60%, do not want to do advanced science as adults. Students do not however know that much about science careers including where to find information regarding science-related careers, steps needed to enter into a science-related career, or the companies that hire scientists. This last trend is the driving force behind the development of the STEM Career Project. If students are unaware of the STEM careers available, then how can they make an informed decision about whether or not to pursue a career in STEM? If school is the main avenue for students to gain information about science topics then it follows that learning about science-related careers would best be served as part of science education.

Research Study Results

The data in this research study provide answers to the overarching question: Do theories of interest apply to the learning of science and pursuit of STEM careers in a suburban high school? and the subsumed questions as indicated below.

Phase I:

1. What are 10th-grade high school students' perceptions of their interest in learning science and pursuing a STEM career? (Quantitative and Qualitative)
2. What are 10th-grade high school science teachers' perceptions of their students' interest in learning science and pursuing a STEM career? (Qualitative)

Phase II:

3. Does the intervention of a STEM Career Project influence student interest in learning science and pursuing a STEM career? (Quantitative and Qualitative)

The data for each phase of the study are presented sequentially. Phase I and its quantitative and qualitative components are presented first. For the Student Science Survey the descriptive statistical data are presented in tables which summarize the survey sections. These data are accompanied by a narrative description of the results. The transcripts of the student interviews were coded through an open and In Vivo coding process in order to generate themes.

The prominent themes generated from the data have been tabulated and are accompanied by a narrative description of the results. The teacher interview transcripts were treated in the same way. The prominent themes generated have been tabulated and also include an accompanying narrative description.

Triangulation is an important research tool that has been utilized in this study to provide a means of corroborating the quantitative Student Science Survey data and the qualitative student interview data in order to generate a more detailed understanding of the student perspective. Additionally, triangulation of multiple perspectives using the teacher and student data provided a way to construct a more accurate and complete representation of science learning. A cross-thematic matrix of the two views has been included highlighting the similarities of the two perceptions. A discussion of these findings is included in the Phase I results.

The results of Phase II are divided into Iteration 1 and Iteration 2. The quantitative results from the Post-STEM Survey are presented in a series of tables, one for each survey question. The qualitative data generated by coding of the student reflections is summarized in a thematic table. A discussion of the data is included for each theme. As part of the action research cycle, the findings of Iteration 1, included a discussion of the implementation process and improvements and modifications for Iteration 2.

The data from Iteration 2 is a narrative summary of the experiences of the three science teachers who implemented the STEM Career Project. In essence this feedback was used to determine whether the STEM Career Project influences student interest in science and if it was a valuable use of instructional time. The interviews conducted by the researcher focus on the procedural aspects of the project including any challenges or issues, suggestions for modifications and improvements, and evidence of the influence of the project on student interest in pursuing science.

Research study Phase I: Quantitative data results. The exploratory phase of the research, Phase I, provided both quantitative and qualitative data to capture the perceptions of 10th-grade students and their science teachers regarding student interest in learning science. The quantitative data from the Student Science Survey gave an overall picture of how students perceive their interest in learning science. The student interview data provided individual experiences in learning science to provide a more descriptive and in-depth understanding of student interest in learning science. The teacher interviews added another dimension to understanding student interest in learning science. These two perspectives, when taken together, depicted a more complete and accurate picture of the current status of student interest in learning science at this site. Exploring this phenomenon at the site enabled the researcher to bring awareness of the local condition in order to facilitate change.

Student science survey. In Phase I the quantitative data collected through the Student Science Survey was one method used to answer the research question *What are 10th-grade high school students' perceptions of their interest in learning science and pursuing a STEM career?* The survey was emailed to 614 addresses provided by the site and targeted the 10th-grade student population. The survey generated 270 responses representing a 44.0% response rate. In reviewing the data, there were nine respondents that, although taking a 10th-grade level science course, did not check 10th-grade as their grade level. There are three plausible reasons why these students did not check 10th-grade. One reason is that the student is taking mostly 10th-grade level courses but due to a credit deficit is classified as a ninth grade student by the school and identifies as such. The second possibility is that the student is taking mostly 11th-grade courses but due to a credit deficit is classified as a 10th-grade student. The third possibility is the student is an 11th-grade student who had not taken this 10th-grade science course when in the 10th-grade. This 3.4% is included in the summary of responses. Eliminating the data from these nine individuals was not possible and has been identified as a fault in the Google software. The respondent answers were tabulated as percentages based on a four-point Likert scale. For most questions the respondent choices were strongly agree, agree, disagree, and strongly disagree. Other 4-point answer choices used in the Careers and Science section of the survey related to how informed students were regarding careers and science and, for the Teaching and Learning section, how often the activity occurred in lessons. For these survey questions a chi square goodness-of-fit test was performed at a significance level of .05. These data are reported in all applicable tables. For the Sources from which Students Learn about Science, there were multiple choices and students could check all that applied. In Learning Time, student response choices were reported in hours spent on the subject.

Of the student respondents, 41.0% were taking Honors Chemistry, 40.0% were taking Regular Chemistry, 6.7% were taking Practical Chemistry and 11.9% were taking Biology 10. The results of the student data are tabulated by category or summarized in a narrative for each section. The questions and percentage breakdown for each choice response are presented in tables and identified by category or section. The sections are: Your Views on Science; Careers and Science; Learning Time; and Teaching and Learning science.

Student views on science. The questions in the survey section Your Views on Science focus on enjoyment in learning science, value of science to society and personal value of science, and student interest in learning science.

Enjoyment in learning science. The first set of questions was designed to measure enjoyment of science, a construct that is associated with interest in science. The questions and the corresponding responses are presented in Table 2.

Table 2

Enjoyment in Learning Science

Survey Question	Percent Response									
	Strongly Agree		Agree		Disagree		Strongly Disagree		Total Response	χ^2
	N	%	N	%	N	%	N	%	N	
a) I generally have fun when I am learning science.	54	20.0	142	52.6	64	23.7	10	3.7	270	134.089*
b) I like reading about science.	40	14.8	110	40.7	99	36.7	21	7.8	270	84.696*
c) I am happy doing science problems.	35	13.0	113	41.9	103	38.1	19	7.0	270	99.837*
d) I enjoy acquiring new knowledge in learning science.	82	30.4	150	55.6	29	10.7	9	3.3	270	176.607*
e) I am interested in learning about science.	77	28.5	142	52.6	42	15.6	9	3.3	270	143.896*

Note. Total percent for each item may not equal 100.0 due to rounding. *p < .05

The data show that 86.0% of the students reported that they enjoy acquiring new knowledge in learning science and 81.1% reported that they are interested in learning about science. However, 72.6% of students responded positively when asked if they have fun when learning science. When asked about if they liked reading about science the percent of students agreeing with the statement was 55.5% while 44.5% disagreed with the statement. When asked if they are happy doing science problems, only 54.9% of the students agreed with the statement and 45.1%

disagreed. The percentage of students that do not enjoy reading about science or doing science problems is only slightly lower than those that enjoy these activities. Student responses are nearly equal which may indicate that a good portion of students do not find these forms learning science enjoyable or interesting. For each question in this section the χ^2 value is greater than the chi square critical value, $\chi^2 = 7.815$ for df = 3 and a level of significance of .05, and therefore the null hypothesis H_0 for each survey question, the frequency of responses are equal among all categories, is rejected.

Value of science to society and personal value. Uncovering how students perceive science in terms of value to society and personal value provides some context in which to look at interest in learning science. The data presented in Table 3 summarize their views.

Table 3

Value of Science to Society and Personal Value

Survey Question	Percent Response									
	Strongly Agree		Agree		Disagree		Strongly Disagree		Total Response	χ^2
	N	%	N	%	N	%	N	%	N	
a) Advances in science and technology usually improve people's living conditions	134	49.6	121	44.8	11	4.1	4	1.5	270	214.948*
b) Science is important for helping us understand the natural world.	159	58.9	98	36.3	10	3.7	3	1.1	270	248.430*
c) Some concepts in science help me see how I relate to other people.	58	21.5	139	51.5	59	21.9	14	5.2	270	120.548*
d) Advances in science and technology usually help improve the economy.	81	30.0	142	52.6	43	15.9	4	1.5	270	153.556*

Survey Question	Percent Response									
	Strongly Agree		Agree		Disagree		Strongly Disagree		Total Response	χ^2
	N	%	N	%	N	%	N	%	N	
e) I will use science in many ways when I am an adult.	63	23.3	118	43.7	72	26.7	17	6.3	270	76.163*
f) Science is valuable to society.	133	49.3	116	43.0	18	6.7	3	1.1	270	196.341*
g) Science is very relevant to me.	85	31.5	104	38.5	61	22.6	20	7.4	270	58.326*
h) I find that science helps me to understand the things around me.	102	37.8	128	47.4	29	10.7	11	4.1	270	141.111*
i) Advances in science and technology usually bring about social benefits.	75	27.8	136	50.4	53	19.6	6	2.2	270	129.496*
j) When I leave school there will be many opportunities for me to use science.	65	24.1	118	43.7	73	27.0	14	5.2	270	80.726*

Note. Total percent for each item may not equal 100.0 due to rounding. *$p < .05$

For questions *a*, *b*, and *f*, pertaining to the general value of science, the student responses for the "strongly agree" category were 49.6%, 58.9% and 49.3% respectively. However when asked specifically about the impact of advances in science and technology on the economy, *d*, and social benefits, *i*, the "strongly agree responses" were lower, 30.0% and 27.8%. This may indicate that although students value science they are not connecting this with outcomes related to the economy or social benefits. For questions relating to personal value, specifically questions *c*, *e*, *g*, and *h*, the "strongly agree" category percentages ranged from 21.5% to 37.8%, respectively, while the percentages of responses for "agree" ranged from 51.5% to 47.4%, respectively. With respect to question *c* related to the value of science and question *e* related to the personal value of science it is noted that far fewer students responded with “strongly agree” compared to those responding “agree.” Question *j* responses regarding opportunities for students to use science after leaving school are 67.8% agreeing with this statement and 32.2% disagreeing. These results may indicate that these students are not translating their perceived value of science into future science learning and career options. The chi square value, χ^2, for each question in this section exceeded the chi square critical value $\chi^2 = 7.815$ for df = 3 and a significance level of .05 and therefore the null hypothesis H_0 for each survey question, the frequency of responses is equal among all categories, is rejected.

Student interest in learning science. In Your Views on Science section, students were directly asked about their interest in learning science topics. In this case the Likert response categories were high interest, medium interest, low interest, and no interest. The percentage summaries are listed in Table 4 below.

Table 4

Student Interest in Learning Science

Survey Question	Percent Response									
How much interest do you have in learning about the following topics?	High		Medium		Low		No Interest		Total Response	χ^2
	N	%	N	%	N	%	N	%	N	
a) Topics in physics	57	21.1	101	37.4	76	28.1	36	13.3	270	34.030*
b) Topics in chemistry	54	20.0	111	41.1	74	27.4	31	11.5	270	51.096*
c) The biology of plants	44	16.3	100	37.0	85	31.5	41	15.2	270	38.770*
d) Human biology	105	38.9	101	37.4	44	16.3	20	7.4	270	79.067*
e) Topics in astronomy	88	32.6	99	36.7	51	18.9	32	11.9	270	43.630*
f) Topics in geology	25	9.3	93	34.4	97	35.9	55	20.4	270	51.600*

g) Ways scientists design experiments	47	17.4	74	27.4	96	35.6	53	19.6	270	22.000*
h) What is required for scientific explanations	34	12.6	72	26.7	96	35.6	68	25.2	270	28.963*

Note. Total percent for each item may not equal 100.0 due to rounding. *$p < .05$

For the topics of physics and chemistry total student responses with "high" and "medium" interest were 58.5% and 61.1% and "low" interest was 28.1% and 27.4% respectively. 88.2% of the survey respondents are currently enrolled in chemistry and have not yet taken a physics course. The highest level of interest was in learning about human biology with a 76.3% total of "high" and "medium" interest responses and a "low" of only 16.3%. This may be affected by the fact that students have already completed a biology course. Topics in astronomy had the next highest level of interest with a "high" and "medium" responses totaling 69.3% and a "low" of 18.9%. The "high" and "medium" interest total for biology of plants 53.3%. For geology although the total for "high" and "medium" interest was 43.7%, only 9.3% was in the "high" interest category. When asked about interest in the way scientists design experiments, the "high" and "medium" response totals were 44.8%. The lowest interest was identified as what was required for scientific explanations with a total "high" and "medium" response total of 39.3%. This question had the largest percentage of all survey questions, *a-h*, in the "no" interest category with 25.2%. For each survey question the chi square value exceeded the chi square critical value, $\chi^2 = 7.815$ for df = 3 and a .05 significance level indicating that the null hypothesis H_0 for each survey question, the frequency of responses is equal among all categories, is rejected.

Sources of learning science topics. In Your Views on Science, students were also asked to identify the sources from which they mainly learn about science topics. Students were allowed to check off as many choices as applied to them individually. The choices were: none of these, I am unsure what this is; my school; TV, radio, newspaper or magazines; my friends; my family; and the internet or books. The topics of science learning were: photosynthesis; continents; genes and chromosomes; soundproofing; climate change; evolution; nuclear energy; and health and nutrition. The data are presented in Table 5.

The predominant source of learning for all topics except soundproofing was school. This suggests the importance of school to science learning. When asked about the topic of soundproofing 42.6 % of respondents checked “none of these, I am not sure what it is.” For every other topic the percent average choosing this response was much lower, only 3.2%. In every case, except soundproofing, the response that these topics were learned mostly from school ranged from a low of 88.5% to a high of 97.4%. The internet was the second most prevalent source of student learning of science topics with responses ranging from 24.4% to 55.2%. The third most commonly identified choice was TV, radio, newspaper or magazines with responses ranging from 16.3 % to 53.7%.

Careers and science. This section addresses what students know about science-related careers and their future motivation to learn science. The data gathered in this section helped to provide support for the STEM Career Project intervention in Phase II of the study by identifying the current level of student knowledge of STEM careers and inquiring about students’ interest in pursuing science after high school.

How informed are you about science careers? The section of the survey, careers and science, asks students to identify how informed they are about science-related careers. Response choices were: “very well informed”; “fairly well informed”; “not well informed”; and “not informed at all.” Table 6 summarizes the responses.

Table 5

Sources of Learning Science Topics

Survey Questions	Percent Response												
From which source(s) did you mainly learn about the science topic? (Please check as many as apply.)	None of these, I am not sure what this is		My school		TV, radio, newspaper or magazines		My friends		My family		Internet or books		Total Responses
	N	%	N	%	N	%	N	%	N	%	N	%	N
a) photosynthesis	8	3.0	259	95.9	48	17.8	17	6.3	41	15.2	125	46.3	498
b) formation of the continents	13	4.8	239	88.5	66	24.4	19	7.0	41	15.2	105	38.9	483
c) genes and chromosomes	3	1.1	263	97.4	46	17.0	14	5.2	33	12.2	92	34.1	451
d) soundproofing	115	42.6	85	31.5	44	16.3	23	8.5	27	10.0	67	24.8	361
e) climate change	5	1.9	241	89.3	145	53.7	54	20.0	92	34.1	138	51.1	675
f) evolution	9	3.3	251	93.0	99	36.7	41	15.2	66	24.4	123	45.6	589
g) nuclear energy	11	4.1	246	91.1	84	31.1	20	7.4	30	11.1	93	34.4	484
h) health and nutrition	11	4.1	242	89.6	130	48.1	81	30.0	155	57.4	149	55.2	768

Note. Percentages do not add up to 100.0% because students could check as many responses as apply.

Table 6

How Informed Are You About Science Careers?

Survey Question	Percent Response									
How informed are you about these topics?	Very well informed		Fairly well informed		Not well informed		Not informed at all		Total Response	χ^2
	N	%	N	%	N	%	N	%	N	
a) Science-related careers that are available in the job market.	31	11.5	108	40.0	97	35.9	34	12.6	270	73.556*
b) Where to find information about science-related careers.	29	10.7	90	33.3	101	37.4	50	18.5	270	50.622*
c) The steps students need to take if they want to a science-related career.	29	10.7	83	30.7	99	36.7	59	21.9	270	41.289*
d) Employers or companies that hire people to work in science-related careers.	25	9.3	77	28.5	105	38.9	63	23.3	270	49.230*

Note. Total percent for each item may not equal 100.0 due to rounding. $*p < .05$

The data reveal that the total percentage of students who are very well informed or fairly well informed regarding science-related careers in the job market is 51.5%. However, when asked about how to find information about these careers, the steps needed to be taken to pursue these careers, and the companies that hire science individuals, the total percentage of students who responded with “not well informed” or “not informed at all” was 55.9%, 58.6%, and 62.2%, respectively. This suggests that students do not know how to go about researching careers in science or the requirements for a career in science. The data from this section of the survey corroborates and supports the information gained from the pilot study. For each question in this section the χ^2 value is greater than the chi square critical value, χ^2 = 7.815 for df = 3 and a level of significance of .05, and therefore the null hypothesis H_0 for each survey question, the frequency of responses are equal among all categories, is rejected.

Future motivation to learn science. Another set of questions in the Careers and Science section addresses future student motivation to learning science. This construct is also identified as student interest in learning science. In this case motivation and interest are interchangeable as motivation has a specific focus: science. The questions inquire about students' plans to study or pursue science after high school. The Likert scale response choices ranged from strongly agree to strongly disagree. See Table 7 below.

Table 7

Future Motivation to Learn Science

Survey Question	Percent Response									
	Strongly agree		Agree		Disagree		Strongly Disagree		Total Response	χ^2
	N	%	N	%	N	%	N	%	N	
a) I would like to work in a career involving science.	60	22.2	92	34.1	73	27.0	45	16.7	270	17.674*
b) I would like to study science after high school.	64	23.7	84	31.1	81	30.0	41	15.2	270	17.319*
c) I would like to spend my life doing advanced science.	46	17.0	53	19.6	104	38.5	67	24.8	270	29.704*
d) I would like to work on science projects as an adult.	43	15.9	72	26.7	96	35.6	59	21.9	270	22.296*

Note. Total percent for each item may not equal 100.0 due to rounding. *$p < .05$

These data show that while 56.3% of students “strongly agree” or “agree” that they would like a career in science, only 36.6% “strongly agree” or “agree” that they would like to spend their life doing advanced science. Students understanding of what “doing advanced science” entails may have affected their response choice. 54.8% of students agreed that they would like to study science after high school. 42.6% of students agree that they would like to work on science projects as adults. For each question in this section the χ^2 value is greater than the chi square critical value, $\chi^2 = 7.815$ for df = 3 and a level of significance of .05, and therefore the null hypothesis H_0 for each survey question, the frequency of responses are equal among all categories, is rejected.

Learning time. The data collected in the Learning Time section focused on the number of hours students spend studying subjects such as English, mathematics and science. The response choices were: “no time”; “less than 2 hours a week”; “2 or more but less than 4 hours a week”; “4 or more but less than 6 hours a week”; or “6 or more hours a week.” The school schedule at this site is based on an 8-day cycle, Days A through H, with six of eight possible courses meeting each day. With this rotating drop-2 schedule not all courses meet every day. For Honors Chemistry the course has six academic blocks plus two additional blocks for science lab, totaling eight blocks in an 8-day cycle. Regular Chemistry has six academic blocks plus one additional science lab block for seven class blocks in a cycle. Practical Chemistry has six academic blocks and no additional science lab blocks in the cycle. English and mathematics courses each have six academic blocks in the 8-day cycle. The data are presented in Table 8.

The data revealed one notable difference: students spend more time studying English and math as compared to studying science. For studying or homework by yourself, English and

Table 8

Time Spent per Week Studying Science, Mathematics, and English

Survey Question	Percent Response										
How much time do you typically spend per week studying the following subjects?	No time		Less than 2 hours a week		2 or more but less than 4 hours a week		4 or more but less than 6 hours a week		6 or more hours a week		Total Response
	N	%	N	%	N	%	N	%	N	%	N
Regular classes at my school in:											
Science	17	6.3	51	18.9	54	20.0	102	37.8	46	17.0	270
Mathematics	10	3.7	46	17.0	59	21.9	118	43.7	37	13.7	270
English	11	4.1	51	18.9	54	20.0	113	41.9	41	15.2	270
Out-of-school-time lessons in:											
Science	152	56.3	60	22.2	41	15.2	10	3.7	7	2.6	270
Mathematics	127	47.0	62	23.0	56	20.7	19	7.0	6	2.2	270
English	134	49.6	57	21.1	45	16.7	27	10.0	7	2.6	270
Study or homework by yourself in:											
Science	20	7.4	102	37.8	93	34.4	39	14.4	16	5.9	270
Mathematics	18	6.7	78	28.9	103	38.1	51	18.9	20	7.4	270
English	23	8.5	72	26.7	100	37.0	57	21.1	18	6.7	270

Note. Total percent for each item may not equal 100.0 due to rounding.

and mathematics had the largest number of student responses in the two or more but less than four hours a week category. For science the largest number of student responses for studying or doing homework alone were less than two hours a week. This corresponds with the result from the Teaching and Learning Science section where students were asked if they believed it was more important to do well in English and mathematics compared to science. See Table 9 below.

Table 9

How Important Is It to Do Well in Subjects?

Survey Question	Percent Response									
In general, how important is it for you to do well in the subjects below?	Very important		Important		A little important		Not important at all		Total Response	χ^2
	N	%	N	%	N	%	N	%	N	
Science	124	45.9	96	35.6	39	14.4	11	4.1	270	118.652*
Mathematics	158	58.5	84	31.1	20	7.4	8	3.0	270	211.244*
English	151	55.9	93	34.4	17	6.3	9	3.3	270	201.407*

Note. Total percent for each item may not equal 100.0 due to rounding. $*p < .05$

The total percent of students responding that they believe it is “very important” or “important to do well” in English was 90.3%, for mathematics 89.5%, and for science 81.5%. These results suggest that students believe it is more important to do well in English and mathematics than in science. This information is useful in identifying the emphasis that is placed on learning among the academic subjects by the district. Since district goals usually reflect attitudes of parents this may be interpreted as corresponding to the biases of parents towards the subjects. For each question in this section the χ^2 value is greater than the chi square critical value, χ^2 = 7.815 for df = 3 and a level of significance of .05, and therefore the null hypothesis H_0 for each survey question, the frequency of responses are equal among all categories, is rejected.

Teaching and learning science. In the section of the survey, Teaching and Learning Science, students were asked about their classroom science learning experiences. The questions addressed the types of learning and teaching strategies that are used in their science lessons. The response choices were: in all lessons; in most lessons; in some lessons; and never or hardly ever. A summary of the data is shown in Table 10 below.

Table 10

How Often Do the Following Occur in Learning Science at School?

Survey Question	Percent Response									
In learning science topics at school, how often do the following activities occur?	In all lessons		In most lessons		In some lessons		Never or hardly ever		Total Response	χ^2
	N	%	N	%	N	%	N	%	N	
a) Students are given opportunities to explain their ideas.	66	24.4	116	43.0	60	22.2	28	10.4	270	58.830*
b) Students spend time in the laboratory doing practical experiments.	31	11.5	83	30.7	130	48.1	26	9.6	270	106.681*
c) Students are required to design a science question that could be investigated in the laboratory.	31	11.5	70	25.9	115	42.6	54	20.0	270	55.956*
d) Students are asked to apply a science concept to everyday problems.	36	13.3	84	31.1	91	33.7	59	21.9	270	27.985*
e) The lessons involve students' opinions about the topics.	40	14.8	78	28.9	82	30.4	70	25.9	270	16.044*
f) Students are asked to draw conclusions from an experiment they have conducted.	66	24.4	100	37.0	85	31.5	19	7.0	270	55.067*

Survey Question	Percent Response									
In learning science topics at school, how often do the following activities occur?	In all lessons		In most lessons		In some lessons		Never or hardly ever		Total Response	χ^2
	N	%	N	%	N	%	N	%	N	
g) The teacher explains how a science idea can be applied to a number of different phenomena.	58	21.5	111	41.1	62	23.0	39	14.4	270	41.852*
h) Students are allowed to design their own experiments.	27	10.0	56	20.7	69	25.6	118	43.7	270	64.074*
i) There is a class debate or discussion.	27	10.0	62	23.0	72	26.7	109	40.4	270	50.563*
j) Experiments are done by the teacher as demonstrations.	48	17.8	79	29.3	108	40.0	35	13.0	270	47.541*
k) Students are given the chance to choose their own investigations.	27	10.0	55	20.4	78	28.9	110	40.7	270	55.007*
l) The teacher uses science to help students understand the world outside of school.	52	19.3	88	32.6	83	30.7	47	17.4	270	19.570*
m) Students have discussions about the topics.	46	17.0	94	34.8	56	20.7	74	27.4	270	19.837*
n) Students do experiments by following the instructions of the teacher.	93	34.4	104	38.5	61	22.6	12	4.4	270	75.630*
o) The teacher clearly explains the relevance of science concepts to students' lives.	57	21.1	87	32.2	82	30.4	44	16.3	270	18.563*

Survey Question	Percent Response									
In learning science topics at school, how often do the following activities occur?	In all lessons		In most lessons		In some lessons		Never or hardly ever		Total Response	χ^2
	N	%	N	%	N	%	N	%	N	
p) Students are asked to do an investigation to test out their own ideas.	29	10.7	60	22.2	72	26.7	109	40.4	270	48.607*
q) The teacher uses examples of technological application to show how science is relevant to society.	43	15.9	87	32.2	83	30.7	57	21.1	270	19.719*

Note. Total percent for each item may not equal 100.0 due to rounding. *p < .05

This information provided a picture of what is occurring in the classroom according to students. Understanding if the classroom is an environment in which situational interest is being stimulated, and if so, how instruction is being delivered and what learning modes are being used are important. This information helped to guide student interview questions in order to ascertain what instructional strategies in the classroom stimulate their interest in learning science and if there are other strategies not being used that students believe would stimulate their interest in learning science. In looking at these data, it appears that students often do not have the opportunity to experience practical laboratory work as evidenced by 48.1% stating this happens only "in some lessons" for question *b* in Table 10. The data also show that when asked about designing their own experiments or doing an investigation to test out their own ideas for questions *h* and *p*, 43.7% and 40.4% of students responded with "never or hardly ever" respectively. Students do have an opportunity to explain ideas, question *a,* but do not often have opportunities to debate their ideas, question *i*. In looking at these responses, it appears that instruction in most lessons is teacher-centered with the instructor delivering information and students are not being provided with opportunities to choose their investigations or test their ideas. For each question in this section the χ^2 value is greater than the chi square critical value, $\chi^2 = 7.815$ for df = 3 and a level of significance of .05, and therefore the null hypothesis H_0 for each survey question, the frequency of responses are equal among all categories, is rejected.

