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IDENTIFYING PIONEERS OF TOMORROW:
A STUDY OF THE RELATIONSHIP BETWEEN MIDDLE SCHOOL STUDENTS’
INNOVATOR SKILLS AND STEM INTERESTS

By
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Abstract

This quantitative survey study explored the innovator skills and STEM interests of students at a middle school in the Pacific Northwest. The purpose of the study was to determine whether a relationship existed between students’ innovator skills, STEM content and career interests, and plans to attend post-secondary education. The literature review describes an increasing need for graduates with innovator skills and STEM interests. Additionally, the current state of innovator education is shared with a focus on STEM education. Social Cognitive Career Theory and Aptitude-Treatment Interaction are presented as frameworks for consideration with regard to which internal and external influences affect student interests. This study employed the Youth Innovation Skills Measurement Tool (YISMT) and the STEM-Student Survey for Middle and High School Students (S-STEM) along with a demographic survey to collect quantitative data. The results revealed significant relationships between innovator skills, STEM content areas, and career interests. In an exploratory phase, gender and grade level were examined with respect to the dependent variables. The researcher identified several significant differences between males and females on the dependent measures. Further, eighth graders scored significantly higher on several dependent measures than did sixth graders. While there are some study limitations, the findings suggest opportunities for instructional adjustments for further development of innovator skills and STEM interests which in turn will likely increase the number of STEM career-oriented graduates with innovator skills. Theoretical and practical implications are discussed with regard to the findings and suggestions for future research are presented.

Keywords: innovators, STEM, middle school
Dedication

To my parents, who told me I could do anything.

To Ava, as proof she can, too.
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This document is evidence of my professional passion for educating youth and supporting their ever-astonishing brilliance in dreaming up innovations. With sincere gratitude and appreciation I acknowledge those who supported me in my work.

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CHAPTER ONE: INTRODUCTION

**Background of the Problem**

Educators are tasked with what is arguably the most important job one can have in society; preparing generations of youth for an unknown future. Leaders in the education field are challenged to advocate for an efficient and effective application of ever-shrinking resources in this pursuit. Teachers, administrators, and legislators alike spend energy seeking best practices and programs, addressing the moving target of what youth will need to know as adults. One such important endeavor includes instruction and support in building students’ innovator skill sets. Jaskyte, Taylor, and Smariga identified the evaluation of instructional activities, the creation of new educational structures and the provision of new resources as an effective means to influence student abilities (2009). Developing student innovator skills promotes flexible, career-ready abilities for economic and social development (Zhao, 2012b).

This study explored the relationship between middle school students’ innovator skills and their interest in Science, Technology, Engineering, and Mathematics (STEM) content and career paths. STEM education, the formal inclusion of STEM concepts in instructional activities, is one such framework, recently gaining popularity on a national scale (President’s Council of Advisors on Science and Technology, 2012). STEM education involves integrated content learning, primarily through project-based learning in their classrooms. For example, students may design a home using environmentally sustainable materials, build robots for simulated space missions, or design a prosthetic appendage. Support for this framework is important because of employers’ changing demands, such as an increase in flexible problem solving practices and a decrease in
assembly line positions. Further, employers demand graduates competent in STEM fields and employees adept in the use of a design process to regain a solid foothold in global economic standings through the creation of new products and processes (Business Roundtable, 2005; Council on Competitiveness, 2008; Hira, 2007; National Science Board, 2010; President’s Council of Advisors on Science and Technology, 2012). One way to fulfill this need is to direct young people’s educational experience toward these interests. Identifying young innovators through STEM education is a relationship to be formally explored.

This study explored the quantitative relationship between innovator skills and STEM content and career interests. Specifically, students were surveyed regarding their perceptions of their innovator skill sets, interest in STEM concepts, awareness of STEM careers, and post-secondary plans. The results suggest some interesting relationships between innovator skills, STEM interests, and basic demographic characteristics. Student perceptions of these concepts are important in determining whether adult-selected learning opportunities are improving student access to appropriately developmental activities.