Motivation to learn science. As part of the Teaching and Learning Science section of the survey, student perceptions of their motivation to learn science were identified. This construct of motivation is specific to learning science and therefore is also representative of interest in learning science. Student opinion options ranged from "strongly agree" to "strongly disagree." These data are presented in Table 11 below.

Table 11

Motivation to Learn Science

Survey Question	Percent Response									
	Strongly agree		Agree		Disagree		Strongly disagree		Total Response	χ^2
	N	%	N	%	N	%	N	%	N	
a) Making an effort in my science class(es) is worth it because it will help me in the work I want to do later.	86	31.9	119	44.1	52	9.3	13	4.8	270	91.926*
b) What I learn in science class(es) is important for me because I need this for what I want to study later on.	69	25.6	109	40.4	70	25.9	22	8.1	270	56.311*
c) I study science because I know it is useful for me.	77	28.5	127	47.0	49	18.1	17	6.3	270	96.637*
d) Studying science is worthwhile for me because what I learn will improve my career prospects.	74	27.4	109	40.4	63	23.3	24	8.9	270	54.474*

Survey Question	Percent Response									
	Strongly agree		Agree		Disagree		Strongly disagree		Total Response	χ^2
	N	%	N	%	N	%	N	%	N	
e) I will learn many things in my science class(es) that will help me get a job.	68	25.2	106	39.3	68	25.2	28	10.4	270	45.081*

Note. Total percent for each item may not equal 100.0 due to rounding. *p <.05

Students were agreeable regarding the study of science for its personal usefulness. Questions *a* and *c*, in Table 11, summarized percent responses for “strongly agree” and “agree” are 76.0% and 75.5%. Question *a* is more general when referring to ‘work’ while questions *b*, *d*, and *e* suggest that what students will be studying in the future is science or science-related, the career prospects are possible science-related, or that students would use the skills learned from studying science. In these questions the total number of students responding to “strongly agree” and “agree” are 66.0%, 67.8%, and 64.5% respectively. For each question in this section the χ^2 value is greater than the chi square critical value, χ^2 = 7.815 for df = 3 and a level of significance of .05, and therefore the null hypothesis H_0 for each survey question, the frequency of responses are equal among all categories, is rejected.

Student science self-concept. Students were asked about their ability in performing science-related tasks, a measure of their science self-concept, using the “strongly agree” to “strongly disagree” responses. Table 12 summarizes these results.

Table 12

Student Science Self-Concept

Survey Question	Percent Response									
	Strongly agree		Agree		Disagree		Strongly disagree		Total Response	χ^2
	N	%	N	%	N	%	N	%	N	
a) Learning advanced science would be easy for me.	46	17.1	114	42.2	82	30.4	28	10.4	270	65.111*
b) I can usually give good answers to test questions in science.	56	20.7	144	53.3	59	21.9	11	4.1	270	137.022*
c) I learn science quickly.	58	21.5	122	45.2	71	26.3	19	7.0	270	80.370*
d) Science is easy for me.	49	18.1	119	44.1	79	29.3	23	8.5	270	75.659*
e) When I am taught science, I can understand the concepts very well.	59	21.9	124	45.9	71	26.3	16	5.9	270	87.837*
f) I can easily understand new ideas in science.	58	21.5	126	46.7	70	25.9	16	5.9	270	91.422*

Note. Total percent for each item may not equal 100.0 due to rounding. *$p < .05$

In reviewing the results of questions *a* and *d* when students report "learning advanced science would be easy for me" and "science is easy for me" there is a consistency in the percentages for each categorical response. However, students may not have an understanding of what learning advanced science entails. The other four questions in this series, *b*, *c*, *e*, and *f*, relate to learning science or being taught science and here the responses are consistent with one other. In these questions the percentage of students responding with "strongly agree" is higher than in *a* or *d*.

This suggests that students have more confidence in learning science when there is someone there to guide or assist them. For each question in this section the χ^2 value is greater than the chi square critical value, χ^2 = 7.815 for df = 3 and a level of significance of .05, and therefore the null hypothesis H_0 for each survey question, the frequency of responses are equal among all categories, is rejected.

Research study Phase I: Qualitative data results.

Student interviews. Obtaining individual stories of student interest in learning science provided a more detailed picture of student perceptions of their interest in learning science. The interview data added to the researcher's growing body of knowledge to answer the research question: *What are 10th grade high school students' perceptions of their interest in learning science and in pursuing a STEM career?* In order to be representative of the 10th-grade student population at the site, the 11 students selected were enrolled in different levels of chemistry. Of the 11 students interviewed, four students were enrolled in Honors Chemistry, two male students and two female students. Five students were from the Regular Chemistry course, three males and two females. From the Practical Chemistry two students were interviewed, one male and one female. The participating students volunteered to be interviewed. Tenth-grade science teachers had asked their students if anyone would be interested in being interviewed as part of a research study. The only requirement was that the student had to have completed the Student Science Survey. Since the survey was anonymous, there was no way to verify if the student had taken survey. The students identified by their teachers as potential subjects were contacted by the researcher to describe the study, the timeframe, and if possible, to set up an interview time. More than 11 students volunteered but it was not possible to schedule an interview time. Two of the students interviewed were the researcher's students but they were interviewed by another individual to prevent any bias as a result of the student-teacher relationship. These interviews took place prior to the STEM Career Project since both students would be participating in that phase of the study as well.

The student interview protocol was comprised of 28 interview questions. In trying to obtain information specific to interest in learning science and the types of teaching and learning that make science interesting to them, the questions included: *Tell me about your interest in learning science; What aspects of science do you find interesting?; Can you provide an example of a classroom situation you found interesting?; Can you tell me some aspects of science that you don't find interesting?*

An additional line of questioning used to further elicit information regarding how to increase student interest focused on asking students about their favorite science teacher and how that science teacher made them more interested in science. Students were asked: *What do you think a science class should look like?* and *How should a science class be conducted to be more interesting?* In addition, students were also asked to describe what the teacher's role should be in the classroom and what students should be doing in the classroom.

The interviews were a source of information for Phase II of the research. Student interviews generated over 102 pages of transcript data. Students were asked directly if they would be interested in pursuing a STEM career, and if so why, or why not. Discovering the reasons for this can help provide insights for creating the intervention and how to create a learning environment that encourages students to consider STEM or science-related careers. Determining how students perceived the life of a scientist was another way to discover their views on the value of science and their knowledge of STEM careers. This information was helpful to the researcher because it provided a starting point from which to refine and hone the components of the STEM Career project. Knowing the current level of student knowledge regarding STEM careers was important to improving the overall design of the project.

The six emergent themes from the student interview data are: interest in learning science; science in the real-world; understanding and experiencing science; roles in learning; life of science; and STEM and students. The thematic data is summarized in Table 13 below.

Table 13

Student Interview Themes

Interest in learning science	**Science in the real-world**	**Understanding and experiencing science**
The reason why science is so interesting to me is how it relates. I am able to learn something, say it is astronomy and then look at the stars and sort of know what is going on.	And I think with science it is kind of cool because no matter what it applies. Everybody gets a cold. Or everybody, everybody is aware of certain hereditary diseases and GMOs is with elections that is a pretty big topic. . . So when you come to school and have to take science it is not just taking science for the sake of four years of science to fulfill a requirement it is really like learning what can apply to your life with it.	It's like if you want to practice something. I don't know if you want to be a basketball player you have to dress like a basketball player, practice like a basketball player, stuff like that. So if you are wearing a science lab coat, you are actually doing the science stuff. I just feel you would be better at it. You will be more interested in it.
I have always been interested. I think it is important to learn, you know like obviously you need to know how things work in the world. And if you know that everything seems to make sense.	I would start out with a real-world application of it and asking the students a question that is related to the topic. Say if I were introducing electricity, I would ask them how do they think it works? And then this would interest them in the topic. And then I would teach them about it. And then try and do experiments with them to show how it works.	And I think it is really nice when there is a good classroom conversation going because it then turns from the teacher talking or giving a lecture to the students to a conversation going around the classroom. It makes everybody feel like, makes everyone feel like they are part of a community.

Interest in learning science	Science in the real-world	Understanding and experiencing science
I didn’t really take an interest in science until last year. I had a really great bio teacher and that was kind of the first time that I liked science. I never liked science before last year.	And I really like when the first day it is being introduced there is a lot of real world examples. Okay we are doing thermodynamics, let’s see where it is used, let’s show some examples and the like after that, maybe more in the middle of class start actually getting down to what is in the curriculum. . . . I think it is cool to start right off the bat so you have a reference point.	I like labs. They are great. Because rather than having something on the board telling us what happens we can actually see it right in front of us. Hands-on . . . you are actually touching your own learning. It makes you more engaged in your own learning. Working together. That also helps with a lot of confusion. That helped this year. Last year we didn’t have the defined groups we do this year. And I could always just as my group partners if I had questions. That’s helpful.
What I didn’t find interesting this year was probably the unit we are doing now which is moles to mass, moles to everything, just converting moles. That’s because I don’t really know why it is necessary. I don’t know when we are going to use it further.	Try to appeal to their age group. Compare it to things they know about the world. Like try to, like if there is a certain way that age group feels, like maybe hormones. Teach them about that. Teach them, connect it to them. That’s what I mean and they will realize hey I understand this now because science, that is how the world works.	He would actually go step-by-step. Not just explain some crazy concept and bounce around but take it like so methodically. So, this is how you start, this is how you go next, this how you go next. And sort of take all the steps that I could understand the most complicated of anything in minutes.
Um, I really, I love understanding how things work so the fact that the human body is run by all these small little systems that if you change one thing everything gets messed up like that is so amazing to me. And that DNA is so long and yet microscopic. It blows my mind.	Why (chemistry is my favorite subject) because the stuff that I learn, new things, like each day that are still somehow relevant, somehow relate. Like the biggest problem with other classes is that you learn something but you really don’t know why you are learning it so what is the point.	I feel like it would be cool if we could like one of these days we could bring in an actual scientist that works in one of those labs. And so they can, so we can actually see what they do or hear about it from their perspective, first hand.

Interest in learning science	Science in the real-world	Understanding and experiencing science
Uh, this is because it combines a lot of the other topics like math and is actually important. I don't feel that a lot of the topics we learn in history can be applied.	Like I don't know, we are learning, we'll be learning in class and she will tell us how it would relate to the real world. So you don't feel like you are wasting your time in class. Say, like you are teaching us balancing equation. But she is teaching us why we need it if we became a chemist. What they are doing while they are balancing it.	Instead of like looking at pictures on our Smartboard of plants and different things we actually went outside of the school. And like change it up for a day. We actually could go outside and witness, and see all these different things we were supposed to see on a board and go outside and find it.

Role in learning	Life of science	Students and STEM
I would say the thing a teacher needs to do is sound passionate about the subject. How can a student be passionate about a subject if the teacher is not. . . . if you are generally interested in what you are doing students will pick up on that, not all of them but at least the few of them that are slightly interested it will sort of like spark that.	Like this sounds bad in my head, but I am just going to say it any way. I feel to be a scientist or to be that advanced in a profession you are just going to be generally smarter than other people because, like by studying it's going to get you almost there. But to be 100% there you have to have the passion for it and like the ability to do so. Some people aren't born with that.	I would consider a career in science because there has been a lot personally in my family there has been a lot issues brain-wise. My grandfather has Parkinson's and my brother is an epileptic so it is like they hardly, they don't know anything about it. And so although it is really difficult research and really hard at being interesting to have that field of work. And be able to know more not just for my family but for everyone affected because I know both of those are very terrible conditions to have. Just like learning more about things that are just sort of mysteries being able to do that would be interesting.
She (the teacher) was one of the first ones that I learned that applied math to science which brought me more into science. Which wanted me to go more into science and try and get my grades up. Try to learn more about science then just closing myself off.	I guess a lot of hard work. I kind of picture it like really time consuming. Definitely, especially if you are trying to solve a problem in the lab, and you are trying to get the results you want but can't. I just figure it would be really frustrating.	Probably not. I liked bio last year but I am not very good at it. Math and science aren't really my strong suits. Especially math, I am not that good at it. And science I find really interesting or really boring. Math I find really boring regardless.

Role in learning	Life of science	Students and STEM
But um I think for learning, as far as learning science I think when a teacher is really passionate about what they are teaching it inspires the students. It shows that there is value in what you are learning.	It seems tiring I guess. It's a lot of dedication and a lot of knowledge to remember and a lot of research. It seems like a very difficult job but if that is something that you are really interested in it is probably a very rewarding job.	I feel like if I was a scientist that is all I would want to do all day. Maybe make new inventions and blow stuff up but I couldn't see me doing science because I would have to do all that background research and stuff.
Answering questions. And elaborating making sure students know the information. And not just saying it but making sure they actually understand what they are learning. . . They know how it relates to things.	I see them as people but I see them as what do you call it, geniuses, I would say. I see them as people who are trying to figure out the world and what it contains	I would and I wouldn't' because math is just really weak for me and I know with a lot those STEM jobs you need physics and your need a certain grade in math and this year I am in geometry.
I would say balance learning. Well not just balance learning with fun because they can be the same thing. But to sort of incorporate fun into learning. Because something I would describe as fun is not only lighting Bunsen burners and you blowing stuff up but learning about a really cool concept.	Someone not cool. Like just someone, I don't know. I always think of the uptight, I'll be honest foreign. And not really smiling too much. You know more stern. Very black and white. Not really sociable or I don't want to say, not really able to interact with people. More, like very smart, and very intelligent of course but not as, not as much as a person I would want to hang out with in all honesty.	My interest, well I want to go and study a science-related field so I find it imperative to study science in high school.
Students need to at least give it a shot because so many times you always hear about kids who say stuff like I hate this class. Students are very quick to jump to conclusions whether it is about teachers or subjects or class or whatever. Give it a shot. Really focus be interested. Really just try and like be interested in the subject and see what results from it.	Well I know it can be stressful. Trials and errors. And I see it as something that even though he fails sometimes, even though he maybe succeeds or fails he still likes what he is doing.	And I think anyone can be a scientist. . . I mean we are all scientists just because we all want to know more.

Interest in learning science. The 11 students interviewed were generally interested in learning science. The most common reason was that learning science helped them to understand the world around them. One student, Tyler, commented "And if you know that everything seems to make sense. . . . Because it is science, it is our understanding of the world." Topics of interest for students ranged from astronomy to human biology. Student interest was higher for topics they found to be both important and relevant to their daily lives. Casey stated that she liked the unit on genes and heredity because she was a twin and the material was directly applicable to her. Students who enjoyed math found science more interesting and easier to understand when they could apply math to the science concepts they were studying. Students found learning science to be different from their other classes because it was more interactive and collaborative. Taylor stated that unlike her English class where the work was more independent, "in science class, in general, the class is working as a whole and it is a lot of teamwork." Students repeatedly commented that in other classes lecture was the most common mode of instruction. JD said "there is no hands-on work in English. The teacher is just standing there talking or reading to the entire class." Science, unlike the other academic courses, uses multiple modalities of learning which may increase students' interest in learning science.

Science in the real-world. One of the most pervasive themes from the student interviews was that students enjoyed learning science when they could see the real-world applications. It not only made science come alive but, according to the students, it also increased their understanding. Without these types of connections students tend to lose their interest. Cole said that he did not find moles interesting because "I don't really know why it is necessary. I don't know when we are going to use it further." Human biology is a topic of great interest to students because they can relate it directly to themselves. As Casey said "everybody gets a cold." For students this is an important part of the learning process. Tyler said it is important to "try and appeal to their age group" and "compare it to things they know about." For students, learning science is about connecting and relating it to what they know and experience in the world. One student Royal P. pointed out that "the problem with other classes is that you learn something but really don't know why you are learning it, so what is the point." Relevancy and examples that students can connect to, see, and experience in the world create a better science learning experience. Students want more than just the "boring facts" found in textbooks.

Understanding and experiencing science. One of the great dilemmas for students when discussing their science learning experiences was why they were not given the opportunity to truly experience science more often. Students noted that this would help with the learning and understanding of science. For example, going outside and seeing and touching nature rather than looking at pictures on a Smartboard. Another student thought it would be "cool" to hear firsthand from a scientist about what he does every day as part of his work. Royal P. was very vocal in saying that if he were to design a classroom it would have all windows because "I feel science explains the world and to be cut off with no windows doesn't really make sense to me." At the site all the chemistry rooms and some of the biology rooms do not have any windows. One student comment that stood out compared practicing science to practicing basketball and how dressing the part and practicing the part makes you more interested. "So if you are wearing a science lab coat, you are actually doing the science stuff. I just feel you would be better at it. You will be more interested in it."

Students found labs and the hands-on experience to be beneficial to their science learning because it was engaging, and enabled students "to touch their own learning." However, even in this hands-on environment students still wanted it connected to the real-world. Iris said "It makes things, it makes sense at the end. You see how it all builds up together and how it all works." Students believe labs should be fun and a positive experience for students. Students found that if the lab included a "daunting lab report" it took the fun out of the experience or "confused" students when they were at home trying to complete it without any guidance. Overall, for students labs are exciting, engaging, fun, and a way to visualize and experience science because "when you are able to do, for lack of a better word, a light-hearted experiment, have fun with it, explain just a little bit on what we have learned, that's my favorite part."

Students also expressed that in order to understand science they wanted order and structure: a methodical step-by-step approach, whether in explaining a concept, moving through a unit of study, or connecting prior learning. Organization of the material was an important factor in their learning and understanding. In describing how they would like a science class to be conducted Jillian said she enjoys "when a new unit is started I like when there is a segue from either the past units or just something from the past to segue that or there is a hint to connect it to what we are going to be doing next. That gets me excited, oh what is next?"

Students did comment that collaboration and working together enhanced their learning and enjoyment. Being able to work together to solve problems or discuss ideas was another positive experience in learning and understanding science. As Casey stated, a good classroom conversation "makes everyone feel like they are part of a community." Michael said "I feel like students should work together to discover some of the science."

What students don't find interesting is reading the textbook or notetaking. Michael said "I don't find much of the text book work very interesting. Because it doesn't feel useful when it is in the text book. It is just solid facts." As for notetaking, some students thought it had a place in the classroom, as Gabby commented it is a way to introduce a unit and "you can reference back to them and that helps you." According to Royal P. "Notetaking isn't terrible but we do so much of it in other classes." Tyler said "I personally would rather watch a video on something because it takes less time. It makes it go by faster but you know what you are watching." As Iris said "because I like the hands-on stuff and reading the text book I don't really retain the information as much. I feel it is just memorizing but I like, mmm, it is just not as like engaging." For students reading the text book is not an engaging activity because it does not help students make sense of the concepts. Students believe reading is simply a way to memorize facts without having a true conceptual knowledge.

Roles in learning. Students have definite opinions about the role a teacher plays or should play in science learning. In all 11 interviews, the comment most frequently used when asked about the teacher's role or their favorite science teacher came down to passion. As one student said, "How can a student be passionate about a subject if a teacher is not?" Another said that "when a teacher is really passionate it inspires students. It shows there is value in learning." Students get their cues about the importance of learning from their teachers. Tyler said "I think I would rather hear a teacher say we are going to do a really fun lab today, than we are going to do a lab. It just entices you more." Michael said that keeping the classroom atmosphere light as opposed to serious was good for science learning, "Well because we still learned but it just didn't feel like we were being forced to learn." Casey said "I think it is up to the teacher to really facilitate a class discussion rather than just giving a lecture. Sometimes I zone out during lectures. So I would imagine other people do too."

Students wanted teachers to mix it up more and balance out the learning with more engaging and fun experiences. Again, students said that when teachers provided real-world examples it enhanced the learning process. Cole commented that "Seeing how it is going to help us in the future is what she (his teacher) does well." Students believe that teachers who provide class time for collaborative work and then circulate the classroom to help students it is one of the best methods for encouraging and supporting student learning. As JD said "when we do a new unit and stuff, she teaches us how to do it and then like for half the class or a little bit more, the rest of the time we do problems by ourselves and she will walk around and she will go to anybody and help us. I like that."

Students also had opinions on the roles they needed to play in their own learning. Adam said that he wanted more responsibility and freedom but understood it depended on the maturity of the class. A common theme about student learning that emerged was the fact that students needed to find a way to get themselves interested. Casey said it could be "doing extra research or seeing how it applies to your life even if you don't like science and just seeing how it kind of all goes together and then coming to class with a better understanding." Both Tyler and Royal P. said students should pay attention and "give it a shot" and just see what results from it.

The life of science. Students place a high value on the work of scientists and STEM professionals. Scientists were called "the driving force behind pretty much everything that we do" or "the people that progress us technology wise and medicine wise" indicating the impact that they had on our world. Students felt that "a lot of science is improving lives" or "I feel like they just make everything work in the world. Whenever something is wrong it is them (scientists) that fix it." Tyler stated "Well, they are kind of like in a way our evolutionary heroes." He went on to add that even if they don't solve the problem they are still "trying to make things happen in the world. And I think that is a real hero to me."

One student commented that he did not feel science was well-portrayed in the media invoking a quote he had heard "we live in a world ever dependent on science and technology as we ever more reject science and technology." Seeing all the negative focus in the media on the ways science harms the environment or hurts people can have a negative impact on kids' views on science according to him. "So it is never really, not too many positive vibes are coming from science."

Even though students value science and the work of scientists, many students view the life of a scientist as one that is time consuming, tiring, difficult, and boring. They believe that scientists are smarter than most people, they are intelligent, intellectual, and as one student saw them "geniuses." They are viewed as individuals working alone in a lab, lacking in social skills, not someone "they would like to hang out with." They did believe that to be a scientist you must enjoy what you do and have a passion for it. The stereotypical scientist in the white lab coat working alone seems to still be pervasive in our society. However, Tyler believes we are all scientists because "there is no difference in the guy who is studying biology and wants to know more and the child who wants to know more about the world as well."

Students and STEM. The most appealing aspect of being a scientist is being able to help people and this aspect could influence whether or not a student considers a STEM field. The medical field was one that held an appeal for some students. A lack of math ability seems to be a detriment to pursuing a career in a science-related field. Of the 11 students interviewed only three seemed sure that science would be a career for them. Michael said he wanted to go into engineering because "it is one of the sciences that is most experimental. It is not a lot of theory, it is very theoretical but at the same time all of it has an application that is direct and you can immediately apply your knowledge into making a product." For Tyler it is the mystery of not knowing that appeals to him. "It's like you see a forest, you are interested in that forest but you are actually going in there to see what it is in there. You are studying it all the time and eventually you are not going to know everything but that is kind of the beauty of it. You don't know everything, but you know things. You are knowing a lot. It is better than knowing nothing."

Teacher interviews. Interviews were conducted with eight science teachers, three males and five females. The teachers were all 10th-grade science teachers teaching different levels of science including 10th-grade Biology, Practical Chemistry, Regular Chemistry, Honors Chemistry and ESL Chemistry. The male teacher, Charlie, is also the research science teacher. The level of teacher experience ranges from 40 years for Dimitri to Arnie with six years of experience. All these teachers have been at the site for six to 18 years.

The eight semi-structured interview questions focused on capturing teacher perceptions of student interest in learning science. Over 80 pages of transcript data were generated in the interviews. Teachers were asked their opinions on the *level of student interest in learning science* and asked to *provide examples that demonstrate interest.* They were also asked to identify the *key indicators of student interest in the classroom* and the *teaching approaches and strategies they employ to stimulate, maintain, and support student interest,* as well as *the indicators they use to assess the effectiveness of these teaching practices*. Teachers were asked about *the changes* they would like to make in the classroom *in order to increase student interest in science.* In addition, teachers were asked their opinions on *why students are not pursuing STEM careers* and what they could do in the classroom *to encourage students to pursue STEM fields.* The thematic data that emerged focused on: interest indicators; change; strategies; connections; freedom/constraints; and STEM education. The information is presented in Table 14.

Table 14

Teacher Interview Themes

Interest Indicators	Change	Strategies
The other thing I try on every test is give a critical thinking question that has a little twist about something we are doing in class. I actually then have an indicator of who is engaging if they can answer those questions well.	It can't be stagnant. It has to change because we know our client is changing. Whatever is happening to the students we knew five years ago and what we have now is very different. But we are still doing the same thing in the classroom.	Keep giving them challenging homework (articles or thinking questions about how it might affect their life outside of the classroom) that makes them think about the world out there in terms of science thinking. Ask them questions, have them design labs, you know, you have to, they have to be engaged.
So for interest I would say they ask the why and how questions. They will bring up things that maybe they have heard of before, like I just sense that they are trying to make connections. . . . And then it is like I see light bulbs going off and when you can make those kinds of connections from previous units or if they can even connect it from a previous class, then I don't know, to me that's a good sign.	I think kids need to do science. I think they not only need to see it, they have to do it. They have to be actively engage. Get them involved. I think that is one way of stimulating their interest in science. I think they are too passive, they need to become more active.	You have to hook those kids in whether it is a personal story, a current event, or maybe even like when I taught genetics we teach about sex-linked traits. I went all out talking about the Romanoff family in Russia. And the kids and I were for 15 minutes not discussing science but I got them hooked in and understanding the history of what the family went through and how it was tied to other royal family histories.
They are taking the initiative. They are working independently. You know they are talking amongst themselves. . . . When kids are doing work in the classroom and helping each other. It kind of tells me they are not just going through the motions. They are really interested in what they are doing. They are more animated when they are doing stuff. They have more smiles on their faces. They interact with each other. They kind of say things off to the side.	(general interest is lost) My instincts tell me it's because they have too many hours on devices doing inane things like tweeting, researching, doing other things and they are more engaged in the social media rather than using those devices as tools to learn. I think there is too much electronics. I think there is too much of instant gratification. So somehow or another, if we could try to keep the kids' interest longer without all these distractions they face, I think that might help them along in their study of science.	The nice thing about demonstrations is that there is no stress on the students. Whereas the lab some students are very worried about doing it wrong, and getting the wrong results and so it's a way for them to see science, explore science, talk about science without the stress of doing it right. It's trying to find that balance between having it engage them while they are not physically doing it.

Interest Indicators	Change	Strategies
Well, part of it is just being in this profession for so long you can just tell by looking at their faces and their body language because looking at kids gives you so much information. You can look at their eyes, look at their body language, what's going on and you can get a really good idea if they are with you or not. Somethings I feel like shouldn't be measured. That is kind of one of them. You kind of have to feel that. Like when you are a musician you can't measure how well your audience is engaged, you have to feel that part.	I think that we really need to do fewer labs but really need to think about which ones we do and have them actually be opportunities for students to do science because every lab we do we struggle to do the inquiry stuff literally because there is none. We have to make it up because there is none. We need to really think about how we can give them a problem to solve, that is not going to blow their eyes out and that they can actually do some science with and I think those two things could really make a big difference.	. . . when you are working for a particular company they are going to give you a job to do but I don't think they are going to tell you or give you a set of directions about how to achieve that job. So it is only by working with others and playing around that you will eventually, hopefully, you will be able to solve this problem. So I think we should start this in high school, middle school, elementary school level.
At least the way my lab reports are and my conclusions, they are going to state their claim based on the problem statement and provide the evidence and then the stickler is the reasoning. Why did this happen in the experiment and that's when I know they got it or they saw what happened in the lab but they don't know how to explain it. And the ones that are interested, the ones that are invested do a phenomenal jobs in writing their reasoning. So maybe that is, that is a way I can measure to see their interest.	It is a me generation because it is all about me and nothing about how I can impact the world, how I can impact society? How can I make an impact to the country and my friends? It is just how will it affect me so I think in fact I am saddened too because I don't know what the world is going to end up to.	So I am always looking for new labs that are a little bit more exciting chemistry wise and I am always looking for new activities to do with them. So you are not straight lecturing the kids because I don't think that is a smart thing to do. . . . And too one thing I do when I try a new lab I have never done with a group, I always ask the kids what they thought of it.

Interest Indicators	Change	Strategies
Well, I think probably an example for me that I would see every day as a teacher is just that key interest when they do lab. You can tell some kids are really, really engaged in the lab and really thinking through the labs about what is going on and then ask good questions going back relating to the concepts because they really want to understand it. I can tell by the level of enthusiasm that they are really engaged and interested in what they are doing.	Shake it up. And I'll admit I don't do it enough. And the reason is it takes work, it does. And so I think, you take for granted that every time you get a new batch of kids it's new to them but sometimes it is new to the deliverer as well; it's new to everybody and that is probably more exciting. So I need to do more of that. You can't shove a kid into a lab if they don't have some idea of what theoretical information is behind it. . . . something I should have done is have more videos they could watch instead of teacher input. I try to limit teacher input to 20 minutes because that's about the limit they have can have. Would it be better if it is 10 minutes and then 10 minutes of video?	Well, I have tried to do projects to get them interested. Different kinds not just the regular poster type thing or report. . . . .But I had them, they could either choose between making up their own rap song, they could act something out, do a news report. Do it at home like a video infomercial, something like that. You know a sort of different way to get them engaged and interested in a topic like learning about an element which may not seem to exciting to them but then they can learn lots of things about them.

Connections	Freedom/Constraints	STEM Education
I thought it was important for them to know why they are learning a particular topic and how they can link it to their own daily lives. . . they kept journals. The journals really helped them reflect on their learning and just again linking it to their daily lives, the real world connections they made and actually some students got so interested that some of them said I love chemistry now and maybe I might become a chemist someday.	A good teacher in the classroom can motivate kids. I work with a lot of good teachers. We motivate them but we are still missing a lot of them. If we had a strong leader and strong input from the district, from the building, from people that are really strong in their content; if we had more collaboration we could do a better job. Period. It makes such a big difference to have some sort of freedom to mold the content to whatever we are experts in but as long as everybody is able to perform the same tasks that's what the focus should be on.	I think first of all we need to be well trained. We have to know our field very well. And I also think that we need to be STEM trained as well. Think there is a little bit of a teacher staff development situation. I think for the last 10 years especially the focus on science as the most important topic for kids to be able to pursue STEM careers is not the prime goal of the school.

Connections	Freedom/Constraints	STEM Education
I think the issue was the connection, the practical aspect of it. What are the practical connections? What are the real connections? Take advantage of that because those are things that are doable in science and not everywhere else. . . . But in chem, bio or physics or whatever, I think the new thing here is you can take the thinking here, you can take the stuff you are learning and it has meaning to make new things.	I think CAPT should really go away. I don't even know why we have CAPT. It is really teaching to the test. It takes a whole month. And when I compare curriculum from the public school here to private school they learn much more because of this CAPT taking a whole month of chemistry where we could actually do at least 2 units, 2 more units or go much more in to depth in whatever topic we want.	So one of the things we might be able to do but it is pretty difficult, if we could bring in outside speakers. People in the industry who have actually been students and now have pursued some kind of scientific career. So I'd say the thing that would be best would be to have a time where the kids can talk to people who are in STEM professions about what they do.
Any time that I can connect it to real-life. If I bring up, if I bring up combustion and I stop and talk about carbon monoxide poisoning and pull up the internet, like the first few hits, oh look at his person who died last week from carbon monoxide poisoning and how you can prevent it. The class gets very animated. Any time it relates to something they already know I find that the electrochemistry, the electromagnetic spectrum can lead to great conversations because they bring up questions. That is where I am finding the interest lies.	With practical I can, I can, I've got a lot more freedom. So, if I want to spend a week and really go into something that they are interested in I can do it. In AP you just have to make sure they are ready for that test. In practical we have a lot of freedom because there isn't such a schedule but like that lets you really start to think about do they really need to know how to write formulas of compounds if they want to have an education that is fit for a student coming out of high school.	But I think the best thing to do would be to educate myself more in terms of all the different careers that STEM entails. I honestly can't say I do know all the jobs that are out there where science in not 100% necessary but would be even an asset to have. And I honestly really don't know all the careers that are out there.
I interact with students just not on a student level but when they come in I do ask them how they are doing or how their weekend was, what is going on if I know they are in a sport. I try to have some type of rapport with something they are interested in so they feel that it is a welcoming place.	It's so nice to have that extra space that you can operate, (ESL Chemistry) if it takes a little longer, it takes a little longer. It is too bad, it is not like that in the other classes but you have got all these targets you have to hit whether it is CAPT or AP you know. It sucks.	I think that in all honesty that is probably because most of those jobs happen to be in computer science which not classified as a STEM class. I mean you can talk all you want about the other sciences but the fact is that when you are talking about computer science you are talking about a million job openings now and the other sciences maybe you are talking about a few thousand.

Connections	Freedom/Constraints	STEM Education
At least what I have seen for biology that they are covering less depth of biology and I am okay with that. I would rather us cross discipline some of those biology topics like I kind of mentioned earlier if they can start to see the connections between one unit with another unit. That is more success to me than just memorizing the anatomy of something and then closing that book and moving on to the next subject and not seeing the connections whatsoever.	And I am not even too sure why besides the fact that we live in the age of plastics sort of and why it's even on the CAPT test. I think between the benchmarks and all these other things that take time away from our classroom and then you just feel the pressure and you want to have the time to cover tougher units with the kids and it always seems there is another stupid thing they put on our plate year-after-year.	I hang those goofy things up for a reason (posters from science fairs, articles from magazines about former research students, awards). I know what I look like but my goal there is to have kids walk out and say look at this, I know these kids and I know who they are. Just to give the idea that this could be you. If you have an interest in it. Not everybody does but if you have an interest this is possible.
Again, just to reiterate on that stuff, there are those kids who once they do a lab sort of take it beyond that and they make their own connections to something in the real-world that is going on. I think that is sort of the real disconnect. I mean students like science stuff because it is cool but actually doing and learning the process of doing science is not cool, and it is difficult.	There are some countries in the world where teachers have more time to collaborate than they have in the classroom. Like Finland. But here we have more time doing things, meetings, the learning centers, that kind of thing, we have more of that time than we have in the classroom, than meeting with each other. I think that is a critical difference. Especially for science. Because science curricula requires laboratories and hands-on activities and it is hard to think of those by yourself. But if you have a group of people that are bright and articulate you can come up with great things.	It is not lucrative enough. Especially in this area. You have parents who are all hedge fund brokers and things of that nature. I think kids are first drawn to economics before they are actually drawn to something they might like. I think some students are enthusiastic about science and they certainly will pursue it to the best of their ability. Other kids are turned off by science thinking it is too hard or it has too much math.

Interest indicators. When asked about key indicators of student interest in the classroom the most common answer was that students asked questions. As Anne, an eight-year veteran stated, "they ask the why and how questions." Other teachers looked at the level of student engagement during the activities or labs, or the number or level of student interactions. As Charlie, noted "the way they are talking amongst themselves" is an indicator of interest. Arnie and Heather, a seasoned 30-year veteran, both remarked on how sometimes it is just that intangible feeling you get that can be seen in their faces or body language. Arnie, who also teaches computer programming and calls himself a data guy, believes “that you have to feel some things in education” because “There is an art and a science and we need to remember that.” He likened it to a musician who can’t measure how engaged the audience is but rather just feels the level of engagement.

In terms of written work, Lulu, Anne, and Heather said it is how students answer the critical thinking questions, how they explain their reasoning, and how they relate the concepts to the labs they are doing. It is being able to connect the learning to the activities and labs and explain what is occurring. Students who can accomplish this show their level of interest not only in their level of participation and engagement but in articulating their newly acquired knowledge.

Change. This theme focuses on how students have changed and the impact of these changes on teaching and learning in the classroom. As Lulu said the way we teach “has to change because we know our client is changing.” Many veteran teachers said it was a lot more difficult to maintain interest in this age of social media. As Dimitri stated “if we could try to keep the kids interest longer without all these distractions they face, I think that might help them along in their study of science.” “Mixing it up,” or “shaking it up” were phrases used whether it was changing how information was presented to students or whether it was finding new ways to reach students through the use of more videos and less lecture. It also was used in referring to finding new labs or doing fewer labs but crafting these labs to truly represent opportunities for students to “solve problems.” Changing it up also meant teaching students how to use their electronic devices as learning tools as opposed to distractions. One teacher, Jean, who was born outside of the United States, said “it’s a ‘me’ generation” and students are not as interested in making an impact or contribution to their country or society. She went on to say that students in the U.S. forget that they are competing with students all over the world, many of whom lack the advantages of U.S. students but have more determination. Jean's other comment "students here I see take it for granted, take their parents for granted and not only their parents, also their teachers for granted and people around them. They want everybody to do things for them." How to address these changes is both complicated and complex.

Strategies. Teachers have a variety of strategies they use in order to create situational interest. All the teachers interviewed spoke about how they were always trying to come up with new ideas on how to better engage students in learning science. Labs and demonstrations are two modes of learning that are unique to science and so teachers take the opportunity to capitalize on these forms of learning in order to create interest. As Heather said, straight lecturing is not a "smart thing" to do so she is always looking for new labs and activities that are more exciting. Mythrin said that for some students labs can be stressful but demonstrations provide a way for them to see, explore, and talk about science without worrying about doing it correctly. She went on to say "it's trying to find the balance between having it engage them while they are not physically doing it." Dimitri believes students need to "play" more and this should be encouraged in elementary, middle, and high school. His analogy about "play" was to a job in the workforce "I don't think they are going to tell you or give you a set of directions about how to achieve that job. So it is only by working with others and playing around that you will eventually, hopefully, you will be able to solve the problem."

Other strategies were creating a "hook" when teaching a concept through the use of storytelling whether that story is grounded in history or a personal story. Anne used the history of the Romanoff family in Russia to talk about sex-linked traits. If students were unfamiliar with the actual history, they knew about the family through the Disney movie *Anastasia* but it piqued their interest. Heather said she used projects in which students explored a topic they were interested in or if it was a standard topic students could demonstrate their knowledge by creating a rap song, a play, a news report, or a home video infomercial something less traditional than a poster or report. In this way students could personalize their learning and showcase their unique talents. For some students this provided a way for them to be successful in a subject in which they often struggle.

Connections. One of them most prevalent themes for teachers was connections. In order for students to see the value in learning science and to be able to understand the concepts, the learning must connect to the real-world and students' daily lives. As Arnie pointed out there is a disconnect because "students like science stuff because it is cool but actually doing and learning the process of doing science is not cool, and it is difficult." Teachers trying to ground the learning in real-world applications and pointing out where these concepts are used are in essence attempting to overcome this disconnect. Mythrin said in discussing combustion reactions she brought up carbon monoxide poisoning and used the internet to find information on it. She said in doing so "the class gets very animated" and this can "lead to great conversations because they bring up the questions." Two other ideas given to help students' link science to their everyday lives were writing about it in journals and providing them with homework such as a current news article about science. Linking science to what is going on in the world helps students make connections that are relevant. Making these types of connections and demonstrating the practicality of science can be inspiring. As Charlie put it "you can take the stuff you are learning and it has meaning to make new things." He went on to say that this is one of the unique ways that science is different from other subjects, the knowledge gained can be used to create new, innovative products.

Anne said whenever you can link topics together it improves student learning and she feels that is more successful than "just memorizing the anatomy of something and then closing that book and moving on to the next subject and not seeing the connections whatsoever." Students need to synthesize and create connections among the topics they learn in order to have a strong science foundation. Lulu said "it is creating those moments in the classroom where you can actually teach them a concept but then try to find a way outside of the classroom to have them see how it might be useful or interesting or how their health and well-being might be affected or how it might affect the materials they use every day." Grounding the learning in what they see or experience every day helps them to connect and imbed this information.

Another type of connection that Heather brought up was making connections with your students. Getting to know them and forming a rapport is another way to make students comfortable since learning science can sometimes be a formidable task. She said finding their interests helps to create a welcoming place. When students are comfortable they tend to be more open to learning.

Freedom and constraints. Teachers have ideas about ways to improve and increase situational interest in the classroom but they lack the freedom to do so. Teachers feel constrained by the pressures of trying to do too many things. Mythrin said it best "One of the things I didn't mention before was that I feel that too much is being asked of us. We are asked to prepare students for the SAT II. We are asked to prepare students for the CAPT. We are asked to prepare students for the AP. We are asked to prepare students for the NGSS standards and how to think about that. . . . It is impossible to do all that so it is a balancing act." In addition, teachers do not have enough time to collaborate with one another because their time is taken up by meetings, corollary duties and other district initiatives. Teachers believe they could make successful improvements in the classroom that stimulated, supported and maintained interest if they were provided with the time required to do so and the freedom and support necessary to execute these changes. Lulu said “But if you have a group of people that are bright and articulate you can come up with great things.” Teachers believe more time spent collaborating can result in a better science learning experience for students.

Freedom to mold the curriculum and spend time on topics students found interesting was one of the benefits of teaching courses such as practical and ESL chemistry. Teachers of these courses were not as constrained by the curricular demands of the regular, honors, or AP courses. Teachers of regular and honors courses talked about how the CAPT test prevented them from covering all the material. They also expressed their dissatisfaction with the disjointedness of teaching the CAPT topics “piecemeal” and doing a “half-assed” job of it because it is “shoved down our throats” as 10th-grade teachers. Teachers want to spend more time covering the tougher topics but CAPT takes a whole month in which “we could actually do at least two more units, two more units or go much more in to depth in whatever topic we want” said Jean. She also commented that for CAPT all we are doing is “teaching to the test.” Trying to hit “all these targets” takes time out of the course classroom learning and creates an environment where teachers feel “the pressure” of more and more department and district demands that take time away from productive student learning.

STEM education. In order to increase the number of students entering STEM fields, education for both teachers and students is necessary. Teachers said they were not aware of all the different STEM careers that are available and would welcome training. Others said they should spend time researching it more on their own. Teachers are of the opinion that students do not enter STEM fields because in this area these jobs are not as lucrative as those in finance and students are often drawn to the economics first. Others believe that students find science and math too hard and therefore don't entertain the possibility of a career in STEM.

In order to combat this, students need to be made aware of the job openings that exist. Arnie said there are a million job openings in computer science and yet his class in programming is not even classified as STEM. Charlie said he hangs posters of his research students around his classroom to show students that if they have an interest in science this could be possible for them as well. A few teachers suggested bringing in speakers from STEM fields to talk to students about their job and what they do on a daily basis. Dimitri took it one step further and suggested bringing in former students who are working in STEM fields as speakers. In order to accomplish this teachers believe that a change in philosophy at the high school and district level would be necessary. Jean and Lulu both commented that the school does not place an emphasis on science education nor the pursuit of STEM careers as a prime goal. Lulu stated that other districts have embraced STEM and moved forward in implementing programs in high schools and have even created high schools devoted to STEM but this district has chosen to place importance on other areas of learning.

Triangulation: Student science survey and student interviews. The 10th-grade students at this site were generally interested in science. The survey results indicated that over 80% of students agreed that they were *interested in learning about science* and *enjoyed acquiring new knowledge in learning science.* The same was true of the student interviewees, who were interested in learning science because as one interviewee put it, science helps us to "understand how things work in the world" and in doing so helps "everything to make sense." The survey response showed that when asked if they had fun learning science, those agreeing dropped to 72.6%. Interview comments about fun in learning science revolved around how teachers could inject more fun in the learning by creating more opportunities for students to practice science without having “daunting lab reports” or by creating a “fun story” about a topic or by appealing or relating concepts to real-world scenarios that are familiar to high school students.

In general students place a high value on science because they believe that science and technology improve our living conditions and help us understand the world. In looking at the survey results asking about *the value of science to improving the world, understanding the world,* and *to society,* the strongly agree responses ranged from 49.3% to 58.9%. However, when asked questions about how science personally impacts them the percent responses for the strongly agree category declined to a range of 21.5% to 37.8%. While students place a high value on science in general, the *personal value* or *personal relevancy* of science as it relates to them is much lower. The information from the student interviews seemed to support that what students want to see in their learning of science are more applications and personal connections to their everyday lives. Science is more meaningful to students when it is related to the real world, “I learn new things, like each day that are still somehow relevant, somehow relate.” These connections are important in order to facilitate student interest in learning science and facilitate student understanding of science.

Students find science topics that they can relate to more interesting such as biology or astronomy. These topics have direct applicability and visibility in their lives. Human biology was the highest rated of all the science topics followed by astronomy. This same trend appeared in the qualitative data as well. In general, student interest in learning science, based on the topics given in the survey, was in the low to medium range for interest. In the qualitative data strand interest in science seemed to be higher; however, this could in part be due to a few different factors: 1) student participants volunteered to be interviewed; 2) the nature of providing information in a one-on-one setting; or 3) the small sample size.

In examining the teaching and learning strategies it was found that the strategies preferred by students are not implemented enough in most science lessons. The survey data reveal that students do not have as many opportunities to experience hands-on work, design their own experiments, test out their ideas, or debate their ideas. When it comes to *spending time in the laboratory doing practical experiments*, 57.7% responded that it happened in some lessons or hardly ever. When it comes to designing their own experiments, 69.3% of students responded with in some lessons or hardly ever. 67.1% said a class debate or discussion occurred in some lessons or hardly ever. Student responses from the qualitative data showed that students enjoyed lab work, the time spent having a "good classroom" conversation, and the opportunities to experience science in natural settings. Students want to practice more at being scientists. One student commented that by wearing a lab coat, like a scientist, you "feel you would be better at it (science)" and "you will be more interested in it." Although these strategies are preferred by students, they are not utilized enough in the classroom as is confirmed by the survey data. It should be noted a per the survey data, student interest in the ways scientists design experiments or what is required for scientific explanations had the lowest levels of interest, except for the topic of geology. The survey data support the fact that if students are not given opportunities to practice what scientists do, for example, designing their own experiments and providing explanations of the results from these types of self-designed experiments, their interest is not high and the lower interest scores in these areas are not surprising.

The survey provided a picture of what students are currently experiencing in their lessons, while the interviews provided student information and input into what they would like to see occur in the classroom. In looking at these together, students want the same changes: more hands-on opportunities, more classroom debates and conversations, and more opportunities to practice scientist as scientists do. Students interviewed believe these changes to teaching and learning in the classroom would increase their interest. From these data, it can be logically concluded that increasing situational interest in the classroom would impact students' personal or individual interest in learning science in a positive way.

Finally, in analyzing the data regarding careers and science, although 51.5% of students believe they are well-informed or fairly well-informed about science careers that percentage decreases to 44.0% when asked about knowing where to find information about these careers; decreases to 41.4% regarding knowing the requirements for these careers; and to 37.8% who feel well-informed or fairly well-informed when it comes to companies that hire these individuals. The data suggests that students only have a cursory understanding of science careers since they are lacking information for how to approach researching information on these types of careers. In looking further at students' future motivation to learn science, the number of students responding with "strongly agree" or "agree" who *would like to work in a science career* and *would like to study science after high school* is 56.3% and 54.8% respectively. However, when asked *would like to spend my life doing science* and *would like to work on science projects as an adult*, those responses in the "strongly agree" and "agree" categories are only 36.6% and 42.6%. These data are corroborated by the qualitative data collected in the interviews. Of the 11 students interviewed, only three students expressed a desire to pursue science, while another three stated they might be interested in a career in science or math. Five of the 11 students interviewed, while interested in science, did not believe they would pursue a career in a science-related field. During the interview process it became clear that students have limited perceptions of scientists and of science careers. Frequent comments about scientists included the fact that many of the interviewees believe that scientists are smarter than most people. In terms of what scientists do, students most often saw them as working extremely hard in a job that is both demanding and difficult. The vision of the solitary scientist working in a lab was prevalent among the student participants. These narrow views of scientists and science careers support what was found in the survey, i.e., students do not have the information needed to make informed decisions regarding a career in a science-related field. They are not aware of the variety of science-related jobs and have only a limited view of the fields of science. The fact that students learn most of their science at school, as demonstrated by the survey data, provides support for implementing a learning experience that enables students to explore possible science-related careers. Students value science and the role it plays in making advancements that positively impact society and the world and therefore believe in its importance. However, they do not see themselves as being these individuals that change the world, as seen in the survey and interview data, perhaps because they do not possess a thorough understanding of the types and varieties of careers available in science fields. Creating and instituting a targeted STEM career intervention may prove beneficial to increasing student awareness of science careers and ultimately increasing the number of students that enter STEM fields.

Student and teacher perceptions. In examining the data from the interviews of both 10th-grade students and 10th-grade science teachers regarding *student interest in learning science, the instructional learning strategies that support situational interest in the classroom*, and their *thoughts on STEM careers*, the following common elements were identified. The four common thematic elements are: situational interest; connections; passion; and STEM awareness. These data are summarized in a cross-thematic matrix in Table 15. Perceptions from the two viewpoints are used as comparative illustrations in order to highlight the similarities.

Table 15

Student and Teacher Cross-thematic Matrix

Perspective	Situational interest	Connections	Passion	STEM Awareness
Student perception:	Like maybe make a cute story out of it. Like HIV, let's say it's a monster and it sneaks up on the t-cell and takes it out. Something like that. That's more interesting then oh, there is a t-cell and an HIV virus and it goes inside the cell.	And I think with science it is kind of cool because no matter what it applies. Everybody gets a cold. Or everybody, everybody is aware of certain hereditary diseases and GMOs, with elections that is a pretty big topic. .	I think when a teacher is really passionate about what they are teaching it inspires the students. It shows that there is value in what you are learning.	So if you are wearing a science lab coat, you are actually doing the science stuff. I just feel you would be better at it. You will be more interested in it.
Teacher perception:	And I'll say why did I talk about algae, what was the big deal about that story? And then it is that aha moment so that kind of is why I think they need that hook. So some kind of story to get the interest going.	And I was really impressed when one of the kids pointed out hey guys this is just for E.coli we don't know what it does for all other types of bacteria out there. At least from a biology perspective if there is any topic I want my kids to take home with them it is probably antibiotic resistance because it is a huge issue.	Like never give up. Honestly, if I were going to be here another year, I would spend the summer thinking about what changes I would need to make to address this new client that I have had.	I hang those goofy things up for a reason . . . but my goal there is to have kids walk out and say look at this, I know these kids and I know who they are. Just to give the idea that this could be you. If you have an interest in it. Not everybody does but if you have an interest this is possible.

Perspective	Situational interest	Connections	Passion	STEM Awareness
Student Perception:	I love labs because I love doing something and then seeing how that connects to the real world on a smaller scale or how doing something that seems simple actually has on a chemical level so much happening.	I would start out with a real-world application of it and asking the students a question that is related to the topic. Say if I were introducing electricity, I would ask them how do they think it works? And then this would interest them in the topic. And then I would teach them about it. And then try and do experiments with them to show how it works.	I think I would rather hear a teacher say we are going to do a really fun lab today, than we are going to do a lab today. It just entices you more. It is more interesting to hear, like you want to do it just because she says it is fun.	I feel like it would be cool if we could, like one of these days, we could bring in an actual scientist that works in one of those labs. And so they can, so we can actually see what they do or hear about it from their perspective, first hand.
Teacher Perception:	And all of a sudden, 7 or 8 kids were around that area, and said what did you do, what did that? And they started doing it. And I think sometimes with doing something like that it is a lot better than writing on the board Mg + HCl yields $MgCl_2$ and H_2. And then $H_2 + O_2$ makes water. I mean it is good to put it on the board and stuff but I think when the kids actually see it, do it, it makes it more meaningful. I think they remember it longer.	Every unit you can link it to something like for example, solutions, why do you put calcium chloride on ice? Then we talked about how they used to make ice cream using salt and how it decreases the freezing point depression and all that so they are like oh yeah, so that is what actually happens. So they can really link it to what they see every day.	It means that it needs to be done in such a way that they look forward to science class. And it involves a lot of things. A teacher who loves what they are doing not when you walk into a class and the teacher doesn't want to be there. It entails doing labs and demonstrations that peak their interest.	So, I'd say the thing that would be best would be to have the time where the kids can talk to people who are in STEM professions about what they do.