**Statement of the Problem**

Society turns to each new generation to identify individuals to solve today’s problems and advance the interests of tomorrow - the innovators who will change our world. Through science investigations and engineering challenges, educators have the opportunity to develop young people’s innovator abilities (Chell & Athayde, 2009). New national academic standards focus on process competencies over content acquisition with the goal of promoting acquisition of skills transferable to future careers (Krajcik, 2013).
In conjunction, STEM education is at the forefront of educators adapting current K-12 curricula to promote the ability of students to answer questions and solve problems. STEM education often requires a change in teaching pedagogy and classroom activities toward an interactive, problem-based learning environment (O'Neill, Yamagata, Yamagata, & Togioka, 2012). This renewed emphasis on STEM education encourages opportunities for students to grow innovator skills, and in combination with other 21st century skills, educators can nurture seeds of future student success. As education practices shift, the appropriate instructional response is unclear. The relationship between middle school students’ innovator skills and their attitudes toward STEM education and careers lacks research at a time when educators seek opportunities to teach students about these interests and how they might translate to potential careers (O'Neill et al., 2012). To effectively continue the drive for students’ enhanced science and engineering abilities, a greater understanding of the middle school age group’s interests and abilities is warranted.

**Purpose of the Study**

The purpose of this quantitative, survey study was to explore the relationship between middle school students’ reported innovator skills and their perceptions of STEM (science, technology, engineering, and mathematics) education and careers at a suburban middle school in the Pacific Northwest.

The independent variable was defined as participants’ scores on an innovator skills assessment. The dependent variable was defined as participants’ scores and responses on a STEM survey.
Research Questions

The following research questions guided this quantitative study:

**Question 1:** What is the relationship between middle school students’ reported innovator skills and their attitudes toward STEM education?

The following sub questions extended the research inquiry:

**Question 2:** What relationship exists between innovator skills and attitudes toward post-secondary opportunities?

**Question 3:** What relationship exists between attitudes toward STEM education and post-secondary opportunities?

As STEM education is buttressed by the use of creativity, self-efficacy, energy, risk-taking, and leadership (Levy & Murnane, 2005; Malyn-Smith, 2010; Partnership for 21st Century Skills, 2008; White House Office of Science and Technology Policy, 2014), students with a greater propensity for these skills will likely connect positively to STEM activities. To this effect, supporting innovator skill development may positively influence students’ STEM interests. To further investigate these ideas, the researcher tested the following hypotheses:

**Hypothesis 1:** Students who possess greater innovator skills are more likely than students who possess fewer innovator skills to identify positive attitudes toward STEM education content.

**Hypothesis 2:** Students who possess greater innovator skills are more likely to have positive attitudes toward STEM career areas.

**Hypothesis 3:** Students who possess greater innovator skills are more likely to plan to attend post-secondary opportunities.
Hypothesis 4: Students who have positive attitudes toward STEM education are more likely to plan to attend post-secondary school opportunities.

Methodology Overview

This study used two quantitative surveys to gather data from middle school students in the Pacific Northwest. This study took place in September 2014. All students at the school received permission and assent forms on the first day of school and all students who returned completed forms within the first two weeks of school were included in the study sample. Participants took the surveys during the last two weeks of September 2014. Quantitative surveys were chosen in order to categorize a large quantity of student responses. The Youth Innovation Skills Measurement Tool (YISMT) was used to collect data on student innovator skills. The YISMT solicits student self-assessment of creativity, self-efficacy, energy, risk-propensity, and leadership (Chell & Athayde, 2009). The Middle and High School Student STEM Survey (S-STEM) was used to collect data on student attitudes toward STEM disciplines, 21st century skills, STEM career interests, and intentions toward post-secondary school (Friday Institute for Educational Innovation, 2012a). The S-STEM is touted as a useful tool for organizing STEM programs in schools and workplaces (Faber et al., 2013).