Situational interest. Students and teachers believe that labs and stories are just two modes of learning that stimulate student interest in learning science. Students find that "touching" their learning helps them experience science, creates meaning and understanding, and connects it to the real-world. "Doing science" is an activity that engages students in their learning. Another way to create situational interest in the classroom is by telling a story or creating a "hook." In this way teachers are able to draw students into the learning process and in doing so increase student interest in the topic. Whether it involves tying in history, a personal antidote, or just creating a "cute story," this is one way to get students interested in learning science.

Connections. Relating scientific concepts to real-world examples demonstrates to students the value and importance of learning science. Being able to look at the world around them and see these examples provides a way for students to connect their learning to something tangible. In this way it creates an understanding and appreciation for why learning science is important. Everyone has experienced a cold, everyone has taken antibiotics and so these common experiences provide an example with which to ground the learning. Students want to see these examples in order to connect the concepts to what they are doing in the labs and other activities and to bridge the gulf that can often exist between theory and practice. Real-world connections and examples are the products of applied theory. Teachers and students are adamant in their beliefs that making connections to what students experience in their everyday lives is one of the most important ways to create situational interest in the classroom, promote understanding, and provide a degree of personal relevancy.

Passion. For students, the term "passion" was used to describe teachers who were inspirational in promoting interest in learning science. Over and over again students commented on how teachers who were enthusiastic and excited about teaching science created an environment where learning science was fun and enjoyable. It demonstrates the value of science and makes students want to come to class.

For teachers, the term “passion” refers to their commitment to creating an enjoyable learning experience. The teachers interviewed were always seeking new labs, activities, and opportunities for students to engage in their science learning. Teachers are constantly challenging themselves to “change it up” in order to serve this changing client. Teachers are seeking new ways to make science more interesting and more relevant.

STEM awareness. When it comes to STEM fields and STEM careers both students and teachers require further education and awareness of the variety of opportunities available in STEM fields. Both teachers and students believe that bringing in individuals from STEM fields to talk about what they do is one of the ways to increase awareness. Another way is to show students what is possible is by looking at their peers who are already engaged in scientific research. Science is not just practiced by adults but also by their classmates. Students want to practice being scientists in the same way athletes practice at becoming better at their sport by spending time engaged in the activity and even by dressing the part. In doing so it helps students feel more like true scientists and increases interest. Science learning and further pursuit of science as a career requires increased awareness of STEM careers through training and educating both students and teachers about the opportunities available.

Research study Phase II: STEM career project. The impetus for the STEM Career Project was generated from the information gathered in Phase I of the research, as well as the data collected in the pilot study. Both demonstrated that students were not well-informed about science-related careers and the requirements necessary for these types of jobs. The STEM Career Project was designed as a strategy to increase student interest in pursuing science. The project sought to answer the research question: *Does the intervention of a STEM Career project influence student interest in learning science and pursuing a STEM career?*

The first iteration of the STEM Career Project was completed in June 2016 with 76 10th-grade students. The researcher facilitated this first cycle with one Honors Chemistry class and three Regular Chemistry classes. A total of 76 projects were submitted and evaluated with 75 student projects presented in the classes. One student did not present his project due to his anxiety over public speaking. A total of 71 student reflections were submitted. In addition, 47 responses to the anonymous Post STEM Survey were submitted electronically, out of a possible 76, representing a 61.8% response rate.

Iteration 2 was carried out by three 10th-grade science teachers at the site in Fall 2016. The teachers were colleagues of the researcher and are experienced science teachers. The teachers implemented the intervention with students in Practical Chemistry, Regular Chemistry, and Honors Chemistry with the modifications and refinements completed as a result of Iteration 1.

STEM career project iteration 1: Quantitative data results. The two methods used to assess the effectiveness of the intervention were the quantitative data collected through the Post-STEM Career Survey and qualitative data collected through the student reflections. The Post-STEM Career Survey provided the researcher with a snapshot of information to see if the project had any influence on student interest in pursuing science. The first question asked if the project had increased student awareness of STEM careers. The results are presented in Table 16.

Table 16

Post-STEM Survey Responses to Increased Awareness

Question 1. The STEM Career Project increased my awareness of STEM careers.

Percent Response									
Strongly Agree		Agree		Disagree		Strongly Disagree		Total Response
N	%	N	%	N	%	N	%	N
18	38.3	28	59.6	0	0.0	1	2.1	47

Note. Total percent may not equal 100.0 due to rounding.

The results indicate that 97.9% of the 47 student respondents agreed or strongly agreed that the project increased their awareness of STEM careers.

In question 2, students were asked if the STEM Career Project had any influence on their interest in learning science. These results are presented in Table 17 below.

Table 17

Post-STEM Survey Responses to Interest in Learning More About Science

Question 2. As a result of the STEM Career Project I am interested in learning more about science.

Percent Response									
Strongly Agree		Agree		Disagree		Strongly Disagree		Total Response
N	%	N	%	N	%	N	%	N
7	14.9	8	59.6	10	21.3	2	4.3	47

Note. Total percent may not equal 100.0 due to rounding.

Looking at these results, 74.5% of students strongly agree or agree that as a result of the STEM Career Project they are interested in learning more about science, 25.6% disagreed or strongly disagreed.

The third survey question addressed if they would have any interest in further exploring STEM careers. The results are shown below in Table 18.

Table 18

Post-STEM Survey Responses to Interest in Learning More About STEM Careers

Question 3. I am interested in learning more about STEM careers.								
Percent Response								
Strongly Agree		Agree		Disagree		Strongly Disagree		Total Response
N	%	N	%	N	%	N	%	N
6	12.8	34	72.3	6	12.8	1	2.1	47

Note. Total percent may not equal 100.0 due to rounding.

Results show that most students, 85.1% agree or strongly agree that they would be interested in learning more about STEM careers as a result of the project.

Question 4 of the survey addressed the topic of whether or not the project was valuable in terms of their personal career aspirations. Table 19 below shows a tabulation of these results.

Table 19

Post-STEM Survey Responses to Personal Value for Future Career Aspirations

Question 4. I found the STEM Career Project to be valuable for my future career aspirations.								
Percent Response								
Strongly Agree		Agree		Disagree		Strongly Disagree		Total Response
N	%	N	%	N	%	N	%	N
10	21.3	26	55.3	0	21.3	1	2.1	47

Note. Total percent may not equal 100.0 due to rounding.

The results indicate that for 76.6% or the respondents the project was valuable for their future career aspirations, 21.3% disagreed indicating the project was not valuable for their future career aspirations and another 2.1% strongly disagreed. A later survey question, question 8, students were simply asked: *Did you find the STEM Career Project to be a valuable use of your time?* For this question 80.9% responded with yes, and 19.1% responded with no.

Question 5 of the Post-STEM Career Survey asked students if the project had any influence on whether or not they would consider pursuing a STEM Career. These results are shown in Table 20 below.

Table 20

Post-STEM Survey Responses to Consideration of Pursuing a STEM Career

Question 5. As a result of the STEM Career Project I would consider pursuing a STEM Career.								
Percent Response								
Strongly Agree		Agree		Disagree		Strongly Disagree		Total Response
N	%	N	%	N	%	N	%	N
6	12.8	21	44.7	7	36.2	3	6.4	47

Note. Total percent may not equal 100.0 due to rounding.

The results for this question show that as a result, 57.5% of students strongly agree or agree that they would consider pursuing a STEM career, while 42.6% disagree.

For the remaining questions 6-9 the response format was “yes” or “no.” Survey question 6: *Do you believe the STEM Career Project changed your ideas about learning science?* 70.2% responded with “yes” while 29.8% responded with “no.” In looking at the results from question 7: *Do you believe the STEM Career Project changed your ideas about pursuing a career in science?* 53.2% responded “yes," and 46.8% responded with “no.” Question 8, asked students: *Did you find the STEM Career Project to be a valuable use of your time?* For this question 80.9% responded with “yes” and 19.1% responded with “no.”   The last survey question,

question 9, asked students: *Do you believe the STEM Career Project should be included in the course?* 76.6% of the student respondents believe that the project should be included while 23.4% do not.

STEM career project iteration 1: Qualitative data results.

Student reflections. Assessing the impact of the STEM Career Project on student interest in pursuing science was also done using a qualitative approach. The 71 student reflections were initially coded using a provisional coding technique. In order to answer the research question *Does the intervention of a STEM Career Project influence student interest in learning science and pursuing a STEM career?*, the provisional codes were 'interest in learning science' and 'future interest in learning science'. Responses could be identified as interest in pursuing future science courses or future interest in pursuing a STEM career. In order to identify any other discernable changes as a result of the project, an open or initial coding strategy was also employed. By using a constant comparative approach in reviewing the data, other emergent themes were identified and synthesized until consistent themes could be finalized. The five themes identified were: impact on interest in learning or future learning of science; impact on interest in pursuing STEM careers; "eye-opening"; changes in perception; and personal value or meaning. Table 21 presents the five themes and the representative data from the student reflections.

Table 21

Five Themes Identified from Student Reflections

Interest in future learning of science	Interest in STEM careers	"Eye-opening"
This project has influenced my learning in science. Many of the careers were interesting and I would like to know more about them, especially aerospace engineering. I plan on taking physics next year to further my knowledge on a science similar to my interests.	Mainly because of the engaging projects created by my peers, I believe I was able to really learn and evaluate the many STEM careers and evaluate whether that was a career I should consider. I feel more inclined to go into a STEM career after learning so much more about all of the many careers.	I think that this project has opened my eyes to the possibility of going into a career in science.
This project made me see I am very interested in the environment, parks, and animals which is why I am taking AP Environmental Science next year.	To my surprise, after studying these different occupations I would consider pursuing a STEM career. Learning about the various requirements and different demand and pay for different jobs made me want to explore these careers better.	This project has definitely opened my eyes into the interest of science because I never realized how some of these careers actually involved science.
It has influenced me in certain types of science. For example, after my project I found out we have an astronomy course at the high school. At first I wouldn't bother but now I am most probably going to take it senior year.	This project was the most helpful project I have done in my life, it actually opened my mind to new jobs and now I am thinking to enter and have a STEM career. Before this project I was 100 percent sure that in college I would have done business or marketing but now I have to make a decision because I have found a bigger passion than economics (aerospace engineering).	After watching all the presentations I could see that there are a lot more jobs out there than I thought and it lets me have more of an open mind in the future.

Interest in future learning of science	Interest in STEM careers	“Eye-opening”
This project has vastly increased my interest in learning and educating myself about pursuing jobs in science. This is because before researching STEM careers, when I thought of a job regarding science, all I could imagine was someone in a lab doing experiments all day. . . Next year I intend to take a class in forensic science to learn more about it.	In the past I have always considered careers mostly centered around data science and computer science. Having researched STEM careers in more depth, and heard about careers such as economics, mechanical engineering, and environmental sustainability, all of which I was rather surprised to find as fascinating as I did, I now understand that my previous view was rather limited and I am able to consider a wider variety of careers in many areas with different skills.	This project has helped me narrow down my choices for STEM because I was able to do in depth research. I found researching different careers to be very interesting and before this assignment I had no idea there was such a variety of jobs involving math and science.
The project has not changed my mind in learning science because even before I had accomplished this project I had wanted to learn physics in college.	This definitely peaked my interest in learning science because it made it that much more real to me. I always knew that I would want to take a job in the field of science, I just never knew which one. In all honesty this project gave me more hope in choosing a STEM career. I was able to see all the projected growth for the future, their salaries, and what their day-to-day duties are. Knowing that information gave me a sort of hope, since the jobs no longer feel foreign to me.	I personally am not the best at science and math, and I don’t want to have a STEM career. That being said, I was surprised how many of the STEM careers were considered STEM, and I was drawn to them.
Yes, the project has influenced my interests in pursuing science because I hadn’t fully researched the pros and cons that go along with certain careers, particularly astronomy. I have decided to take an astronomy course next year to help myself decide if it really interests me.	When I began this project I was unsure as to whether or not I would like to pursue a STEM career. However, now a STEM career is a promising option. Both the fields of engineering and medical research have piqued my interest.	Yes, it has influenced my interest because I was able to see a variety of careers in science and realized the relevance and importance of science in our world.

Changes in perception	Personal value or meaning
When I previously thought about careers in science I would think about the stereotypical chemists in lab coats conducting experiments; however, I now understand the span of different careers that come from science and how many of them are much more interesting than I had thought.	Part of the reason I really enjoyed this project is because it is something we could use in the future. Unlike other things we learn in school, that we think we won't use ever again in our lives, the things we learned in this project could guide us in our decisions for what career we want to pursue.
Before I thought that the only STEM jobs were working on a computer or in engineering. After my research, I found out that there is pretty much a STEM job for all different people and all different interests. I also realized that a lot of these jobs have a positive outlook for the future in terms of job growth.	What I found most meaningful or interesting in completing this project was all of these jobs are actually highly possible for me to pursue. I used to think when I was in middle school I couldn't pursue a science based career because I was never really interested in science, or I didn't think I could connect the dots the way I wanted to. But as I started high school, I saw that I could actually apply my knowledge and connect the dots if I worked hard, and after studying what is entailed in each of these careers, I feel very confident that if I work hard I could achieve any of these careers because of my improvement in science-related areas in high school.
I was surprised how much collaboration STEM careers necessitate and how versatile people in STEM careers must be.	It put the job searching world into perspective and broadened my view of my future.
I used to think that pursuing STEM careers would be very boring. On the contrary, the scientists do very interesting things. They aren't in an office the whole time, instead they are doing labs or helping people with their experiments.	What I found most meaningful or interesting in completing this project was the fact that I realized what I want to do when I am older and found out much more about it then I knew before. During my research I also found a list of colleges that major and minor in requirements that you need to become an agent in this field.
What shocked me was how high the growth rates were and the commitment level. One has to be really passionate about what they are studying if it's a STEM career because the education and hours required can be very demanding.	While most people tend to push away their futures to senior year, when they're then faced with a very difficult decision, this helps us narrow our interests. It helped me determine that my true interest lies in STEM careers, and now that I know this I can strive toward achieving goals in these fields.

Changes in perception	Personal value or meaning
This was so meaningful because there are actual people who want to help by trying to advance the world. The work done by these people in STEM is so magnificent because these people care so much about innovating and improving the Earth.	This project has influenced whether or not I could pursue a career in science. This is because of how outside of the careers I researched, there were other careers that caught my attention and had gotten me even more engaged in the project. The most meaningful aspect of the project was how I got to explore different careers that I had not previously considered as something I was interested in or that is was one in STEM.

Interest in future learning of science. This theme is representative of the impact of the intervention on future interest in learning science. As a result of the project, students indicated that it has helped them decide what courses to take in high school. One student commented that "I hadn't fully researched the pros and cons that go along with certain careers, particularly astronomy. I have decided to take an astronomy course next year to help myself decide if it really interests me." Another student expressed how the project "vastly increased my interest in learning and educating myself about pursuing jobs in science. This is because before researching STEM careers, when I thought of a job regarding science, all I could imagine was someone in a lab doing experiments all day. Next year I intend to take a class in forensic science to learn more about it." These comments echo those of many others where the immediate impact is on the courses they will take.

Interest in STEM careers. Regarding interest in pursuing STEM careers, student comments were focused on the positive impact that their own research and the presentations by their peers had on increasing their interest in pursuing a STEM career. For some students this opened up a whole new realm of career opportunities. One student wrote, "To my surprise, after studying different occupations, I would consider pursuing a STEM career." Another commented that the project "gave me hope in choosing a STEM career. I was able to see all the projected growth for the future, salaries, and what their day-to-day duties are. Knowing that gave me a sort of hope, since the jobs are no longer foreign to me."

"Eye-opening." In analyzing the student reflections, the use of the term 'eye-opening', or a variation of this same theme, kept surfacing and therefore the In Vivo code became one of the prevalent themes. The use of this term refers to an 'eye-opening' awareness to the number and variety of STEM careers and even the possibility of a STEM career. The connotation from the data implies that for some students the project was enlightening or 'eye-opening' and the resultant impact was an increased openness to the possibility of a career in STEM. One student wrote, "I think this project has opened my eyes to the possibility of going into a career in science." Another comment that echoes this same theme was "I personally am not the best at math and science, and I don't want to have a STEM career. That being said, I was surprised at how many of the STEM careers were considered STEM and how drawn I was to them."

Two other themes that emerged from the data were changes in perception of science or STEM careers and the personal value or meaning that students derived from the experience.

Changes in perception. "I used to think that pursuing STEM careers would be very boring. On the contrary, the scientists do very interesting things" was just one example of how the exploration of STEM careers changed student perceptions of science and STEM careers. Another student wrote "Before I thought that the only STEM jobs were working on a computer or in engineering. After my research, I found that there is pretty much a STEM job for all different people and all different interests."

Personal value or meaning. Many of the reflections included comments on the personal value or meaning they derived from the project. "Part of the reason I really enjoyed this project is because it is something we can use in the future. Unlike other things we learn in school, that we won't use ever again in our lives, the things we learned in this project could guide us in our decisions for what career we want to pursue." Another student wrote, "While most people push away their futures to senior year, when they're faced with a very difficult decision, this helps us narrow our interests. It helped me determine that my true interest lies in STEM careers, and now that I know this I can strive toward achieving goals in these fields."

Looking at the quantitative and qualitative data, the STEM Career Project did increase student awareness of STEM careers and provided them with new information about these careers, requirements, and the variety of possibilities presented by STEM fields.

Findings from STEM career project iteration 1: Procedural improvements and refinements. Part of any action research project is keeping a reflective journal or field notes documenting the cyclic nature of reflect, act, evaluate, repeat in order to capture the thoughts and ideas as the project proceeds (see Appendix Q). In reflecting upon the procedural aspects of the project, there were some areas that required clarification both for students and for the teachers who will be implementing the project in the next action research cycle. The videos worked well as a kick-off for the project. Seeing a variety of careers and the stories behind why these individuals became STEM professionals was interesting to most students. The number of videos shown or the use of the videos in more than one classroom block can be done to accommodate time restrictions or as a way to increase student attention or engagement in the project. Teachers have flexibility in how they choose to use the videos. In fact, there is also flexibility in terms of the overall timeframe for the project depending on the curricular requirements, teaching time constraints, and academic level of the class. In Iteration 1 a two-week timeframe was used.

While helping students plan the project, the most asked question by students was “do you want a PowerPoint or a document?” Since each student would be doing a presentation to the class, the researcher decided that at least one career had to be presented as slideshow in either PowerPoint or Google slides and the others could be done as a document as long as the six required elements of job title, education or training, responsibilities and activities, companies that employ individuals in this career, projected growth, and salary range were included. In order to alleviate any confusion on the part of the student for the next cycle, all three careers must be presented in the same format, preferably a slideshow format. Since students can be expected to present any one of their three chosen careers and, in order to limit duplication in the classroom presentations, this uniform format will enable any student to present any career in a visually appealing manner. This change from simply stating that the project be created as an electronic document to one that is created specifically in PowerPoint, Google Slides, or any other similar electronic slideshow format. This revision was included in both the revised teacher lesson plan and student handout. In this way there is less repetition in what is presented to the classes and it is easier to incorporate the use of the classroom Smartboard.

Another recommended change was that the initial research begin with students identifying five potential careers and then narrowing the research to three. The reason for this is because of the changing definition of STEM careers (Brown et al., 2011; Lichtenberger & George-Jackson, 2013). The recent inclusion in some literature of social sciences and psychology as STEM careers can create confusion in defining what has been traditionally science, technology, engineering, and math careers. The recommendation for the inclusion of psychology is because it examines human behavior through the use of the scientific method and accrual of basic scientific knowledge, advances the theoretical understanding of human behavior, and understanding human capacities and limitations as technology requires human operators (American Psychological Association, 2009 Presidential Task Force on the Future of Psychology as a STEM Discipline, 2010). Additionally, careers in the medical field are not classified as STEM careers according to the 2010 Standard Occupation Classification (SOC) System, even though these careers require science education (Bureau of Labor Statistics, 2016; Vilorio, 2014). Teachers are therefore being provided with a list of traditional STEM careers as a guideline for helping students identify STEM careers. Ultimately, teacher discretion in using the guidelines will determine the applicability of the career. In Iteration 1, students who felt strongly about researching a career that was not designated as STEM but required an understanding of science or math or science and math skills were allowed to do so for one of the three careers. For example one student was interested in working in the Behavior Analysis Unit of the FBI, a career that involved science and science skills although not classified as STEM. Another student was interested in the work done by financial analysts. If there was a true passion for this career, then the student was allowed to research it as one of the three careers. In addition, the modified teacher lesson plan contains more detailed information than the original regarding STEM jobs, as others will be implementing it (see Appendix R).

For the student project handout, five of the six requirements elements were elaborated upon to provide clarity and examples. Proper citing of sources is often an area with which high school students have limited familiarity. Students at the site typically use Modern Language Association (MLA), so examples of proper MLA citing have been included in the student handout. A link to a website on preparing citations is also included if further questions concerning citing arise. These revisions are incorporated into the revised STEM Career Project handout (see Appendix S).

Students may also require more help in understanding how to write a reflection if they have not had experience with this form of writing. In addition to the class discussion about how to write a reflection and its use as part of the project, students will also be given a handout entitled “Tips on Writing a Reflection” (see Appendix T).

In retrospect, many elements of the intervention worked seamlessly. No changes to the grading rubric or Post-STEM Career Survey were necessary. One of the most well-received and enjoyable aspects of the project were the student presentations. The presentations gave students an opportunity to learn about more careers than the ones they researched themselves. Many students commented that they enjoyed learning from their peers’ presentations. It also provided an opportunity for some students to showcase their presentation skills and develop more confidence in their ability to communicate. Learning from peers was a positive experience for most students and created a supportive and collegial environment.

During the summer, the researcher had an opportunity to test the refinements and make any further improvements before the implementation of Iteration 2 in the fall. The newly modified intervention was completed by a colleague teaching chemistry in summer school. Due to the small number of students, four, the sample was not large enough to provide any significant data; however, it did provide the researcher with an opportunity to observe the intervention and pilot the teacher training. This teacher also agreed to participate in the second action research cycle. There were two notable results from this summer trial: first, using the student feedback, the final student directions for creating the electronic document is clearer than the researcher’s first improvements; second, because the teacher and researcher both used the rubric to grade the projects, interrater reliability demonstrated the consistency of grading when using the rubric. In each case the researcher and teacher were within 2 to 3 points for each assessment area. The area of most subjectivity is creativity and visual presentation. In discussing these areas the researcher and teacher were able to come to a consensus even though the differences were small. In providing training for other teachers implementing the project in the second cycle it is important to review this same point using examples from the researcher's initial study.

Findings from STEM career project iteration 2.

Teacher feedback. Iteration 2 of the STEM Career Project was carried out by three 10th-grade science teachers. All three teachers were approached by the researcher and asked if they would be interested implementing the STEM Career Project with their students. The teachers graciously agreed and, in fact, were excited about the project. The teachers were all teaching different levels of chemistry, Practical, Regular, and Honors. The number of students in the Regular and Honors classes was 22 to 24. In the Practical classes it was 18 to 20 students. Through this collaborative process multiple cases have been generated in order to establish and improve the credibility and validity of the intervention. The teachers completed the project with their students in the fall of 2016. The information gained from their experiences with the different academic levels provided the researcher with the ability to create a final STEM Career Project that includes how the project could be differentiated to meet the needs of a variety of students.

The three teachers were interviewed after implementing the intervention. The nine semi-structured questions were used to seek feedback about the STEM Career Project (Appendix P). The questions focused on three main areas, the first being *was the project a valuable use of instructional time.* All three teachers found the STEM Career Project to be a valuable use of instructional time. Teacher A carried out the project with her three Honors Chemistry classes and noted "I think it was a valuable experience. I think sometimes we get so hung up on the curriculum; we have to cover this, we have to cover that, and in the big picture, their lives won't be ruined if we don't get to a unit." Teacher B who carried out the intervention in two Honors Chemistry classes and two Regular Chemistry classes said "I think we should all do it every year. They (students) need to be exposed to these careers. It doesn't take a lot of time. If they know that they want to do it (STEM career) or don't want to do it, it is helpful because it helps them narrow down their search." Teacher C implemented the intervention with her two Practical Chemistry classes and had this to say, "It was five or six class periods, but they were working on research and presentation skills and they were learning things that could apply to their future careers so I think it was valuable." The project topic was specific to science; however, the skills used in the project were applicable to all subjects and can be used in the future.

Procedural improvements and refinements. The second area of focus was how the intervention worked for them. The teachers were asked specifically: *what aspects worked well; were there any procedural challenges or issues; what modification or refinements were needed;* and *what recommendations or suggestions they might have for improving the intervention.* For Teachers A and B, who used the intervention in Regular and Honors chemistry classes, the materials and procedures worked exceedingly well. Both commented that the organization provided by the lesson plan and supporting materials made it easy for them to implement the components of the intervention. Teacher A, "I compliment you, it was really well put together, the rubric was great, even the quick survey." Teacher B, "The videos were great. They (students) were really into it. . . . They were so enamored by that whole video with the young people. Everything was laid out well. Students knew what was expected." Teacher C who was working with the Practical level students did make modifications to the project; however she had this to say "and the fact that you found these websites and you started this whole thing and created a structure to which all I had to do was make modifications made it really easy for me." For me, the researcher, her input regarding the modifications necessary for the Practical level student was most valuable as I had personally not done the intervention with this type of student.

The project timeframe for the Regular and Honors chemistry students was two class blocks which included the project introduction and preliminary student work. Students were given two additional days to work on the project outside of school. Class presentations required two to three class blocks. For the Practical students, the project was done only in class and took five to six class blocks and one to two additional blocks for presentations. In discussing where the project would work best in terms of the school year the three teachers had different thoughts. Teacher A believed it would be better to complete it in the second quarter of the year after midterms or right after winter or spring break. Teacher B said "I feel in the beginning is better because they (students) are not stressed out and we are not rushing against time." Teacher C felt that for Practical Chemistry students after the Connecticut Academic Performance Test (CAPT) would be the best time to implement it because the pressure to get the students ready for CAPT was over. The general response from the teachers was that the project was valuable in creating student awareness of STEM careers, did not take up too much curricular time, and allowed flexibility for when it could be introduced in the school year.

In terms of improvements, Teacher A thought that the tip sheet on writing a reflection was useful to students and suggested that including one on the elements of a good power point would also be helpful. Teacher B felt that the tip sheet on writing a reflection also helped students with formulating answers. When asked if a tip sheet on elements of a good PowerPoint would be useful, Teacher B thought that for most of the Honors Chemistry and Regular Chemistry students it wasn't necessary but could be useful. In terms of the number of researched careers, Teacher B felt three was the perfect number. Teacher A suggested that researching the three was fine but thought another approach that could be used was having the one being presented done in even more depth because she had students who actually did go beyond the scope of the project due to their level of interest in the career. For these teachers, there were no challenges to implementing the project or other suggestions for improvements. Teacher A did make the point that for a large class presentations can take up more time than expected especially when students ask a lot of questions.

For Teacher C, there were several suggestions for improvements for the Practical level student. Teacher C made modifications as she progressed through the project. She began the project differently. She had students go to one of the websites and begin by identifying ten careers. She then had students write them on the board and discuss some of these identified careers which led into defining STEM careers and the project introduction. For these students the videos stimulated moderate interest but some students did not connect with the individuals in the video. Teacher C stated that some students may not have interest in science-related careers or they may not see themselves as capable of pursuing these careers. She showed two to three videos over the course of a few blocks and felt that although interest wasn't high there was no downside to including them in the project. She said "My goal for them was to become aware of the possibilities."

In terms of the project itself students were able to find the information but struggled with putting it together. She said "The Practical kids who struggled with these things didn't know where to start." To alleviate this she decided to require only two careers and a third could be extra credit. Since she required all students to use Google sheets, the software platform used by the site for electronic documents, and share their documents with her from the start, she could monitor progress and identify students who were able to create successful documents. She then asked these students to present their information and used it as a way to model what students should be trying to create. This helped create a structure for students who were struggling. She then allowed students more class time to make improvements to their documents before presenting to the class. Teacher C talked about giving a template to students who struggle. She commented that not every kid needs one and therefore would not provide one until she had seen their initial work. However, for those struggling having a template of three or four slides available as a model would be useful. Another area of struggle was citations. Students in 10th-grade spend a great deal of time learning how to cite as part of the required sophomore research project but this does not begin until later in the school year. Teacher C said she was fine with their citing the website URL for this project at a minimum. One other requirement of the project that she felt students didn't understand was "projected growth." She said that if she did this again she might take it out because "not one kid understood what that meant. It didn't mean anything to them."

Another improvement that Teacher C made was to the rubric itself. She said the reason was two-fold. One, was to make it easier for her to look for the required elements and two, to make it easier for the students to see and understand what was required. She found that it was better "having the rubric really fit the particular group that you are dealing with and having the rubric laid out in a way that they can use it easily for their needs." Teacher C has a great deal of experience working with this type of student and her insights are truly valuable if the researcher is to be successful in creating a differentiated intervention that can be used across all academic levels. This teacher also chose to combine the survey questions and the reflection into one on-line document. She felt that by condensing the two into one on-line document it would be less overwhelming for her students and would increase the number of students completing the survey.

Influence on student interest. The third area of focus was the influence of the STEM Career Project on student interest in science. The goal of the STEM Career Project was to determine its influence on student interest in pursuing science. The three cases created by the teachers in Iteration 2 demonstrate that it did have an influence on students' interest in pursuing science. Teachers believed that it definitely increased student awareness of STEM careers and all three used the term "eye-opener" to describe its influence on increasing student awareness of STEM careers and its impact on future interest in pursuing science. Teacher A said "I think it was an eye-opener talking about the daily activities. Some kids asked do you learn that stuff in college? No, I replied, you will have the knowledge but you have to apply it." Teacher B in sharing one of her student's reflections read, "It opened my eyes up to more science and more careers involving science. In completing this project, I found that having the resources and exposure to so many different career options was very helpful to my future." Teacher C had a similar experience noting that some kids when talking about why they chose the particular career really went into depth about their reasons. She went on to say that although what she saw in the classroom did not provide overwhelming evidence of a positive influence, the survey results did. Teacher C said that in reviewing her survey data responses to the questions *As a result of the project I am interested in learning more about science* and *I am interested in learning more about STEM careers* more than 62% responded with strongly agree and agree for both.

Another indicator of the positive impact of the intervention was that students were now linking this information to what was being discussed in the classroom. Teacher B said "it was definitely valuable because of how they are linking the projects to what we are discussing in class." She also said that students were also "now looking at the relevance of math and chemistry and how they go together." Teacher A stated that what surprised her most was "that kids really enjoyed listening to their classmates but not just the careers themselves, they were interested in why they wanted to do that." Teachers A and B went on to talk about students who went beyond the scope of the project and started researching more about the daily job activities, more about the areas of the country where these jobs are prevalent and the specific companies that employ individuals in STEM. Teacher B said one of her Honors Chemistry students had mapped out his entire plan to become a medical doctor knowing each step and detail to becoming a neurosurgeon. Teacher A felt that before this project many students had a very narrow view about the types of jobs available and math and science. She also thought that for some students STEM careers can be intimidating but "after doing this they are not as intimidated by the education they need to pursue." She went on to say "definitely for kids that want to pursue STEM it was an eye-opener to the importance of getting that foundation now in order to get ready for college."

Overall, the teachers stated that the reflections, survey data, and what they experienced and observed in the classroom supported the fact that the intervention was a valuable learning experience for both students and teachers. Teacher A commented, "From a teacher point of view I really enjoyed listening to it. It was an eye-opener for me." Teacher B went on to say "It opened my eyes, too, in terms of the scope of these different fields and where they can work." The number of different careers and upcoming fields that students explored from climate change specialist to renewable energy scientist to cyber-security analyst during the project showed students the possibilities and opportunities available to them through learning science.

The findings from Iteration 2 support the findings of Iteration 1 that was completed by the researcher. These additional cases demonstrate that the STEM Career Project was a positive learning experience for students, increased student awareness of STEM Careers and had a positive influence on student interest in pursuing science. The positive feedback regarding the ease of implementation, organizational structure of the materials, and project timeframe make the project universally applicable to any high school science course. The suggestions and recommended changes will be included in the final STEM Career Project (Appendix U).

Summary

The information gathered in Phase I of the study helped to create a picture of the current status of science learning at the site. The Student Science Survey coupled with the student interviews captured students' perceptions of their interest in learning science, identified the instructional and learning strategies in the classroom that create interest for them, and provided information on students' possible pursuit of STEM careers. Merging the data strands provided a more complete picture of student interest in their learning of science and, through the interviews, captured the voices of their individual stories. In general, students believe that science is valuable to society and to understanding the world. Students generally show an interest in science but believe that in order for interest to thrive in the classroom, science concepts must be grounded in real-world problems and experiences that are familiar to them. In order for science to become more personally relevant, science instruction needs to connect with their daily activities and experiences. Students enjoy laboratory experiments and the collaborative classroom activities that are generally part of their science experience; however, they would welcome more opportunities to think, work, play and act like scientists. Students also stated that having a teacher who was passionate about science helped to inspire their interest in learning science. Students felt that students not interested in science need to try and make more of an effort in the classroom.

The results showed that the number of students interested in pursuing science is much less than the number interested in science itself. The results also showed that most students were not fully aware of the career opportunities in STEM fields. The prevailing idea of scientists being exceedingly dedicated and smarter than most individuals seems to continue. The stereotypical scientist wearing a white lab coat and working in a lab is still a common perception of a career in science.

Teachers' ideas of how to increase student interest in learning science and the strategies to accomplish this were very similar to the ones students discussed in their interviews. Teachers believe that students' learning of science needs to connect the concepts studied to what they see in the world. Teaching science through the lens of real-world applications is an important way to create situational interest in the classroom. Other strategies involved creating stories that connect students to the ideas they are studying, allowing students to play with science in order to develop problem-solving skills, changing what they do in the classroom because the students and how they learn has changed. Student involvement in social media through cell-phones and computers has created more distractions in the classroom and has also created a need for teachers to more fully integrate these forms of technology into their classroom instructional practices. Teachers believe that changes such as grounding science learning in real-world applications, providing students with time to experience science as scientists do, more opportunities to "play" with science, bringing in STEM professionals to talk about their careers, and using a variety of instructional practices can create more interest in science but to implement these changes will require time. This includes time to work collaboratively to create curricula, labs, activities, and digital resources. However, in the current climate covering the curriculum, standardized testing, and teacher time spent on duties not related to teaching are all impediments to creating a more interesting classroom environment.

In trying to address why students are not interested in pursuing STEM careers a multitude of reasons were offered from financial rewards to the level of dedication required, lack of math skills, and a lack of awareness regarding career opportunities. Teachers themselves were honest in expressing that they, too, required additional information and training in the area of STEM careers. Teachers also agreed with students that hearing about STEM careers from professionals in these fields would be beneficial to increasing the number of students interested in pursuing STEM fields.

The insights in Phase I provided support for Phase II's action research project, the STEM Career Project. Both iterations of the project were successful in increasing student awareness and interest in pursuing science as demonstrated in the multiple cases. The teachers and researcher believed it was a valuable use of classroom instructional time and created a positive science learning experience for students. The data gathered from the student reflections and survey data indicate that the STEM Career Project positively influenced student interest in pursuing science.

CHAPTER V: CONCLUSIONS

In this chapter the research study is summarized, conclusions are drawn from the major findings, recommendations for future research are presented, study limitations are discussed, and the researcher discusses the impact of the study and its findings on her praxis.

Summary

The action research case study was conducted to: 1) determine the perceptions of students and teachers regarding student interest in learning science and pursuing STEM careers, and 2) test the effectiveness of the STEM Career Project in influencing student interest in pursuing science. The guiding theoretical framework of POI and the 4-phase model of interest development was used throughout the study to define the construct of interest as the relationship between an individual and the domain of science, and to provide the lens through which to collect, analyze and interpret the data. The study design used an exploratory approach in Phase I to collect data from students and teachers regarding their perceptions of student interest in learning science and the instructional and learning strategies that support situational interest. The Student Science Survey used to collect the data from 270 students utilized excerpted sections from the 2006 PISA Student Questionnaire. The Survey results were analyzed using descriptive statistics. Eleven students who participated in the Survey were interviewed in order to provide a more descriptive and detailed understanding of the student perspective. By coding the interview data, emergent themes were generated. In addition, eight science teachers were interviewed to provide a more balanced picture of the teaching and learning at this high school. These interview data were also coded to ascertain themes. Triangulation of the quantitative Student Science Survey data and qualitative student themes data generated from the interviews were corroborated and helped create a deeper understanding of student perceptions of their interest in learning science   Triangulation of the student and teacher interview themes provided a comparative look at the two perspectives.

The collaborative action research approach of Phase II allowed the researcher to determine the influence, if any, of the STEM Career Project on student interest in learning and pursuing science. The Project was designed to increase student awareness of STEM careers by having students explore three careers that they would be interested in pursuing. The purpose of the intervention was to provide students with an experience that was personally relevant and to provide new information in an area they had identified in Phase I as having limited knowledge. Iteration 1 was completed by the researcher with her four chemistry classes. Student data were collected by means of the 71 student reflections that had been coded to determine themes and the results of the 47 responses to the Post-STEM survey. All survey data were analyzed using the descriptive statistic of frequency and, where applicable, a chi square goodness-of-fit test was performed. The results of the chi square analyses on student responses prior to the intervention suggest that there are factors affecting student interest in science as the chi square values exceeded the critical value with three degrees of freedom at a significance level of $p < .05$. No additional analysis tools such as Pearson product-moment correlation, ANOVA, or multiple regression were conducted because the focus of the research was to determine the current state of students' interest in science and their attitudes towards STEM careers in a sample of students currently enrolled in 10th-grade chemistry at a suburban high school. Iteration 2 was completed by three colleagues teaching different levels of chemistry. Teacher feedback was provided through interviews. Their responses from the semi-structured and open-ended questions provided information for refining and modifying the intervention and input on any perceived influence of the project on their students' future interest in science.

Findings

The most important findings about student interest in learning science include:

1. More than 80% of the survey respondents were interested in learning about science and enjoyed acquiring new knowledge about science.
2. More than 50% of the students place a high value on science because it improves society through its innovations and technological advancements. However, fewer than 40% of the students see the personal value or personal relevancy of science in their own lives even though they believe it helps them to understand the world.
3. School is the primary source for student learning of science.
4. For students, human biology has the highest level of interest compared to other science topics.

Findings of teaching and learning strategies that support situational interest in the classroom were reported from the student perspective and teacher perspective. Students:

1. believe that in order to increase their interest in learning science, science must be grounded in real-world applications that connect to their daily lives and experiences.
2. enjoy laboratory experiments, practical hands-on activities, and the collaborative work that makes science learning different compared to what they experience in their other classes.
3. want more opportunities to think, work, play, and act like scientists. They want more than just scientific facts. For them this would increase their interest in learning science.
4. believe a teacher who is passionate about science inspires their own interest in learning science.

Teacher perceptions in the use of strategies to increase student interest were similar to those of students. Teachers:

1. currently use real-world applications to connect and increase student understanding of science concepts; use laboratory experiments, hands-on activities and collaborative work to increase engagement and interest in science learning; and want to increase the use of these strategies and to create more meaningful activities experiences.
2. know they need to vary what they do in the classroom to keep students engaged.
3. believe that bringing in STEM professionals to talk to students about their careers would increase student awareness of science applications and science in the workforce.
4. require time to collaborate in order to create labs, activities, and a classroom environment that stimulates student interest in learning science. However, impediments to doing this include the emphasis on standardized testing, covering the curriculum, and the time spent on duties not related to teaching.

Findings from the implementation of the STEM Career Project include:

1. Students indicated that completing the STEM Career Project was a positive learning experience that increased their awareness of STEM careers.
2. Students gained new information about the variety of STEM career opportunities because before the intervention students were not well-informed about the variety of STEM careers.
3. Student perceptions of scientists and the daily responsibilities of their jobs has changed.
4. Students have been made aware of the possibilities of a career in science.
5. Student interest in learning science and pursuing science has been positively influenced by the intervention.

Conclusions and Implications

Students are generally interested in science and value the importance of science and technology. However students need to see the personal relevancy of science in order to increase their interest in learning and pursuing science (Basu & Barton, 2007; Carson, Hodgen, & Glaser, 2006; Christidou, 2011; Hofstein, Eilks, & Bybee, 2010; Maltese & Tai, 2011; Pressick-Kilborn, 2015; Root-Bernstein & Root-Bernstein, 2013; Rustum, 1990; Turner et al., 2015).

Students and teachers expressed similar thoughts on the strategies and learning approaches to increase student interest in learning science. Both agreed that grounding science learning in real-world applications helps students to visualize and connect science to their own lives. This strategy aids in students' understanding of science, demonstrates the value and importance of science in their daily lives, and increases student interest (Faria et al., 2012; Feierabend & Eilks, 2010; Hasni & Potvin, 2015; Raved & Assaraf, 2011; Seiler, 2011; Valente, Fonesca, & Conboy, 2011). Science unlike other subjects lends itself to a practical hands-on approach that students find enjoyable. Laboratory experiments and activities should be meaningful and connect to the learning but they should also have an element of fun and excitement in order to engage students and further interest (Bulunuz & Jarrett, 2015; Lin et al., 2012; Swarat, Ortony, & Revelle, 2012). Students need opportunities to "play" with science, experience science in natural settings, and practice science as scientists. Teachers should use a variety of learning strategies and modalities in the classroom to keep students engaged.

Teachers who are passionate about the subject inspire student learning. Teachers who are passionate are constantly learning and finding new ways to make the science classroom experience positive and enjoyable (Logan & Skamp, 2013; Maltese & Tai, 2010). To accomplish this, teachers need time to collaborate in order to find new ways to encourage student interest in science. As one teacher put it, our client is changing and teachers have to find new ways to engage students in their learning. Most teachers seem to have ideas about how to accomplish this but do not have the time nor the support needed to make these changes a priority. Teachers believe that the emphasis on standardized testing, benchmark assessments, and the activities associated with them interfere with the class time needed to present the given curriculum. Teachers are expected to accomplish all of these and, as one teacher stated, "yet nothing is taken off our plates."

If students are to enter STEM careers, education about STEM is necessary for both students and teachers. Students are not aware of the variety of opportunities that exist in STEM fields or the requirements of these jobs. Students and teachers would like to invite STEM professionals to speak to students about their job responsibilities, what they do every day, and the requirements necessary to enter the field. The instructional approach of the intervention capitalized on two important components essential to the development of interest: an opportunity to acquire new knowledge in an area of which students have limited knowledge and a task that is personally relevant to students and their future (Durik, Hulleman, & Harackiewicz; Hidi & Renninger, 2006; Krapp, 2005; Schiefele et al., 1983; Wigfield & Cambria, 2010; Wigfield & Eccles, 2000). The change in student attitude toward studying science and pursuing a STEM career indicates the success of this type of instructional approach.

Limitations

This action research study is a single case of one suburban high school and therefore the findings presented are specific to the site. Generalizing the results from this small sample of 10th-grade students and 10th-grade science teachers beyond the scope of this site is not possible. However, the results do provide a means to gauge student and teacher perceptions of interest in learning science at this high school. The methods of data collection used in Phase I of this research can be applicable to other sites interested in exploring how to increase student interest in science. The final STEM Career Project could be implemented at any high school.

Students participating in the interviews were a nested sample of students from the larger student sample that completed the Student Science Survey. However, as the Survey was anonymous, it was not possible to confirm student interviewees' participation. In using self-reporting data, the researcher must acknowledge that respondents' answers may be influenced by what the respondent believes the researcher wants to hear. The students participating in the interviews volunteered to be part of the research study and therefore any bias or threats to validity associated with it needs to be acknowledged. Teacher participants are colleagues of the researcher and although this relationship may help to elicit frank and honest responses it nonetheless may influence the resulting data. The researcher is also a teacher at the site which enabled access and provides a level of familiarity with the science program and curriculum. In addition, the researcher was the only individual to code the interview data. If the data had also been coded by a peer, researcher bias would have been reduced. The emic and etic roles of the researcher in different phases of the research needed to be acknowledged as the credibility and validity of the research is impacted by the ethical conduct of the researcher.

In Iteration 2 of the STEM Career Project it was not possible for the researcher to observe the three other teachers implementing the intervention due to conflicts in our teaching schedules. Observations could have provided another data source for the research and enabled the researcher to experience in situ how the implementation process worked for these teachers. Finally, although the STEM Career Project was well received by students and the immediate results did have a positive impact on student interest in pursuing science, the long term effect is unknown. In order to assess any long-term influences follow-up with these students at a later point in time would be necessary.

Recommendation for Future Research

Many factors contribute to the process of developing interest in learning science (Ainley & Ainley, 2011a; Ainley & Ainley, 2011b, 2011; Durik, Hulleman, & Harackawiewicz, 2015; Hasni & Potvin, 2015; Hidi & Renninger, 2006; Krapp & Prenzel, 2011; Maltese & Tai, 2010; Osborne, Simon, & Collins, 2003; Parsons, Miles, & Petersen, 2011; Pressick-Kilborn, 2015; Skamp & Logan, 2013; Turner et al., 2015). Instructional practice is just one of these factors. Further exploration into identifying and testing specific instructional practices other than a STEM career project and their impact on student interest is required. Creating situational interest in the classroom is essential for stimulating and maintaining interest.

Just as different instructional practices impact student interest so does the teacher. Students in this study repeatedly commented on how a passionate teacher helps to inspire and create interest. Therefore, further research on the impact of the teacher on student interest in learning science should be explored. Understanding the reasons why and when students lose interest in learning science is an important area for future research. If a student does lose interest, can that interest be revived, and if so how? In a society ever dependent on science and technology, scientific literacy is important for all individuals, not just those entering a STEM field.

Future research as an outcome of the study would involve implementation of the STEM Career Project by individuals at this site or other sites to provide multiple cases for assessing its effectiveness. Providing students with the ability to explore STEM careers creates personal relevancy and knowledge that is applicable to their future. In the short term, students indicated that the intervention had a positive influence on their interest in learning science. However, only follow-up would provide a means of assessing any long term effects.

Researcher Praxis

This research study afforded the researcher the opportunity to determine the current state of student interest in learning science at the site in order to implement changes in the classroom. Student input has been valuable as another lens through which to critique praxis and to create a more stimulating learning experience. The application of science to current world problems and daily student experiences is paramount to student interest in learning and understanding science. This has made the researcher even more convinced and determined to draw upon real-world applications and the experiences from working in industry to help students see and understand the world around them. Children are naturally curious. They learn through observation but learning science requires more than just observation it requires making connections and acquiring the ability to ask how does this relate to everyday life and why is it important? Teachers need to pose the how and why questions to students in order to help them develop this skill. Allowing students to search for these answers instead of providing them outright helps students develop their research skills and take responsibility for their learning. The researcher-teacher has become much more aware of this responsibility as a result of the study. Taking the time to create connections to demonstrate the applicability of science to real-life activities in the curriculum is important but it is also important to be cognizant of the opportunities that arise in the classroom and capitalize on these as well. In addition, listening to students and encouraging their feedback is also an important component to creating a better learning experience. Students have definite ideas about their learning and how to make it more interesting. For teachers this can be a helpful source of information.

The pilot study results were the reason for the choice of a STEM career project. Until that time the researcher was still formulating research questions and struggling with how to effectively design a study that would answer the questions. From the pilot study it was clear that students lacked information about STEM careers. Designing the intervention itself was an interesting undertaking and provided the researcher a way to create a learning experience for students that she thought they would find both enjoyable and interesting. The more difficult part was in designing effective measures of attitudes. Surveys can provide general background information but they lack the detail required for understanding how perceptions are created and how they can be changed. In hearing the lived stories through student and teacher interviews, and in the written reflections of students, the researcher captured the details surrounding how these perceptions of learning science and pursuing science were created and how they changed. Creating the interview questions and the reflection questions in order to distill this type of information took time and planning. In working with students, questions had to have a logical progression and had to be clear and direct. Finally, while literature searches can help provide ideas and a direction for a research study, it is only through formulating the research questions and effective measures to answer those questions that a researcher is born.

The STEM Career Project was a useful tool to increase student awareness of STEM careers. Awareness and knowledge of the variety and types of occupations in STEM fields is critical to increasing the number of students who go on to pursue science. If students don’t have this type of career information while they are in high school and beginning to formulate career options, how can they entertain the possibility of a STEM career? Schools are the primary source of science learning and therefore critical to developing a scientifically literate population and workforce. Students need to see the impact of science and technology on their lives and they need to be able to connect science to their daily experiences. Learning about topics such as chemical reactions or stoichiometry and how to use them to solve a word problem on paper does not demonstrate the power or importance of these concepts in real-world applications. The STEM Career Project was designed to demonstrate the relevancy of the concepts being learned by providing a way for students to explore how these concepts are used and applied in careers.

The STEM career project was well-received by both students and teachers. Completion of iteration 1 by the researcher provided the means to modify and revise the lesson plan and measures. Student feedback in iteration 1 was positive and demonstrated the need to include more details in the student directions and project requirements. For iteration 2, being done by three other teachers, the researcher had to include more details in the teacher materials so that it could be easily implemented. Reviewing the materials and field notes, in order to include all the details required for another teacher to implement the project, enabled the researcher to truly analyze the project through a fresh pair of eyes thereby improving upon the original design. Discussing the project with the teachers before they carried out iteration 2 helped answer questions and provide clarity. As the researcher learned first-hand, the success of an action research study is dependent upon the willingness and active participation of colleagues, and the collaborative and open dialogue required for implementation of the intervention. Iteration 2's repeated cases provided further proof that the intervention created a positive learning experience for students and increased student awareness of STEM careers. For the researcher, one of the most positive comments came from the teachers. All three teachers commented that the teacher materials were clear, detailed and logical making it easy for them to implement the project.

As for student feedback in iteration 2, one of Teacher A's students spoke with her uncle about the project. Her uncle is a well-renowned scientist, former head of research and development for a major pharmaceutical company, medical school professor working on an AIDS vaccine, and recently head of infectious diseases for a privately funded science initiative. He has been inducted into the National Academies of Sciences, Medicine and Engineering. He told his niece he thought the project was an excellent idea. That is a truly exciting endorsement.

This research study has been a very personal journey that stemmed from the researcher's own love affair with science, specifically chemistry. The researcher's decision to study chemistry in college was made in the 10th-grade because of the positive learning experience created by very dynamic chemistry teacher. The researcher only hopes that she too is able to inspire her own students to pursue a science career or, at the very least, help students develop an appreciation for the importance of science in their lives. Reflecting on the results of the research, and the honest opinions and voices of students, the researcher has become more aware and more critical of her teaching practices. The experience has enabled the researcher to become a better teacher and to challenge herself to try new ideas, strategies, and interventions that create situational interest in the classroom and an enjoyable science learning experience for students. Traditional academic measures of performance do not adequately represent the level of student interest in science learning. Classroom opportunities that offer students creative ways to obtain and demonstrate knowledge, such as the STEM Career Project, can go a long way in developing student interest in science. Providing new ways for students to experience science learning that demonstrate direct applicability to their lives and even future career goals is critical to creating student interest in science. Additionally, providing formal and informal opportunities for student feedback can provide insights into creating an atmosphere in which interest can develop and thrive. This researcher has learned that students have very definite ideas about how to increase their interest in learning and pursuing science. Listening to these ideas can help to create an environment that can 'catch and hold' student interest.

The researcher believes this quote from Tyler, one of the students interviewed in the study, describing his view of science and the attitudes he believes exist towards science demonstrates that, given a chance, there is an interesting form of science for everyone. "They generalize science but there are different subsections, just like in art. There is painting, there is drawing. Science in a way is our art. It is the world's art. It is our understanding of the world's art. That is what I think science is." Science is a beautiful art form and bringing attention to its beauty is an important component of good teaching.