Definition of Terms

The following terms were used operationally within this study.

21st century skills: critical thinking, communication, and collaboration

Creativity: imagination, connecting ideas, unique problem solving, and curiosity (Chell & Athayde, 2009a)

Energy: drive, enthusiasm, motivation, and persistence (Chell & Athayde, 2009a)
Engineering: engagement in the system of identifying an appropriate problem to solve, envisioning a unique solution, and actualizing that idea (Gwynne, 2012)

Innovator skills: creativity, self-efficacy, energy or stamina, risk-propensity, and leadership (Chell & Athayde, 2009a)

Innovators: persons who regularly apply innovator skills in design to create new products and/or processes

Leadership: vision and ability to mobilize action (Chell & Athayde, 2009a)

Middle school: an educational institution housing students in grades 6-8

Post-secondary school: college, university, technical, or trade school attended after high school completion

Risk-Propensity: risk tolerance, ability to calculate and take risks (Chell & Athayde, 2009a)

Science: systematic study of structures and behaviors of the physical and natural world through observation and investigation (Jacobs, 2010)

Self-Efficacy: self-assurance, self-empowerment, and social confidence (Chell & Athayde, 2009a)

Suburban: a smaller community adjacent to a city

STEM content: Math, Science, Engineering and Technology (Friday Institute for Educational Innovation, 2012a)

STEM education: intentional integration of STEM concepts, content, and literacy into classroom students’ classroom middle school experiences

Technology: human-made systems and processes
Assumptions

The underlying assumption of this study was that student skills, attitudes, and levels of awareness, are identifiable. Specifically, it was assumed that the Youth Innovation Skills Measurement Tool is an appropriate instrument for measurement of participant innovator skills for middle school students. The YISMT was developed for use with secondary school-aged youth to illuminate innovator skills of participants (Chell & Athayde, 2009a). It was also assumed that the S-STEM is an appropriate instrument of measurement of participant attitudes toward STEM, awareness of STEM careers, and post-secondary opportunities. The S-STEM was designed specifically for middle school and high school students (Friday Institute for Educational Innovation, 2012a). Additionally, it was assumed participants would respond honestly and to the best of their ability on study instruments.

Delimitations

The delimitations of this study surround the sample of participants. One delimitation is that data collection was confined to students in one middle school model in one district in one state. Middle school education models vary by district and state, and all students within a school are unlikely to have the same exposure to survey content. This study collected data from participants in the first month of school and does not account for changes in participant perceptions, attitudes, or experiences that occur over time. Finally, this study did not account for perceptions of all middle school students outside of the study’s sample with regard to innovator skills and STEM content and career interests or experiences.
Limitations

There are two major limitations in this study; relatively small sample size and sample selection. One school was selected for this study and all participants were sampled from within the current student body. Additionally, student participation was based on parental permission. This may have unintentionally created a sample with similarities and differences among participants that might not exist using random sampling. As a result, this may affect the generalizability of the study to students within the same school, at different schools, or in different districts.

Other limitations include student experiences and survey structure. Students sampled did not necessarily share the same teachers, classroom experiences, or exposure to study-related concepts in or outside of school. Students across all three grades completed the same instruments. Some participants may have had limited comprehension of survey items and response choices. Students at different grade levels are sometimes at different reading comprehension levels and some students in the sample may receive reading or language support in the general education setting that was not supported in this study. To support the students, the researcher was available to define terms and students received additional supports as provided by an Individual Education Plan (IEP) as well as modifications and accommodations that normally occur in the classroom. Participants took the surveys at school in the presence of teachers with whom they were familiar, a potential opportunity for bias. Participants might have selected responses based on perceived need to perform or self-represent as academically oriented to school staff. Further, the instruments provide only a snapshot of participants’ self-reported perceptions that may be unique to the time of survey. Lastly, the researcher
knew some of the participants as their former or current teacher and the researcher’s experience as a classroom teacher might have influenced interpretation of results.