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Appendix A

UBmail

Vartuli, Cindy <cvartuli@my.bridgeport.edu>

2006 Student Survey

4 messages

Vartuli, Cindy <cvartuli@my.bridgeport.edu> Mon, Mar 10, 2014 at 3:55 PM
To: rights@oecd.org

To Whom It May Concern,

I am interested in using your 2006 OECD Program for International Student Assessment survey as part of a case study. I am a doctoral student at the school of education at the University of Bridgeport in the United States. I am interested in using this science survey to gather information for my dissertation research. After reading your PISA product license information, it appears that it is possible to use the survey as long as it is not to be commercially distributed and no official mark or logo appears on the document. Credit of course will be given to the OECD.

Before using the survey, I wanted to get confirmation that it could be used and if there were any other restrictions not clearly outlined in the products license information.

Thank you for your consideration. I look forward to hearing from you.

Sincerely,

Cindy Vartuli
University of Bridgeport
Bridgeport, CT USA

PACRights@oecd.org <PACRights@oecd.org> Thu, Apr 17, 2014 at 6:10 AM
To: cvartuli@my.bridgeport.edu
Cc: PACRights@oecd.org

Dear Cindy,

Thank you for your request. We are pleased to confirm that you are authorized to reproduce for non-commercial purposes OECD (2008),PISA 2006: Volume 2: Data, PISA, OECD Publishing. http://dx.doi.org/10.1787/9789264040151-en in your dissertation research.

Please cite the material you wish to use as follows:

OECD (2008),PISA 2006: Volume 2: Data, PISA, OECD Publishing.

http://dx.doi.org/10.1787/9789264040151-en

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Appendix B

Student Science Survey

In this survey you will be asked questions about your views on science, careers in science, learning, and teaching and learning science. Your participation is voluntary. The information collected is confidential and the survey does not contain information that can personally identify you. The information collected has no influence on your grade, or relationship with your teacher or school. The collected information is stored in a password protected electronic format.

* Required

1. **By checking this box, I agree to be in the research study described above. ***
   Check all that apply.

   - [ ] I agree to participate in the study.

Section 1: About You

2. **Q1a What grade are you in? ***
   Mark only one oval.

   - 10th
   - 11th
   - Other: ____________

3. **Q1b What science class are you currently taking? ***
   Mark only one oval.

   - Honors Chemistry
   - Regular Chemistry
   - Practical Chemistry
   - Biology 10
   - Honors Biochemistry

Appendix C

GREENWICH PUBLIC SCHOOLS

Havemeyer Building
290 Greenwich Avenue
Greenwich, Connecticut 06830-6521
(203) 625-7400

William S. McKersie, Ph.D.
Superintendent of Schools

FAX: (203) 618-9379
William_McKersie@greenwich.k12.ct.us

October 14, 2015

To Whom It May Concern,

The district has been asked by Cindy Vartuli, a doctoral student at the University of Bridgeport and a chemistry teacher at Greenwich High School, to conduct research as part of her dissertation proposal within the Greenwich Public Schools, specifically Greenwich High School. Our understanding of the research to be conducted is as follows.

The overriding purpose of this research is to explore student interest in learning science in order to understand how to make learning science more interesting. The research seeks to understand student perceptions of interest in learning science, teacher perceptions of student interest in learning science, and what instructional and learning strategies support the development of situational interest. Situational interest represents the earliest phase of engaging in a relationship with a specific subject or domain, in this case science. It evolves from Dewey's idea of "catch and hold" where learning must first grab the attention of the individual and then be maintained through learning activities. The classroom is the venue through which students develop situational interest which can lead to the more enduring personal interest. Research has established that nationally and globally there has been a decline in students entering STEM fields and many nations are concerned for their countries economic prosperity. The research findings will be shared with the district in an effort to provide understanding of the local conditions in order to increase student situational interest in learning science in the classroom. The research can assist in informing teacher praxis, in designing learning and instructional activities, and in implementing science curricula. The Greenwich Public Schools bear no responsibility for the findings and publication of results.

To obtain the necessary information, the first phase of the research involves inviting all 10th grade science students to participate in an online Student Science Survey. Participation is voluntary. The survey questions have been excerpted from the PISA 2006 Student Science Questionnaire. The sections excerpted focus on students' views on science, careers and science, learning, and teaching and learning science. In addition, six to ten 10th grade students, who have completed the survey, will be interviewed using semi-structured interview questions that relate to their perceptions of student interest in learning science and teaching and learning in the science classroom. Student selection will be from 10th grade science classes but not from Ms. Vartuli's class. Five to six, 10th grade science teachers will also be interviewed using semi-structured interview questions that ask them about their perceptions of student interest in science and the teaching and learning strategies they employ in their classrooms to engage student interest. The

Appendix D

GREENWICH HIGH SCHOOL

A collaborative community of learners dedicated to academic excellence, civic engagement, social responsibility and personal integrity.

Dr. Christopher S. Winters
Headmaster
TEL (203) 625-8000
FAX (203) 863-8813
chris_winters@greenwich.k12.ct.us

December 2, 2015

Dear Parent/Guardian,

We are writing to inform you about a research project that is being conducted at Greenwich High School as part of a doctorate program.

The purpose of this research project is to explore student interest in learning science in order to understand how to make learning science more interesting. This research seeks to capture the student and teacher perspectives in order to develop a more complete picture of how to increase student interest in learning science in the classroom.

This research project is being conducted by Cindy Vartuli at the University of Bridgeport. Cindy Vartuli is also a chemistry teacher at Greenwich High School. Your child is being invited to participate in the research project because he or she is a 10^{th} grade science student at Greenwich High School.

The procedure involves filling out an online survey that will take approximately 20 to 25 minutes. The survey is anonymous. Your child's responses will be confidential and we do not collect identifying information such as your child's name, email address or IP address. The survey questions are about views on science, careers and science, learning time, and teaching and learning related to science instruction. The link to the survey will be emailed to your child.

We will do our best to keep your information confidential. All data is stored in a password protected electronic format. To help protect confidentiality, the survey does not contain any information that will personally identify your child. The results of the study will be used for scholarly purposes only and may be shared with University of Bridgeport representatives and once the research is published, with the district. The survey is available for you to review at https://goo.gl/3lzMze

If you have any questions about the research study, please contact Cindy Vartuli

(cvartuli@my.bridgeport.edu or cindy_vartuli@greenwich.k12.ct.us). This research has been reviewed according to the University of Bridgeport IRB procedures for research involving human subjects.

Your child's participation in this research study is voluntary. You may choose not to participate. If you decide not to participate in the study your child will not be penalized. The student can also stop participation at any time while completing the survey until submission.

We are contacting you to ensure that you know that if you DO NOT want your child to participate that you may opt-out by completing the online electronic Opt-out form. The link to the Opt-out form is http://goo.gl/forms/G4IE7p4HeS All responses will be recorded to ensure students do not participate.

All opt out forms must be returned by December 16, 2015, as this phase of the study is scheduled to begin on Dec. 17, 2015. If you have any questions, please feel free to contact Cindy Vartuli at cvartuli@my.bridgeport.edu or cindy_vartuli@greenwich.k12.ct.us.

Sincerely,

Dr. Christopher S. Winters
Greenwich High School Headmaster

Cindy Vartuli
GHS Chemistry Teacher
Doctoral Candidate
University of Bridgeport

Appendix E

Research Study Survey Opt-Out Form

Complete the information below if you DO NOT want your child to participate in the Student Science Survey. Please make sure to submit this form prior to December 4, 2015.

The purpose of this research project is to explore student interest in learning science in order to understand how to make learning science more interesting to students. Please read the complete information regarding the study in the email that was sent with this form. If you have any questions please feel free to contact me at cindy_vartuli@greenwich.k12.ct.us. Thank you.

* Required

I DO NOT give permission for my child to participate in the 2015 Student Science Survey being conducted at Greenwich High School.

1. **Student Last Name** *

   ____

2. **Student First Name** *

   ____

3. **Student Grade** *

   Mark only one oval.

   ◯ 9
   ◯ 10
   ◯ 11

Appendix F

Student Interview Protocol

Researcher: Thank you again for agreeing to participate in this interview. I would just like to ask your permission to audiotape this interview. (Interviewee responds.) Again, all information obtained during this interview will remain confidential and a chosen pseudonym will be used in place of your name to protect your identity. The interview should take approximately 15 to 30 minutes. The focus of the interview is on your interest in learning science. Do you have any questions about my study or interview procedures? (Pause. Answer any interviewee questions before proceeding.)

1. In thinking about your school experience, what is your favorite academic subject?

2. Why is that your favorite subject?

3. Tell me about your school science learning experience.

4. When was your first classroom experience with science?

5. Tell me about your interest in learning science.

6. What aspects of science do you find interesting?

7. What is your favorite part of science class?

8. Can you give me an example of a classroom situation that you found interesting?

9. On the other hand, can you tell me some aspects of learning science that you don't find interesting?

10. Can you give me an example?

11. Tell me about your favorite science teacher?

12. What made them your favorite teacher?

13. What did they do in the classroom?

14. How is that different from other subject teachers?

15. How did they make science interesting to you?

16. Can you share a story about them with me?

17. What do you think a science class should look like?

18. How should a science class be conducted in order to be interesting?

19. What should the teacher do?

20. What should the students do?

21. Describe this scenario to me.

21. I know that as a 10^{th} grader you have probably begun to think about careers. Would you share with me what careers you have started to think about?

22. Would you consider a career in a science, technology, engineering or math (STEM) field? Why or why not?

23. When you think about a person in a science, technology, engineering or math (STEM) field, who do you think about? Why?

24. In your mind, what do they do?

25. How do you see the life of a scientist?

26. Do you think they are different from people in other careers?

27. Do you have any additional comments to our discussion?

28. Is there anything you would like to add that you think is important to understanding your interest in learning science?

Researcher: Thank you again for agreeing to be a part of my study. I greatly appreciate the time you have given up in order to answer my questions. I will be getting back in touch with you to share the transcript of the interview and confirm the accuracy of your responses. If you think of anything else you would like to add or have any further questions, please feel free to email me at cindy_vartuli@greenwich.k12.ct.us or call me at 203-610-9610. Again, thank you for sharing your views and insight.

Appendix G

1 - Title of research study: Exploring Student Interest in Learning Science: How Can Learning Science be more Interesting?: A Case Study

2 - Investigator: Cindy Vartuli

We invite your child to take part in a research study because he or she is a 10th-grade student in Greenwich and has completed the on-line Student Science Questionnaire.

3 - What you should know about a research study

- Cindy Vartuli will explain this research study to you.
- You volunteer to be in a research study.
- Whether or not you take part is up to you.
- You can choose not to take part in the research study.
- You can agree to take part now and later change your mind.
- Whatever you decide it will not be held against you.
- Feel free to ask all the questions you want before you decide.

4 - Who can I talk to?

If you have questions, concerns, or complaints, or think the research has hurt you, talk to the research team at: Cindy Vartuli, cindy_vartuli@greenwich.k12.ct.us.
This research has been reviewed and approved by an Institutional Review Board. You may talk to the IRB Co-Chair at (203) 576-4973 or chemp@bridgeport.edu about any of the following:

- Your questions, concerns, or complaints are not being answered by the research team.
- You cannot reach the research team.
- You want to talk to someone besides the research team.
- You have questions about your rights as a research subject.
- You want to get information or provide input about this research.

5 - Why are you doing this research?

My name is Cindy Vartuli and I am currently a chemistry teacher at Greenwich High School and a fourth year doctoral student at the University of Bridgeport working on my dissertation. I am sending you this letter because I would like to interview your child as part of my research study exploring student interest in learning science.
Before agreeing to be part of the study, please read the following:
The purpose of the research is to understand how to make learning science more interesting for students. You may be familiar with the research as your child has completed the on-line Student Science Questionnaire. The survey was the first phase in this sequential study. The next phase involves interviewing students in order to understand the student perspective on their interest in learning science. The semi-structured questions will focus on interest in learning science, student views on the types of science teaching that make science interesting, student views on teaching methods that maintain, support and increase student interest in learning science, and STEM (Science, Technology, Engineering, and Math) careers. The research will include both the student and teacher perspectives in order to provide a more balanced and comprehensive look at student interest in learning science.

In order to decide whether or not you wish your child to be a part of the study you should know enough about its risks and benefits to make an informed decision. This consent form provides you with the detailed information about the study. I will discuss any aspects of the study with you that you do not understand. Once you understand the study, you will be asked to give permission for your child to participate. If you agree to participate you will be asked to sign this form.

6 - How long will the research last?

We expect that your child will be in this research study for 4 months beginning in March 2016. During this timeframe the initial interview with your child will take place at school and the follow-up meeting to confirm the accuracy of your child's responses. The initial interview will take 15 to 30 minutes and the follow-up meeting will take 10 to 15 minutes.

7 - How many people will be studied?

We expect about ten to twelve 10th-grade students here will be in this phase of the research study out of the 10^{th}-grade student population who participated in the on-line Student Science Questionnaire. We expect that your child will part of this research study for 4 months or until the follow-up meeting is completed.

8 - What happens if I say yes, I want my child to be in this research?

If you agree to have your child participate, the researcher will set up an interview time to ask you child a series of semi-structured interview questions that focus on interest in learning science, student views on the types of science teaching that make science interesting, student views on teaching methods that maintain, support and increase student interest in learning science, and STEM careers. The interview will take approximately 15 to 30 minutes and will be conducted at school in a science classroom. The interview will be audiotaped using a dedicated digital recorder and a pseudonym chosen to protect your child's identity. After the researcher has transcribed the data from the interview, a second meeting will be scheduled to confirm the accuracy of your child's responses. This second meeting should take approximately 10 to 15 minutes and occur within three weeks of the initial interview.

9 - What happens if I say no, I do not want my child to be in this research?

You may decide not to have your child take part in the research and it will not be held against him or her. Participation is voluntary and opting out will not impact or affect your child academically or their relationship with their classroom teacher.

10 - What happens if I say yes, but I change my mind later?

You agree to allow your child to take part in the research now. You may stop at any time and it will not be held against your child. If you decide to remove permission for your child to participate in the research, contact the investigator so that the investigator can cancel the initial interview or follow-up interview. If the interview data has been audiotaped, transcribed, and or coded, the researcher will destroy any data collected and copies will be given to you. Withdrawal from the study will not impact or affect your child academically or their relationship with their classroom teacher.

11 - Is there any way being in this study could be bad for my child?

There is minimal risk to your child as the topic is not controversial and the findings when published are anonymous.

12 - Will being in this study help my child in any way?

We cannot promise any benefits to your child or others from your taking part in this research. However, possible benefits include that the insights gained from your child's perspective can help in understanding how to increase student interest in learning science and how to improve the way science instruction is delivered in the high school classroom.

13 - What happens to the information that is collected?

Efforts will be made to limit your and your child's personal information to people who have a need to review this information. Personal information obtained during the study will remain confidential. We cannot promise complete secrecy. Organizations that may inspect and copy your information include the Institutional Review Board of the University of Bridgeport and my dissertation committee members.

14 - Can I be removed from the research without my OK?

The person in charge of the research study, Cindy Vartuli, or the sponsor institution, University of Bridgeport, can remove your child from the research study without your approval. Possible reasons for removal include that the researcher can also end the research study early.

15 - What else do I need to know?

Thank you for your consideration in participating in this study. If you have any further questions, please feel free to contact me. Cindy Vartuli, cindy_vartuli@greenwich.k12.ct.us

Chosen Pseudonym: ____

Signature Block for Children

Your signature below documents your permission for the child named below to take part in this research.

DO NOT SIGN THIS FORM AFTER THIS DATE →

Printed name of child

Signature of parent or guardian

Date

Printed name of parent or guardian

- ❑ Parent
- ❑ Guardian (See note below)

Note on permission by guardians: An individual may provide permission for a child only if that individual can provide a written document indicating that he or she is legally authorized to consent to the child's general medical care. Attach the documentation to the signed document.

Assent

- ❑ Obtained
- ❑ Not obtained because the capability of the child is so limited that the child cannot reasonably be consulted.

[Add the following block to all consents]

Signature of person obtaining consent and assent

Date

3/9/2016

Printed name of person obtaining consent

Form Date

Appendix H

1 - *Title of research study:* Exploring Student Interest in Learning Science: How Can Learning Science be more Interesting?: A Case Study

2 - *Investigator:* Cindy Vartuli

We invite you to take part in a research study because you are a 10th grade science teacher in Greenwich.

3 - *What you should know about a research study*

- Cindy Vartuli will explain this research study to you.
- You volunteer to be in a research study.
- Whether or not you take part is up to you.
- You can choose not to take part in the research study.
- You can agree to take part now and later change your mind.
- Whatever you decide it will not be held against you.
- Feel free to ask all the questions you want before you decide.

4 - *Who can I talk to?*

If you have questions, concerns, or complaints, or think the research has hurt you, talk to the research team at: Cindy Vartuli, cindy_vartuli@greenwich.k12.ct.us.
This research has been reviewed and approved by an Institutional Review Board. You may talk to the IRB Co-Chair at (203) 576-4141 or irb@bridgeport.edu about any of the following:

- Your questions, concerns, or complaints are not being answered by the research team.
- You cannot reach the research team.
- You want to talk to someone besides the research team.
- You have questions about your rights as a research subject.
- You want to get information or provide input about this research.

5 - *Why I am doing this research?*

My name is Cindy Vartuli and I am currently a chemistry teacher at Greenwich High School and a fourth year doctoral student at the University of Bridgeport working on my dissertation. I am sending you this letter because I would like to interview you as part of my research study exploring student interest in learning science.

Before agreeing to be part of the study, please read the following:

The purpose of the research is to understand how to make learning science more interesting for students. You may be familiar with the research as many of your students have completed the on-line Student Science Survey. The survey was the first phase in this sequential study. The next phase involves interviewing science teachers in order to understand their perspective on student interest in learning science. The semi-structured questions will focus on your perceptions of student interest in learning science, the types of teaching strategies that you use in the classroom, your views on the effectiveness of those strategies in maintaining, supporting and increasing student interest in learning science, and your views on how to improve student interest in learning science. The research will include both the student and teacher perspectives in order to provide a more balanced and comprehensive look at student interest in learning science.

In order to decide whether or not you wish to be a part of the study you should know enough about its risks and benefits to make an informed decision. This consent form provides you with the detailed information about the study. I will discuss any aspects of the study with you that you do not understand. Once you understand the study, you will be asked to participate. If you agree to participate you will be asked to sign this form.

6 - How long will the research last?

We expect that you will be in this research study for 6 months beginning in December 2015. During this timeframe the initial interview will take place and the follow-up meeting to confirm the accuracy of your responses. The initial interview will take 40 to 45 minutes and the follow-up meeting will take 20 minutes.

7 - How many people will be studied?

We expect about six to seven 10th-grade science teachers here will be in this phase of the research study. We expect that you will be in this research study for 6 months or until the follow-up meeting is completed.

8 - What happens if I say yes, I want to be in this research?

If you agree to participate, the researcher will set up an interview time to ask you a series of semi-structured interview questions regarding your perceptions of student interest in learning science, the types of teaching strategies that you use in the classroom, your views on the effectiveness of those strategies in maintaining, supporting and increasing student interest in learning science, and your views on how to improve student interest in learning science and your views on the current Science, Technology, Engineering and Mathematics (STEM) situation. The interview will take approximately 40 to 45 minutes and will be conducted at school in a science classroom. The interview will be audiotaped and you will be allowed to choose a pseudonym to protect your identity. After the researcher has transcribed the data from the interview, a second meeting will be scheduled to confirm the accuracy of your responses. This second meeting should take approximately 20 minutes and occur within three weeks of the initial interview.

9 - What happens if I say no, I do not want to be in this research?

You may decide not to take part in the research and it will not be held against you.

10 - What happens if I say yes, but I change my mind later?

You agree to take part in the research now. You may stop at any time and it will not be held against you. If you decide to leave the research, contact the investigator so that the investigator can cancel the initial interview or follow-up meeting. If the interview data has been audiotaped, transcribed, and or coded, the researcher will destroy any data collected and copies will be given to the individual.

11 - Is there any way being in this study could be bad for me?

There is minimal risk as the topic is not controversial and the findings when published are anonymous.

12 - Will being in this study help me any way?

We cannot promise any benefits to you or others from your taking part in this research. However, possible benefits include that the insights gained from the information can help in understanding student interest in science and how to improve the way science instruction is delivered in the high school classroom.

13 - What happens to the information you collect?

Efforts will be made to limit your personal information to people who have a need to review this information. Personal information obtained during this study will remain confidential. We cannot promise complete secrecy. Organizations that may inspect and copy your information include the IRB and other representatives of this organization.

14 - Can I be removed from the research without my OK?

The person in charge of the research study or the sponsor can remove you from the research study without your approval. Possible reasons for removal include that the researcher can also end the research study early.

15 - What else do I need to know?

Thank you for your consideration in participating in this study. If you have any further questions, please feel free to contact me. Cindy Vartuli, cindy_vartuli@greenwich.k12.ct.us

Chosen Pseudonym:____

Signature Block for Capable Adult: Long Form

Your signature below documents your permission to take part in this research.

DO NOT SIGN THIS FORM AFTER THIS DATE →	July 2016
Signature of subject	Date
Printed name of subject	
Signature of person obtaining consent	Date
	10/26/15
Printed name of person obtaining consent	Form Date

Appendix I

Teacher Interview Protocol

Researcher: Thank you again for agreeing to participate in this interview. I would just like to confirm your permission to audiotape this interview. (Interviewee responds.) Again, all information obtained during this interview will remain confidential and your chosen pseudonym will be used to protect your identity. The interview should take approximately 40 to 45 minutes. The focus of the interview is on student interest in learning science. Do you have any questions about the study or interview procedures? (Pause. Answer any interviewee questions before proceeding.)

Semi-structured Interview Questions:

1. Research studies show that there are not enough individuals to meet the current and growing number of STEM jobs. In your opinion, why are students not pursuing STEM careers?

2. Think about your own classroom. In your opinion what do you think is the general level of student interest in science? What do you perceive as students' level of interest in learning science? Can you provide examples that demonstrate student interest?

3. What do you believe are the key indicators of student interest in the classroom? Can you give me examples?

4. What teaching approaches do you use in the classroom that you think stimulate interest in science? What makes you think these promote student interest in science?

5. Do you believe the instructional strategies that you use are effective in maintaining, supporting or increasing student interest in learning science? What are the indicators that you use to assess the effectiveness?

6. What changes would you like to implement in your classroom in order to increase student interest in learning science? Have you thought about how you would apply them in your science class? Can you give me an example?

7. What can high school science teachers do to encourage students to pursue STEM fields? How would you address this in your own class?

8. Do you have any additional comments to our discussion? Is there anything you would like to add that you view as important to understanding student interest in learning science?

Researcher: Thank you again for agreeing to be a part of my study. I greatly appreciate the time you have given up in order to answer my questions. I will be touching base with you to share the transcript of the interview and confirm the accuracy of your responses. If you think of anything else you would like to add or have any further questions, please feel free to email me at cindy_vartuli@greenwich.k12.ct.us or call me at 203-610-9610. Again, thank you for sharing your views and insight.

Appendix J

1 - *Title of research study:* Exploring Student Interest in Learning Science: How Can Learning Science be more Interesting?: A Case Study

2 - *Investigator:* Cindy Vartuli

We invite your child to take part in a research study because he or she is a 10th-grade student in Mrs. Cindy Vartuli's chemistry class.

3 - *What you should know about a research study*

- Cindy Vartuli will explain this research study to you.
- You volunteer to be in a research study.
- Whether or not you take part is up to you.
- You can choose not to take part in the research study.
- You can agree to take part now and later change your mind.
- Whatever you decide it will not be held against you.
- Feel free to ask all the questions you want before you decide.

4 - *Who can I talk to?*

If you have questions, concerns, or complaints, or think the research has hurt you, talk to the research team at: Cindy Vartuli, cindy_vartuli@greenwich.k12.ct.us.
This research has been reviewed and approved by an Institutional Review Board. You may talk to the IRB Co-Chair at (203) 576-4973 or chemp@bridgeport.edu about any of the following:

- Your questions, concerns, or complaints are not being answered by the research team.
- You cannot reach the research team.
- You want to talk to someone besides the research team.
- You have questions about your rights as a research subject.
- You want to get information or provide input about this research.

5 - *Why are you doing this research?*

My name is Cindy Vartuli and I am currently your child's chemistry teacher at Greenwich High School and a fourth year doctoral student at the University of Bridgeport working on my dissertation. I am sending you this letter because I would like to use the data collected from a STEM (Science, Technology, Engineering and Math) Career Project being implemented as part of the chemistry activities in the classroom and also as a research vehicle for my research study exploring student interest in learning science.

Before agreeing to be part of the study, please read the following:

The purpose of the research is to understand how to make learning science more interesting for students. You may be familiar with the research as your child may have completed the on-line Student Science Questionnaire. The survey was the first phase in this sequential study. The next phase involves the implementation of an instructional intervention about STEM careers. The objective of the STEM Career project is to create situational interest and awareness of STEM careers in order to increase student interest in learning science and in pursuing science as a potential career. The STEM Career project involves the creation of an electronic document of 3 possible STEM Careers the student has identified as interesting to them. The student will also write a reflection of the experience.

In order to decide whether or not you wish your child to be a part of the study you should know enough about its risks and benefits to make an informed decision. This consent form provides you with the detailed information about the study. I will discuss any aspects of the study with you that you do not understand. Once you understand the study, you will be asked to give permission for your child to participate. If you agree to have your child participate you will be asked to sign this form. If you do not agree, an alternative and comparable learning experience will be provided to your child.

6 - How long will the research last?

We expect that your child will be in this research study for 4 to 6 weeks beginning in March 2016. During this timeframe the student will be researching potential careers, creating an electronic document of these careers, presenting one of the careers to the class, and writing a reflection of the experience. This will be done during chemistry class time and as a homework assignment as well. If you do not want your child to participate in the research study alternative and comparable assignments and tasks will be provided.

7 - How many people will be studied?

We expect about eighty 10th-grade students here will be in this phase of the research study. We expect that your child will be a part of this research study for approximately 4 to 6 weeks or until completion of the STEM Career project.

8 - What happens if I say yes, I want my child to be in this research?

If you agree to have your child participate, the researcher will use the data collected from the student as part of the research study.

9 - What happens if I say no, I do not want my child to be in this research?

You may decide not to have your child take part in the research and it will not be held against him or her. Opting not to participate will not impact or affect the student's grade and alternative and comparable activities for the STEM Career project will be provided.

10 - What happens if I say yes, but I change my mind later?

You agree to allow your child to take part in the research now. You may stop at any time and it will not be held against your child. If you decide to remove permission for your child to participate in the research, contact the investigator so that the investigator does not include the student's data in the research study. If a student participant withdraws from the STEM Career project, any written documentation collected up to that point will **not** be included in the study but will be used as an assessment up to the point of withdrawal and an alternative assessment given in the course grade. Withdrawal from the study will not impact or affect the student's project grade.

11 - Is there any way being in this study could be bad for my child?

There is minimal risk to your child as the topic is not controversial and the findings when published are anonymous.

12 - Will being in this study help my child in any way?

We cannot promise any benefits to your child or others from taking part in this research. However, possible benefits include that the insights gained from the information can help in understanding how to increase situational interest in the high school classroom that increases student interest in learning science and in STEM careers. Completion of the project provides students' with greater awareness of potential careers in STEM fields.

13 - What happens to the information that is collect?

Efforts will be made to limit your and your child's personal information to the primary investigator. Personal information obtained during the study will remain confidential. Any personally identifiable information collected as part of the STEM Career Project will be removed. Assigned codes will be used in place of student names. The assigned codes will be stored in a password protected computer and will only be known to the primary investigator. I cannot promise complete secrecy. Organizations that may inspect and copy your information include the Institutional Review Board at the University of Bridgeport and my dissertation committee members.

14 - Can I be removed from the research without my OK?

The person in charge of the research study, Cindy Vartuli, or the sponsor institution, University of Bridgeport, can remove your child from the research study without your approval. Possible reasons for removal include that the researcher can also end the research study early.

15 - What else do I need to know?

Thank you for your consideration in participating in this study. If you have any further questions, please feel free to contact me. Cindy Vartuli, cindy_vartuli@greenwich.k12.ct.us

Signature Block for Children

Your signature below documents your permission for the child named below to take part in this research.

DO NOT SIGN THIS FORM AFTER THIS DATE →

Printed name of child

Signature of parent or guardian | Date

Printed name of parent or guardian

- ❑ Parent
- ❑ Guardian (See note below)

Note on permission by guardians: An individual may provide permission for a child only if that individual can provide a written document indicating that he or she is legally authorized to consent to the child's general medical care. Attach the documentation to the signed document.

Assent

- ❑ Obtained
- ❑ Not obtained because the capability of the child is so limited that the child cannot reasonably be consulted.

[Add the following block to all consents]

Signature of person obtaining consent and assent | Date

3/9/2016

Printed name of person obtaining consent | Form Date

Appendix K

3-2-16

Dear Parent or Guardian,

I am writing to inform you about a classroom activity that your child will be completing in chemistry. For this project students will investigate potential STEM (Science, Technology, Engineering and Math) careers that are of interest to them. They will create an electronic document of three potential careers, present one career to the class, and write a reflection of the experience (see attached document). The STEM Career project is being completed as part of the normal classroom activities. The data collected from the activity will also be used as part of my doctoral research.

The focus of my doctoral research project is exploring student interest in learning science in order to understand how to make learning science more interesting. The STEM Career project is just one form of data that is being collected. As you may recall, your child was previously invited to participate in an on-line Student Science Survey which is also being used in the research project.

As your child is one of my 10th grade chemistry students, they are being invited to participate in the STEM Career Project as part of my research study. Your child will be completing the project for a course grade; however, in order to use the data collected from the STEM career project as part of my research study, I need to obtain consent. If you and your child agree to participate, the attached consent form needs to be completed and returned to me. Participation as part of the research study is voluntary and choosing not to participate will **not** affect the project grade. An alternative and comparable activity will be provided if you do not want your child to participate. In addition, if you as the parent or the student participant wants to withdraw from the STEM Career project, any written documentation collected to that point will **not** be included in the study but it will be used along with subsequent alternative activities as an assessment in the course grade. Withdrawal from the study will **not** impact or affect the student's project grade.

All electronic data is stored in a password protected electronic format. Any personally identifiable information will be removed by myself from the collected data. The results of the study, without your student's identity, will be used for scholarly purposes only and may be shared with University of Bridgeport representatives and once the research is completed, with the district and published as a dissertation.

Thank you for your consideration. Please feel free to contact me with any questions, cindy_vartuli@greenwich.k12.ct.us.

Cindy Vartuli
Chemistry

STEM Career Project

Objective: To explore and investigate Science, Technology, Engineering, Math (STEM) careers that are of interest to you.

For this project you will research **3** STEM careers that are of interest to you. The **3** careers can be in one field or 3 different fields of interest. After selecting these careers you will create an electronic document that includes the following:

- Name or job title for the career
- Education or training required
- Responsibilities and daily activities
- Companies that employ individuals in this career or use their expertise, for example as an independent contractor.
- Projected growth for this career
- Salary Range

You may use a variety of sources to research and collect the required information. A minimum of 5 sources is required. All sources must be properly cited.

Be creative in creating your career document. This project will also be graded on whether the information presented is comprehensive, complete, easily readable, and visually appealing.

In addition, each student will present and share with the class **1** of the three selected careers.

After the projects have been shared, each student will write a reflection of the experience answering the following questions.

1. Why did you choose these careers?
2. Would you consider pursuing any of these careers? Why or why not?
3. Would you consider pursuing a STEM career? Why or why not?
4. Has this project influenced your interest in learning science or in pursuing science? Why or why not?

5. What did you find most meaningful or interesting in completing this project?

The project will be assessed using the grading rubric.

We will begin research for the project in class so that I can answer any questions that might arise in the initial research phase. 2 to 3 class blocks will be devoted to research. You will have 2 weeks from the start of the project to complete the final assignment. Class presentations will begin after that time.

Suggested websites to begin your research:

http://stemcareer.com/

http://www.sciencebuddies.org/science-engineering-careers

http://stemjobs.com/

Appendix L

STEM Career Project Lesson Plan

Objective: Students will explore and investigate 3 STEM careers that are of interest to them.

Teacher will introduce project in class and students will be given a handout of the assignment and the grading rubric. The initial websites listed in the assignment will help students begin their research.

Learning Tasks and Activities:
After introducing the project, the class will discuss the following:

- What is a STEM career?
- What defines a STEM career?
- What careers do you think are STEM careers?

This discussion will help students define what constitutes a STEM career and uncover possible areas of initial research.

The teacher will show the students videos of individuals in STEM fields. The selected individuals explain how they became interested in their respective STEM fields.

Videos:

Dr. Craig Mello – 2006 Nobel Prize Winner for Physiology or Medicine, along with Andrew Z. Fire for the discovery of RNA interference.
http://www.nobelprizeii.org/videos/want-become-scientist/

Selected 3 individuals telling their story about why they became scientists. Two are engineers, one is a Ph.D. material scientist.
http://portal.knme.org/show/why-did-you-become-scientist/

Dr. Nancy Jackson, 2011 President of American Chemical Society
https://vimeo.com/25093481

Dr. Charles Preston, Founding Curator of the Draper Museum of Natural History and Senior Curator of the Buffalo Bill Historical Center
https://www.youtube.com/watch?v=mZPZrVA4Ays

Variety of young science individuals from different STEM fields discussing why they entered these fields.
https://www.youtube.com/watch?v=fOC9ESRoXU8

Student questions regarding the project will be addressed. Students will have two weeks to complete the assignment. Students will have one to two additional class blocks to work on this project.

Appendix M

STEM Career Project

Objective: To explore and investigate Science, Technology, Engineering, Math (STEM) careers that are of interest to you.

For this project you will research **3** STEM careers that are of interest to you. The **3** careers can be in one field or 3 different fields of interest. After selecting these careers you will create an electronic document that includes the following:

- Name or job title for the career
- Education or training required
- Responsibilities and daily activities
- Companies that employ individuals in this career or use their expertise, for example as an independent contractor.
- Projected growth for this career
- Salary Range

You may use a variety of sources to research and collect the required information. A minimum of 5 sources is required. All sources must be properly cited.

Be creative in creating your career document. This project will also be graded on whether the information presented is comprehensive, complete, easily readable, and visually appealing.

In addition, each student will present and share with the class **1** of the three selected careers. After the projects have been shared, each student will write a reflection of the experience answering the following questions.

1. Why did you choose these careers?
2. Would you consider pursuing any of these careers? Why or why not?
3. Would you consider pursuing a STEM career? Why or why not?
4. Has this project influenced your interest in learning science or in pursuing science? Why or why not?

5. What did you find most meaningful or interesting in completing this project?

The project will be assessed using the grading rubric.

We will begin research for the project in class so that I can answer any questions that might arise in the initial research phase. 2 to 3 class blocks will be devoted to research. You will have 2 weeks from the start of the project to complete the final assignment. Class presentations will begin after that time.

Suggested websites to begin your research:

http://stemcareer.com/

http://www.sciencebuddies.org/science-engineering-careers

http://stemjobs.com/

Appendix N

STEM Grading Rubric

STEM Project	Level 4	Level 3	Level 2	Level 1	**Points**
Content Required Elements	The required 6 elements are present for the 3 careers. (30 pts)	5 required elements are present for the 3 careers. (24 pts.)	4 required elements are present for 3 careers. (18 pts.)	3 or less required elements are present for 3 careers. (0 to 12 pts.)	/ 30 pts.
Details of required elements	All elements are clearly explained and include sufficient and specific details. (40-36 pts.)	Most elements are clearly explained and include sufficient and specific details. (35 to 30 pts.)	Some elements are clearly explained but not all in sufficient detail. (29 to 24 pts.)	Some elements are explained clearly but not in sufficient detail. (23 to 16 pts.)	/ 40 pts.
Background Research and Works Consulted	Includes 5 or more correctly cited sources. (8 pts.)	Includes 5 or more sources but not all are correctly cited. (6 pts.)	Includes 3 to 4 sources and most are correctly cited. (4 pts.)	Includes less than 3 sources. (2 pts.)	/ 8 pts.
Creativity and Visual Presentation	Information is presented in a format that is easy to understand and visually appealing. (12 pts.)	Information is presented in a format that is understandable and includes visual elements. (10 pts.)	Information is presented in a format that is readable but lacks visual elements. (8 pts.)	Information is presented but is not easily readable. (6 pts.)	/ 12 pts.
Oral Presentation of Project	Student communicates information in a clear, logical, and succinct manner. (10 pts.)	Student communicates information in a clear manner. (8 to 9 pts.)	Student communicates information in a somewhat clear manner. (6 to 7 pts.)	Student is not clear in communicating information. (4 to 5 pts.)	/ 10 pts.

Appendix O

Post-STEM Career Project Questions

1. The STEM Career Project increased my awareness of STEM Careers.

Strongly Agree Agree Disagree Strongly Disagree

2. As a result of the Project I am interested in learning more about science.

Strongly Agree Agree Disagree Strongly Disagree

3. I am interested in learning more about STEM careers.

Strongly Agree Agree Disagree Strongly Disagree

4. I found the STEM Career Project to be valuable for my future career aspirations.

Strongly Agree Agree Disagree Strongly Disagree

5. As a result of the Project I would consider pursuing a STEM career.

Strongly Agree Agree Disagree Strongly Disagree

6. Do you believe the project changed your ideas about learning science?

Yes No

7. Do you believe the project changed your ideas about pursing science as a career?

Yes No

8. Did you find the project to be a valuable use of your time?

Yes No

9. Do you believe that the project should be included in the course?

Yes No

Appendix P

Iteration 2: Intervention Interview Questions

1. How did the intervention work for you?

2. What aspects worked well? What specific aspects need refinement or improvement?

3. Did you see any evidence that the intervention increased student awareness of STEM Careers? Can you provide any specific information?

4. Did you see any evidence that the intervention increased student interest in pursuing science? What specific examples can you provide?

5. Do you believe the intervention provided a positive science learning experience for students? Can you provide any specific examples?

6. How was the overall process of implementing the intervention? Where there any procedural issues or challenges?

7. What recommendations or suggestions do you have for improving the intervention? Why are the changes necessary? How can it be improved for other teachers?

8. Was the STEM Career Project a valuable use of instructional time? Why or why not?

9. Any final thoughts you would like to provide concerning the STEM Career Project?

Appendix Q

Researcher Reflective Journal

July 2015

My inspiration for the STEM Career Project was based on my personal belief that students were unaware of the variety of jobs available in STEM fields. Most students associate STEM careers with becoming a doctor or a scientist wearing a white lab coat working in a lab or an engineer. Even in looking at just these 3 examples, they were unaware of how many different fields of medicine, research, or engineering exist. If students are going to pursue STEM careers they need to know what opportunities exist. Piloting the PISA 2006 Science Questionnaire in June 2015 with 56 of my honors and regular chemistry students I was able to confirm that most students are not aware of all the opportunities that exist in STEM fields. While 60.7% believed they were well informed or fairly informed about science-related careers in the job market as the questions moved to where to find information about these careers or the steps to take to enter these careers the percentages shifted with the very well informed and fairly informed responses being approximately 50 to 52% and the not well informed and not informed approximating 48 to 50%, an almost even split. In asking about employers and companies that hire people to work in science related careers, on 5.3% of students felt very informed, 37.5 % fairly informed, 42.9% not well informed and 14.3% not informed at all. Nearly 60% strongly agreed or agreed with the statement that they would like to work in a career involving science and 65% strongly agreed or agreed that they would like to study science after high school, however, the number of students who strongly agree or agreed with the statement I would like to spend my life doing advanced science or would like to work on science projects as adults was 33.9% and 39.2% respectively.

In looking at the responses generated in this pilot, what I found most positive was that 92.9% of students strongly agreed or agreed with the fact science is valuable to society and 84.0% strongly agreed or agreed with the statement science was relevant to them. Other positive indicators were that 39.3% strongly agreed and 58.9% agreed that they enjoyed acquiring new knowledge in science and 33.9% strongly agreed and 58.9% agreed that they were interested in learning science. My belief is that if interest is there then by providing students with the opportunity to learn more about science careers so that they can make informed career decisions may in fact increase the number of students who entertain the idea of a STEM career and therefore ultimately lead to an increase in the number of students entering the STEM fields.

This STEM career project is really an enrichment activity that helps students connect the concepts that they are learning with the jobs that use these concepts in their careers. Learning about topics such as chemical reactions or stoichiometry and how to use them in a problem does not show the power or importance of these concepts unless students can see them being used in real-life examples. This career project is one way to demonstrate the relevancy of what they are learning and provides a way of seeing how these concepts are used and applied in careers. By allowing students to choose careers of interest to them the activity becomes personally relevant and meaningful. Acquiring new knowledge that demonstrates relevancy to their daily lives, as well as, fostering a degree of personal relevancy through choice, interest can develop.

The STEM career project was created after searching through the literature and looking at other similar activities on-line. The activity that stood out for me was the Project Lead the Way Career activity. This model was most interesting to me because it allowed student the opportunity to research careers of interest to them. Using this as my starting part I began to craft my own activity. For me, I thought it best to start by showing students video clips of individuals working in STEM fields and their stories for why the entered their chosen career. Viewing several websites, I narrowed it down to a few that showed Nobel Prize winning scientists, as well as individuals working as scientists, engineers, and mathematicians. I purposely chose one site from Australia that showed graduate students working toward their degrees and the focus of their research. I felt that students would identify more closely with individuals closer to their age who have recently decided on their chosen STEM career path.

Designing the lesson plan, and the activities was the least difficult part for me. Crafting the rubric for grading the project and deciding upon the reflection questions took time. To create the rubric I looked at several generic rubrics for grading projects. From these I began to create assessment categories, levels of performance and associated point totals. I went through several iterations on the point totals asking myself what the difference between the levels for each category would look like in order to determine the number of points in each level. This took time because I wanted to create a rubric that was easy to use and yet was fair in assessing student work.

For the reflection questions, I decided it was best to limit the number of questions to elicit more student elaboration in answering the questions. Sometimes too many questions result in sparse answers. I also wanted the questions to progress as the project progressed beginning with why they chose their careers and finishing with what was most meaningful or interesting to them. This information will be coded for themes so that I have the opportunity to uncover the personal stories associated with the project. Student have been doing reflections as part of the Capstone project that the high school has been developing. Writing reflections has become part of the culture so I feel that students will not require direct instruction in this area but more of a reminder about how answers to these questions are more than “yes” and “no” and afford the opportunity for students to ask themselves more thought provoking questions related to their own personal ideas, decisions, and learning outcomes.

Additionally, I chose to include a quick post STEM career survey to elicit a more immediate response to the project. I decided to make it an anonymous on-line survey. The only pitfall to this is that not all students will answer the questions; however, all students who complete the project will turn in a reflection.

The STEM career project was introduced to my three regular chemistry classes and my one honors chemistry class. My honors students knew more about STEM careers as was obvious from the discussions in each class of what constitutes a STEM career. In fact in my honors class a discussion of the percentages of individuals graduating with STEM degrees ensued and one student argued with me that one third of all degrees were in STEM. I explained to him that the definition of STEM had changed or rather been interpreted differently to include the social sciences and psychology thereby increasing the numbers. However, the traditional STEM degrees still held at 16 to 18% of all degrees conferred. This discussion of what constitutes a STEM degree needs to be clarified before students proceed in researching their selected careers.

The videos of STEM individuals went better in some classes than others. Some students found the information exceedingly interesting and the stories told by the selected individuals fascinating. Depending on the class and time, the number of videos shown could be changed. Also, I found another individual story that of Dr. Peter Agre quite interesting in that he dropped out of school and became a truck driver before going back to school and eventually becoming a medical doctor and researcher. I showed this one as a substitute for Dr. Nancy Jackson in two of the four classes. I believe the videos did work well to kick-off the project but depending on the time in class or the level of student attention, one can adjust how many videos to show or break it up and show some in another class block if students are using class time for the project.

In going over the project itself with students the expectations of required elements seemed straight forward. The most asked question was do you want a PowerPoint or document? I told them that it should be visually appealing. I reminded them they would be presenting one of the three. Students asked if they could do a PowerPoint for the one being presented and something else for the others. I told them that would be fine. I pointed out the rubric to them which provided the elements and points for the project. From their reactions and lack of questions regarding the point totals it appeared that this was self-explanatory. In terms of citation format I asked the classes what they were using in their sophomore research project. Most students said MLA but a few others said they were using Chicago so I said they could use whichever format they had learned.

For the reflection we spent some time in class going over how to write a reflection and that it was more than answering yes or no to the questions.   I told them I wanted them to write it after they had seen the presentations. Students have been writing reflections in their history classes as it pertains to the sophomore research project and as part of the Capstone experiences so I am hoping that the brief discussion in class is enough. Additionally, I told them there would be a Post STEM Career survey on-line that I would like them to complete as well after all the presentations. In all classes after the introduction I allowed students time to get started on the project and begin by looking at some of the websites I had given them. Many students quickly navigated the information finding more websites including those that provided a career test to see what types of careers best suited their skills and interests. Students in 10th grade have had exposure to these career test through Naviance, a college process website. I told students to start looking for careers of interest and then bring them to me tomorrow when we spend some time again working on the project. In this way any questions related to the qualification of a career as a true STEM career are possible.

Students did ask questions about some careers such as a career in finance which technically is not a STEM career but uses STEM skills so in these cases I told them they could include this as one career but the other two must be true STEM careers.

The two week timeframe provided more than enough preparation time. Student submitted their projects on-line which made it easy to put up on the SmartBoard. Some students mixed their formats providing a PowerPoint for the career presented and a simple document of required information for the other two. Some students chose to keep the format the same for all three. Presentations went well and some students seemed to shine in front of an audience. The students enjoyed the presentations and were very attentive during them. The creativity shown in some of the presentations and the poise of some students in speaking in front of an audience was quite remarkable. I had one student even bring an oil sample for his petroleum engineer career. Seeing the presentations and students asking questions of their classmates demonstrated to me the enjoyment that they seemed to get from the project. Additionally the variety of careers presented enabled students to gain a wealth of knowledge about STEM careers.

After implementing this intervention there are improvements that need to be made. First, I would go over in the class discussion what a STEM career is and have students come up with careers they think are STEM. In terms of the lesson plan I would show most if not all the video clips depending on the class and timeframe. I would definitely follow the videos with an introduction of the project and allow students some class time to begin. That first night though I would ask students to identify five careers and to research what fields are considered STEM and bring this information to class. This will help begin the discussion of what is truly a STEM career and what has recently been included as STEM, the addition of social science and psychology. This will then enable the teacher to circulate around the room and look at the five careers students selected and then eliminate any that are not traditionally STEM. The teacher can decide, as I did, if a career outside of STEM but uses STEM skills can be included in the three final careers.

Providing more details for the required elements will also help students so I am going to elaborate on education and training required, responsibilities and daily activities, companies, and remind students to include the year or years associated with their growth projections.

For citation, depending on when the project is completed students may not be familiar with MLA citation, so providing an example of how to cite an electronic source will be helpful. Additionally providing a link to a website, such as OWL Purdue, for help in citing sources. Some students did not cite according to either format. Some students though asked if the pictures used had to be cited so clarification and examples are necessary.

For their electronic documents students should use the same format type for all three careers. This simplifies the selection for the presentation and also provides consistency in the grading process. PowerPoint or Google Slides help make the presentations flow easily. Using the platform that the school uses is probably best. Electronic submissions also make it easy to call up the presentations and saves time. Most of the projects were well done with pictures, animations, and even video clips while others simple addressed the required elements with little creativity.

Reflections need to be discussed. An emphasis on how the reflection provides students the opportunity to think about the impact of the project on their learning needs to be stressed. Also, students need to know how it is an important tool for them and for the teacher. Students need to know answers require elaboration and even examples to help make the reflection truly meaningful. While some students provided short answers with little thought others actually went into more depth explaining in detail why they would or would not pursue STEM careers showing they knew how to write a reflection.

Finally, if all students are to respond to the on-line post career survey then giving it in class and having them complete it on their Chromebooks should be done. By putting it on-line students could complete it on their own time which I thought would help in getting students to participate. Not all students completed the survey. Of the 76 10th grade students who were part of the research study, 47 students completed the survey or 62% of the total sample.

For me, the most successful element was the grading rubric. It provided a consistent and easy, straightforward way to grade the projects. Of all the elements I felt this needed no modifications. The time I spent crafting it paid off.

July-August 2016

Laura's summer school class though small, 4 students, afforded me the opportunity to pilot the improvements made to the STEM Career project. The sample was not large enough to provide significant data for the study but did provide a venue for training. Laura has volunteered to implement the STEM Career Project in the fall so it provided an opportunity for teacher training and for further professional input into how to improve the project. Summer school is only 6 weeks and the class make-up was two students who had not taken chemistry, one being an advanced 8^{th} grader, and two students who did not pass chemistry so they were repeating the class.

The revisions to the project made it easier for students but the one point which needs further clarification is that all chosen careers should be presented in a similar format because which one they present will depend on what other class members have already presented. I believe stressing this point will ensure that there is uniformity in the student work.

Laura and I both graded the projects simultaneously using the rubrics and then compared our results. Our results were similar within a 2 to 3 points for each assessment area and in some cases assigning the same score. The area of must subjectivity is creativity and visual presentation but even then from our discussions we could come to a consensus even though the differences in our scores were no more than 3 points. If other teachers volunteer to do the project, I will go through the same type of exercise using examples from my earlier students as a way to improve interrater reliability.

Sept. 12, 2016

Three teachers have volunteered to implement the intervention. Each one has a different level of chemistry class so this will help in devising a differentiated product appropriate for each level. The most challenging would be for the practical level which will mostly require modifications. The teachers and I met and went through all the documents and the videos. I told them how I used the videos and how many I showed. Again sometimes from class to class this varies. We discussed the project requirements and for this intervention I have made the modifications based on my iteration and on the small summer school sample. Clarification of what is expected of students in terms of the format used for all three careers. I explained how students should prepare each career using a similar format so that they can present any of the 3. Students in my classes sometimes did an outstanding job on 1 career and simply fulfilled the requirements on the other 2. If they can be called upon to present any of the 3 then all should be similar. I also provided the teachers with a list of STEM careers and we discussed how in some literature STEM is defined as including social science and psychology while the more traditional stance only include math, technology or computers, engineering and sciences. Come classifications

include the medical profession and science teachers while others do not. Some blue collar jobs are also considered STEM such as electricians, mechanics, machinists, by the U.S. Labor Dept. Because of these differences I told the teachers they could use this list as a guideline but they could also use their own discretion. If a student has a real passion for a job that might not be considered a true "STEM" job but uses STEM skills, then I did allow those students to include it as one job. The example I used was an individual working in the FBI's BAU or behavioral analysis unit where forensics and problem-solving are part of the job description.
In reviewing the reflection tips, we discussed how this iteration is at the beginning of the school year so students may not have had the same level of familiarity and practice with reflection writing that my students had at the end of the year.

I also shared with the teachers examples of the projects my students completed and we looked at these as we went through the grading rubric. In this way we could gauge how the rubric worked and if we could come to an agreement when viewing the projects as a form of interrater reliability. I decided that at the end of the project I would sit with each teacher individually and look at their projects and grading to hear their suggestions in order to help me better understand how to improve the intervention. I answered any questions they had and provided them with all the documents needed both in hard copy and electronically. In addition the student survey was shared with each teacher through Google forms so that they can have their students complete it electronically.

One of the teacher asked if she could modify what was being done if she felt it necessary for her practical students. I said that was fine because until that time I had never really thought about creating an intervention that also included product differentiation for the level of the class or for students within a class making it more universal in terms of use. It provides a teacher with an intervention that is ready to go for any level of student.

Appendix R

STEM Career Project Lesson Plan

Objective: Students will explore and investigate 3 STEM careers that are of interest to them.

Teacher will introduce project in class and students will be given a handout of the assignment and the grading rubric. The initial websites listed in the assignment will help students begin their research.

(Students require access to computers for the project. Teacher will require SmartBoard or other electronic medium for student presentations.)

Learning Tasks and Activities:
Briefly introduce the project and hand out the STEM Career Project, the grading rubric, and the tips on writing a reflection. After all students have the materials, lead the class in a discussion of the following:

- What is a STEM career?
- What defines a STEM career?
- What careers do you think are STEM careers?

This discussion will help students define what constitutes a STEM career and uncover possible areas of initial research.

The teacher will show the students videos of individuals in STEM fields. The selected individuals explain how they became interested in their respective STEM fields.

Videos: (each is 2 to 5 minutes in length)

Dr. Craig Mello – 2006 Nobel Prize Winner for Physiology or Medicine, along with Andrew Z. Fire for the discovery of RNA interference.
http://www.nobelprizeii.org/videos/want-become-scientist/

Selected 3 individuals telling their story about why they became scientists. Two are engineers, one is a Ph.D. material scientist.
http://portal.knme.org/show/why-did-you-become-scientist/

Dr. Nancy Jackson, 2011 President of American Chemical Society
https://vimeo.com/25093481

Dr. Peter Agre, 2003 Nobel Prize Winner for Chemistry for aquaporins
https://vimeo.com/25093309

Dr. Charles Preston, Founding Curator of the Draper Museum of Natural History and Senior Curator of the Buffalo Bill Historical Center https://www.youtube.com/watch?v=mZPZrVA4Ays

Variety of young science individuals from different STEM fields discussing why they entered these fields.
https://www.youtube.com/watch?v=fOC9ESRoXU8

After the videos explain the project in more depth and address student questions. Students will have one to two weeks to complete the assignment depending on the teacher's schedule and curriculum requirements. As it is an enrichment activity it can be worked into or around the other class requirements. Students will need one to two additional class blocks to work on this project.

The teacher may choose to show all videos or specifically selected videos to introduce the topic. Another option is to show some of the videos at the introduction of the project and others later when students have begun researching careers.

Students should begin by identifying 5 careers that they believe are STEM careers. This can be done as class work after the initial project introduction and preliminary discussion of STEM careers. Another option is to assign this as homework, after the introduction and have students come to class with their list of 5 careers. This will enable the teacher to review the students' lists and foster a further discussion on the classification of STEM careers in order to help students identify careers that fit the STEM criteria.

In some of the recent literature, STEM has been expanded to include the fields of social science and psychology thereby increasing the number of STEM degrees conferred to nearly one-third. However, the traditional STEM degrees are still only 16 to 18% of all degrees conferred. An attached list of STEM occupations is provided to assist teachers in determining if the careers selected by students are traditional STEM careers. At the teacher's discretion a student may select a career that uses STEM skills as one of the three selected but is not a designated STEM career. For example a student shows a keen interest in investigating a career in the FBI working in the Behavioral Analysis Unit, although this is not a STEM career it requires a knowledge of STEM fields such as forensics.

In addition to the project itself, students will write a reflection answering the designated questions. A tip sheet about writing reflections is included in the student materials. Reviewing this information will be helpful as some students may not be familiar with this process. The reflection is not included in the grading of the project but is a required element which provides feedback for future improvements. Students will complete the reflection after the presentations.

A Post STEM Career Survey is also included and can be administered on-line. It is anonymous and provides immediate feedback about the project. Students can easily access it on their own time; however, completing it as an in-class activity will generally provide more responses.

Table 1: STEM occupations, by occupational group

Management
Architectural and engineering managers
Computer and information systems managers
Natural sciences managers
Computer and mathematics
Actuaries
Computer and information research scientists
Computer network architects
Computer network support specialists
Computer programmers
Computer systems analysts
Computer user support specialists
Database administrators
Information security analysts
Mathematical technicians
Mathematicians
Network and computer systems administrators
Operations research analysts
Software developers, applications
Software developers, systems software
Statisticians
Web developers
Computer occupations, all other
Mathematical science occupations, all other
Architecture and engineering
Aerospace engineering and operations technicians
Aerospace engineers
Agricultural engineers
Architectural and civil drafters
Biomedical engineers
Chemical engineers
Civil engineering technicians
Civil engineers
Computer hardware engineers
Electrical and electronics drafters
Electrical and electronics engineering technicians
Electrical engineers
Electro-mechanical technicians
Electronics engineers, except computer
Environmental engineering technicians
Environmental engineers
Health and safety engineers, except mining safety engineers and inspectors
Industrial engineering technicians
Industrial engineers
Marine engineers and naval architects
Materials engineers
Mechanical drafters
Mechanical engineering technicians
Mechanical engineers
Mining and geological engineers, including mining safety engineers
Nuclear engineers
Petroleum engineers
Surveying and mapping technicians
Drafters, all other
Engineering technicians, except drafters, all other
Engineers, all other
Life, physical, and social sciences
Agricultural and food science technicians
Animal scientists
Astronomers
Atmospheric and space scientists
Biochemists and biophysicists
Biological technicians
Chemical technicians
Chemists
Conservation scientists
Environmental science and protection technicians, including health
Environmental scientists and specialists, including health
Epidemiologists
Food scientists and technologists
Forensic science technicians
Forest and conservation technicians
Foresters
Geological and petroleum technicians
Geoscientists, except hydrologists and geographers
Hydrologists
Life, physical, and social science technicians, all other
Materials scientists
Medical scientists, except epidemiologists
Microbiologists
Nuclear technicians
Physicists
Soil and plant scientists
Zoologists and wildlife biologists
Biological scientists, all other
Life scientists, all other
Physical scientists, all other
Education, training, and library
Agricultural sciences teachers, postsecondary
Architecture teachers, postsecondary
Atmospheric, earth, marine, and space sciences teachers, postsecondary
Biological science teachers, postsecondary
Chemistry teachers, postsecondary
Computer science teachers, postsecondary
Engineering teachers, postsecondary
Environmental science teachers, postsecondary
Forestry and conservation science teachers, postsecondary
Mathematical science teachers, postsecondary
Physics teachers, postsecondary
Sales and related
Sales engineers
Sales representatives, wholesale and manufacturing, technical and scientific products

Source: 2010 Standard Occupational Classification (SOC) System, SOC Policy Committee recommendation to the Office of Management and Budget. Healthcare occupations are not included.

STEM Project Grading Rubric

STEM Project	Level 4	Level 3	Level 2	Level 1	**Points**
Content Required Elements	The required 6 elements are present for the 3 careers. (30 pts)	5 required elements are present for the 3 careers. (24 pts.)	4 required elements are present for 3 careers. (18 pts.)	3 or less required elements are present for 3 careers. (0 to 12 pts.)	/ 30 pts.
Details of required elements	All elements are clearly explained and include sufficient and specific details. (40-36 pts.)	Most elements are clearly explained and include sufficient and specific details. (35 to 30 pts.)	Some elements are clearly explained but not all in sufficient detail. (29 to 24 pts.)	Some elements are explained clearly but not in sufficient detail. (23 to 16 pts.)	/ 40 pts.
Background Research and Works Consulted	Includes 5 or more correctly cited sources. (8 pts.)	Includes 5 or more sources but not all are correctly cited. (6 pts.)	Includes 3 to 4 sources and most are correctly cited. (4 pts.)	Includes less than 3 sources. (2 pts.)	/ 8 pts.
Creativity and Visual Presentation	Information is presented in a format that is easy to understand and visually appealing. (12 pts.)	Information is presented in a format that is understandable and includes visual elements. (10 pts.)	Information is presented in a format that is readable but lacks visual elements. (8 pts.)	Information is presented but is not easily readable. (6 pts.)	/ 12 pts.
Oral Presentation of Project	Student communicates information in a clear, logical, and succinct manner. (10 pts.)	Student communicates information in a clear manner. (8 to 9 pts.)	Student communicates information in a somewhat clear manner. (6 to 7 pts.)	Student is not clear in communicating information. (4 to 5 pts.)	/ 10 pts.

Post-STEM Career Project Questions

1. The STEM Career Project increased my awareness of STEM Careers.

Strongly Agree Agree Disagree Strongly Disagree

2. As a result of the Project I am interested in learning more about science.

Strongly Agree Agree Disagree Strongly Disagree

3. I am interested in learning more about STEM careers.

Strongly Agree Agree Disagree Strongly Disagree

4. I found the STEM Career Project to be valuable for my future career aspirations.

Strongly Agree Agree Disagree Strongly Disagree

5. As a result of the Project I would consider pursuing a STEM career.

Strongly Agree Agree Disagree Strongly Disagree

6. Do you believe the project changed your ideas about learning science?

Yes No

7. Do you believe the project changed your ideas about pursing science as a career?

Yes No

8. Did you find the project to be a valuable use of your time?

Yes No

9. Do you believe that the project should be included in the course?

Yes No

Appendix S

STEM Career Project

Objective: To explore and investigate Science, Technology, Engineering, Math (STEM) careers that are of interest to you.

For this project you will research **3** STEM careers that are of interest to you. The **3** careers can be in one field or 3 different fields of interest. After selecting these careers you will create an electronic document that includes the following:

- Name or job title for the career
- Education or training required
  Include any required licensing or any skills that would be useful for this career.
- Responsibilities and daily activities
  What do these individuals do on a daily basis? Specific examples can be used to highlight these activities.
- Companies that employ individuals in this career or use their expertise, for example as an independent contractor.
  Individual companies or types of companies may be used.
- Projected growth for this career
  In citing this data be sure to include the year or years it represents.
- Salary Range

You may use a variety of sources to research and collect the required information. A minimum of 5 sources is required. All sources must be properly cited using the MLA (Modern Language Association) formatting. Most citations for this project will use electronic sources. The following is an example:

"Summary Report for: Chemists." *O*NET Online.* National Center for O*NET Development, n.d. Web. 27 July 2016. <http://www.onetonline.org/link/summary/19-2031.00>

(Page on the website. Website (in italic print). Publisher and date, if no date then use n.d. Medium of publication. Date accessed. URL)

Additionally, the following website will be helpful in preparing electronic source citations: https://owl.english.purdue.edu/owl/resource/747/08/

Be creative in creating your career document. Use a uniform format for each career.

The electronic document can be prepared in PowerPoint, Google Slides or any other electronic presentation format that can be easily accessed. All presentations will be submitted electronically to the teacher or shared with the teacher depending on the format.

This project will be graded on whether the information presented is easily readable and visually appealing.

Each student will present and share with the class **1** of the three selected careers. Each selected career should have the same presentation format so that you will be prepared to share any of the three careers.

The grading rubric provided shows how the components of the project will be accessed and the points for each component.

After the projects have been shared, each student will write a reflection of the experience answering the following questions.

1. Why did you choose these careers?
2. Would you consider pursuing any of these careers? Why or why not?
3. Would you consider pursuing a STEM career? Why or why not?
4. Has this project influenced your interest in learning science or in pursuing science? Why or why not?
5. What did you find most meaningful or interesting in completing this project?

We will begin research for the project in class so that I can answer any questions that might arise in the initial research phase. 1 to 2 class blocks will be devoted to research. You will have 1 to 2 weeks from the start of the project to complete the final assignment. Class presentations will begin after that time.

Suggested websites to begin your research:

http://stemcareer.com/

http://www.sciencebuddies.org/science-engineering-careers

http://stemjobs.com/

Appendix T

Tips on writing a reflection

What is a reflection? : A thought or an opinion that results from careful consideration or thinking.

In other words:

- ✓ It is a personal account of your experience. It is more than answering “yes” or “no”.
- ✓ A reflection allows you to incorporate and discuss what you have learned through the experience by providing examples and details.
- ✓ A reflection enables you to integrate your personal experience with your beliefs. It allows you to contemplate on how the experience has impacted your views.
- ✓ A reflection provides input on how to improve the experience.
- ✓ A reflection should be honest and straight forward. It should express your opinion.

Appendix U

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Selected 3 individuals telling their story about why they became scientists. Two are engineers, one is a Ph.D. material scientist.
http://portal.knme.org/show/why-did-you-become-scientist/

Dr. Nancy Jackson, 2011 President of American Chemical Society
https://vimeo.com/25093481

Dr. Peter Agre, 2003 Nobel Prize Winner for Chemistry for aquaporins
https://vimeo.com/25093309

Dr. Charles Preston, Founding Curator of the Draper Museum of Natural History and Senior Curator of the Buffalo Bill Historical Center https://www.youtube.com/watch?v=mZPZrVA4Ays

Variety of young science individuals from different STEM fields discussing why they entered these fields.
https://www.youtube.com/watch?v=fOC9ESRoXU8

After the videos explain the project in more depth and address student questions. Students will have one to two weeks to complete the assignment depending on the teacher's schedule and curriculum requirements. As it is an enrichment activity it can be worked into or around the other class requirements. Students will need one to two additional class blocks to work on this project.

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Students should begin by identifying 5 careers that they believe are STEM careers. This can be done as class work after the initial project introduction and preliminary discussion of STEM careers. Another option is to assign this as homework, after the introduction and have students come to class with their list of 5 careers. This will enable the teacher to review the students' lists and foster a further discussion on the classification of STEM careers in order to help students identify careers that fit the STEM criteria.

In some of the recent literature, STEM has been expanded to include the fields of social science and psychology thereby increasing the number of STEM degrees conferred to nearly one-third. However, the traditional STEM degrees are still only 16 to 18% of all degrees conferred. An attached list of STEM occupations is provided to assist teachers in determining if the careers selected by students are traditional STEM careers. At the teacher's discretion a student may select a career that uses STEM skills as one of the three selected but is not a designated STEM career. For example a student shows a keen interest in investigating a career in the FBI working in the Behavioral Analysis Unit, although this is not a STEM career it requires a knowledge of STEM fields such as forensics.

In addition to the project itself, students will write a reflection answering the designated questions. A tip sheet about writing reflections is included in the student materials. Reviewing this information will be helpful as some students may not be familiar with this process. The reflection is not included in the grading of the project but is a required element which provides feedback for future improvements. Students will complete the reflection after the presentations.

A Post STEM Career Survey is also included and can be administered on-line. It is anonymous and provides immediate feedback about the project. Students can easily access it on their own time; however, completing it as an in-class activity will generally provide more responses.

Table 1: STEM occupations, by occupational group

Management
Architectural and engineering managers
Computer and information systems managers
Natural sciences managers
Computer and mathematics
Actuaries
Computer and information research scientists
Computer network architects
Computer network support specialists
Computer programmers
Computer systems analysts
Computer user support specialists
Database administrators
Information security analysts
Mathematical technicians
Mathematicians
Network and computer systems administrators
Operations research analysts
Software developers, applications
Software developers, systems software
Statisticians
Web developers
Computer occupations, all other
Mathematical science occupations, all other
Architecture and engineering
Aerospace engineering and operations technicians
Aerospace engineers
Agricultural engineers
Architectural and civil drafters
Biomedical engineers
Chemical engineers
Civil engineering technicians
Civil engineers
Computer hardware engineers
Electrical and electronics drafters
Electrical and electronics engineering technicians
Electrical engineers
Electro-mechanical technicians
Electronics engineers, except computer
Environmental engineering technicians
Environmental engineers
Health and safety engineers, except mining safety engineers and inspectors
Industrial engineering technicians
Industrial engineers
Marine engineers and naval architects
Materials engineers
Mechanical drafters
Mechanical engineering technicians
Mechanical engineers
Mining and geological engineers, including mining safety engineers
Nuclear engineers
Petroleum engineers
Surveying and mapping technicians
Drafters, all other
Engineering technicians, except drafters, all other
Engineers, all other
Life, physical, and social sciences
Agricultural and food science technicians
Animal scientists
Astronomers
Atmospheric and space scientists
Biochemists and biophysicists
Biological technicians
Chemical technicians
Chemists
Conservation scientists
Environmental science and protection technicians, including health
Environmental scientists and specialists, including health
Epidemiologists
Food scientists and technologists
Forensic science technicians
Forest and conservation technicians
Foresters
Geological and petroleum technicians
Geoscientists, except hydrologists and geographers
Hydrologists
Life, physical, and social science technicians, all other
Materials scientists
Medical scientists, except epidemiologists
Microbiologists
Nuclear technicians
Physicists
Soil and plant scientists
Zoologists and wildlife biologists
Biological scientists, all other
Life scientists, all other
Physical scientists, all other
Education, training, and library
Agricultural sciences teachers, postsecondary
Architecture teachers, postsecondary
Atmospheric, earth, marine, and space sciences teachers, postsecondary
Biological science teachers, postsecondary
Chemistry teachers, postsecondary
Computer science teachers, postsecondary
Engineering teachers, postsecondary
Environmental science teachers, postsecondary
Forestry and conservation science teachers, postsecondary
Mathematical science teachers, postsecondary
Physics teachers, postsecondary
Sales and related
Sales engineers
Sales representatives, wholesale and manufacturing, technical and scientific products

Source: 2010 Standard Occupational Classification (SOC) System, SOC Policy Committee recommendation to the Office of Management and Budget. Healthcare occupations are not included.

STEM Career Project

Objective: To explore and investigate Science, Technology, Engineering, Math (STEM) careers that are of interest to you.

For this project you will research **3** STEM careers that are of interest to you. The **3** careers can be in one field or 3 different fields of interest. After selecting these careers you will create an electronic document that includes the following:

- Name or job title for the career
- Education or training required
  Include any required licensing or any skills that would be useful for this career.
- Responsibilities and daily activities
  What do these individuals do on a daily basis? Specific examples can be used to highlight these activities.
- Companies that employ individuals in this career or use their expertise, for example as an independent contractor.
  Individual companies or types of companies may be used.
- Projected growth for this career
  In citing this data be sure to include the year or years it represents.
- Salary Range

You may use a variety of sources to research and collect the required information. A minimum of 5 sources is required. All sources must be properly cited using the MLA (Modern Language Association) formatting. Most citations for this project will use electronic sources. The following is an example:

"Summary Report for: Chemists." *O*NET Online.* National Center for O*NET Development, n.d. Web. 27 July 2016. <http://www.onetonline.org/link/summary/19-2031.00>

(Page on the website. Website (in italic print). Publisher and date, if no date then use n.d. Medium of publication. Date accessed. URL)

Additionally, the following website will be helpful in preparing electronic source citations: https://owl.english.purdue.edu/owl/resource/747/08/

Be creative in creating your career document. Use a uniform format for each career.

The electronic document can be prepared in PowerPoint, Google Slides or any other electronic presentation format that can be easily accessed. All presentations will be submitted electronically to the teacher or shared with the teacher depending on the format.

This project will be graded on whether the information presented is easily readable and visually appealing.

Each student will present and share with the class **1** of the three selected careers. Each selected career should have the same presentation format so that you will be prepared to share any of the three careers.

The grading rubric provided shows how the components of the project will be accessed and the points for each component.

After the projects have been shared, each student will write a reflection of the experience answering the following questions.

6. Why did you choose these careers?

7. Would you consider pursuing any of these careers? Why or why not?

8. Would you consider pursuing a STEM career? Why or why not?

9. Has this project influenced your interest in learning science or in pursuing science? Why or why not?

10. What did you find most meaningful or interesting in completing this project?

We will begin research for the project in class so that I can answer any questions that might arise in the initial research phase. 1 to 2 class blocks will be devoted to research. You will have 1 to 2 weeks from the start of the project to complete the final assignment. Class presentations will begin after that time.

Suggested websites to begin your research:

http://stemcareer.com/

http://www.sciencebuddies.org/science-engineering-careers

http://stemjobs.com/

Tips on writing a reflection

What is a reflection? : A thought or an opinion that results from careful consideration or thinking.

In other words:

- ✓ It is a personal account of your experience. It is more than answering “yes” or “no”.
- ✓ A reflection allows you to incorporate and discuss what you have learned through the experience by providing examples and details.
- ✓ A reflection enables you to integrate your personal experience with your beliefs. It allows you to contemplate on how the experience has impacted your views.
- ✓ A reflection provides input on how to improve the experience.
- ✓ A reflection should be honest and straight forward. It should express your opinion.

Elements of a Good PowerPoint

1. **Be Consistent.**
   - ✓ The background design should be the same throughout the presentation.
   - ✓ Avoid designs that distract the reader.
   - ✓ If you want to use color keep it easy on the eyes.
   - ✓ Remember to think about the contrast in colors between the background and the text, graphics or images.
   - ✓ The slide layout should be uniform.
   - ✓ The font style should be the same in all slides.

2. **Make it readable.**
   - ✓ Use a font style that is easily readable.
   - ✓ Be sure to use a large enough font size to make it easy to read. A font size of at least 20 will probably be required.

3. **Keep it simple.**
   - ✓ Avoid putting too much text on a slide. Use bullet points to provide information. These will be your cues or your talking points.
   - ✓ Use images and graphics that enhance the information and ideas.
   - ✓ Don't overuse animation or special effects.

4. **Check spelling, grammar, and punctuation.**

5. **Check your organization of the material.**
   - ✓ Does it flow?
   - ✓ Does it make sense in this order?
   - ✓ Is it visually appealing?

6. **Keep your audience in mind.**
   - ✓ Make it interesting for your audience.
   - ✓ Talk to your audience. Interact with them.

7. **Practice.**
   - ✓ The more familiar and more comfortable you are with the material, the better the presentation.

STEM Project Grading Rubric

STEM Project	Level 4	Level 3	Level 2	Level 1	**Points**
Content Required Elements	The required 6 elements are present for the 3 careers. (30 pts)	5 required elements are present for the 3 careers. (24 pts.)	4 required elements are present for 3 careers. (18 pts.)	3 or less required elements are present for 3 careers. (0 to 12 pts.)	/ 30 pts.
Details of required elements	All elements are clearly explained and include sufficient and specific details. (40-36 pts.)	Most elements are clearly explained and include sufficient and specific details. (35 to 30 pts.)	Some elements are clearly explained but not all in sufficient detail. (29 to 24 pts.)	Some elements are explained clearly but not in sufficient detail. (23 to 16 pts.)	/ 40 pts.
Background Research and Works Consulted	Includes 5 or more correctly cited sources. (8 pts.)	Includes 5 or more sources but not all are correctly cited. (6 pts.)	Includes 3 to 4 sources and most are correctly cited. (4 pts.)	Includes less than 3 sources. (2 pts.)	/ 8 pts.
Creativity and Visual Presentation	Information is presented in a format that is easy to understand and visually appealing. (12 pts.)	Information is presented in a format that is understandable and includes visual elements. (10 pts.)	Information is presented in a format that is readable but lacks visual elements. (8 pts.)	Information is presented but is not easily readable. (6 pts.)	/ 12 pts.
Oral Presentation of Project	Student communicates information in a clear, logical, and succinct manner. (10 pts.)	Student communicates information in a clear manner. (8 to 9 pts.)	Student communicates information in a somewhat clear manner. (6 to 7 pts.)	Student is not clear in communicating information. (4 to 5 pts.)	/ 10 pts.

Post-STEM Career Project Questions

1. The STEM Career Project increased my awareness of STEM Careers.

Strongly Agree Agree Disagree Strongly Disagree

2. As a result of the Project I am interested in learning more about science.

Strongly Agree Agree Disagree Strongly Disagree

3. I am interested in learning more about STEM careers.

Strongly Agree Agree Disagree Strongly Disagree

4. I found the STEM Career Project to be valuable for my future career aspirations.

Strongly Agree Agree Disagree Strongly Disagree

5. As a result of the Project I would consider pursuing a STEM career.

Strongly Agree Agree Disagree Strongly Disagree

6. Do you believe the project changed your ideas about learning science?

Yes No

7. Do you believe the project changed your ideas about pursing science as a career?

Yes No

8. Did you find the project to be a valuable use of your time?

Yes No

9. Do you believe that the project should be included in the course?

Yes No

STEM Career Project Modifications

The STEM Career Project can be modified to accommodate different learners. For learners requiring support the following adaptations can be used.

1. The number of careers students are required to explore can be limited to 2 careers and the 3rd career can be optional and treated as extra credit. In a mixed ability class using adjusted point totals may also be an option.

2. Eliminating the projected growth requirement. Students may not understand what it means.

3. For students that require help getting started, the website http://www.sciencebuddies.org/science-engineering-careers may be the best place to begin.

4. For citations have students, at a minimum, use the URL of the website to document the source of their information.

5. Modifying the grading rubric according to changes in requirements or to make it easier for students to identify the required elements. (See example provided).

6. For students that struggle to create a PowerPoint, provide a template.

7. Other adaptations are having students provide at least one picture of a person engaged in the career and at least two pictures of something related to the career.

8. The Post-STEM Survey and student reflection can be combined into one document for feedback. (See attached.)

9. The project can be completed as an in-class project. If students are using a shared platform, such as Google, and students share the document with the teacher, it will be possible for the teacher to assess their progress and make any necessary modifications to the lesson or to provide individual students with additional support.

Career	Education/ Training	Responsibilities/Daily Activities	Employers	Salary Range	Images (1) per slide	Total Points
						/ pts.
						/ pts.
						Extra Credit
Citations (2 or more correctly cited)						

Creativity and visual presentation	Information is presented in a format that is easy to understand and is visually appealing. (pts.)	Information is presented in a format that is understandable. (pts.)	Information is presented in a format that is not easily readable. (pts.)	/ pts.
Oral presentation	Student communicates clearly. Student explains why he or she is interested in the career. (pts.)	Student doesn't communicate information in a clear manner **or** student doesn't explain interest in this career. (pts.)	Student doesn't communicate information in a clear manner **and** student doesn't explain interest in this career. (pts.)	/ pts.

Final Grade _______________ / pts.

Post-STEM Career Project Questions (Survey and reflection questions.)

1. The STEM Career Project increased my awareness of STEM Careers.

Strongly Agree Agree Disagree Strongly Disagree

2. As a result of the Project I am interested in learning more about science.

Strongly Agree Agree Disagree Strongly Disagree

3. I am interested in learning more about STEM careers.

Strongly Agree Agree Disagree Strongly Disagree

4. I found the STEM Career Project to be valuable for my future career aspirations.

Strongly Agree Agree Disagree Strongly Disagree

5. As a result of the Project I would consider pursuing a STEM career.

Strongly Agree Agree Disagree Strongly Disagree

6. Do you believe the project changed your ideas about learning science?

Yes No

7. Do you believe the project changed your ideas about pursing science as a career?

Yes No

8. Did you find the project to be a valuable use of your time?

Yes No

9. Why did you choose the careers you researched?

10. Would you consider pursuing any of these careers? Why or why not?

11. What did you find most meaningful or interesting in completing this project?