Through a variety of control measures, the researcher controlled for many of these potential limitations as thoroughly as possible. For example, all students with parental permission for participation and who assented to the study were included to provide as large of a sample population as possible. Further, all participants received the same instrument directions and opportunity to complete the study, and as students of the same middle school, participants were likely to have similar educational experiences with regard to study topics.

**Significance of the Study**

This study contributes to the general knowledge of youth innovators and STEM education in the field of secondary education. Although the population of this study was middle school students, results have some broad application for K-12 education, post-secondary education, and STEM fields. The results provide information regarding self-perceptions, reflections, and opinions of youth in middle grades. The results also inform future topical studies with regard to middle school students’ geographic experiences and create a potential baseline for future research in these areas. Additionally, the study may serve to inform further study of students who later become STEM industry leaders.

This study addresses students’ experiences and understanding of innovator skill building and STEM education. Educators making program and curricular modifications outside of the study site may also find these results useful as they consider these programmatic outcomes at their own school and district. Additionally, educators may gain insight regarding students’ interests in future career opportunities. Finally, study
results may guide programming about students’ pre-career exploration experiences in secondary schools.

Finally, this study may influence decisions regarding education policy. Education should be designed to prepare students for the future and school experiences should reflect the best estimations of that future to be effective. The results of this study may also provide insight regarding appropriation of innovator skill-building programs and the inclusion of STEM-centered and project-based programs in curricular mandates.

Summary

Our education systems must support the needs of students’ future endeavors to remain relevant in their duty to prepare students for the workforce. Industrial shifts toward highly skilled employees with the ability to solve problems and advance market share through innovations should result in educational experiences that support such development. STEM education is a popular framework to provide hands-on experiences for students, yet the connection to growth in student innovator capabilities is still undetermined. The purpose of this quantitative study was to explore the relationship between innovator skills and STEM education among middle school students. Participants were surveyed with regard to perceptions of their innovator skills sets, interest and awareness of STEM content and career fields. The study assumed middle school students would provide accurate information regarding their self-identification, perceptions, and opinions through the provided survey instruments. Study results were likely influenced by the given population and may not be applicable to all middle school students, however, the study results may influence further research about innovator skill-
building, STEM education, teaching practices, and education policy in the pursuit to fully support youths in their educational endeavors.
CHAPTER TWO: LITERATURE REVIEW

Introduction

Young people are influenced by their environment, our rationale for sending children to learn at educational institutions. The majority of our youth spend significant portions of their developmental years in schools where their interests and abilities can be supported. Middle school students are at a crux in their educational journey; they are poised to choose high school coursework, a snowballing influence on collegiate and career opportunities. While consideration of educational influences at all ages is prudent, middle school students’ identification and development of their innovator skills should be highly supported in a societal pursuit of graduating young innovators. A large body of research explores the effect of these educational variables on the development of students’ interests and achievements.

Other research explores the various factors that influence youths’ innovator skills. Providing support for young innovators requires an understanding of society’s interest in innovation, the current state of innovation education, and the potential for future change. Innovators are in high global demand for their influence on current and future economic sustainability and growth. Further, these individuals are also likely to use problem solving skills and entrepreneurial application to better their communities (Zhao, 2012b). Developing innovators is paramount to global economic and social success and education systems are a natural place for this enrichment.

Innovator skill-building activities can be built into the education environment to maximize and influence students’ skills. STEM education is one means to give students meaningful exposure to industry-valued innovation practices, in addition to supporting
STEM content areas (National Science Board, 2010). Some countries, such as the United States, import college graduates from other countries to fill STEM jobs, often in lieu of developing employment-ready youth within their own boarders (National Science Board, 2010). As education systems reorganize and transform, systemic educational shifts may enable effective development of youth innovators.

Education systems are only as effective as what happens within the walls of classrooms. At the classroom level, educators can use students’ abilities and interests to effectively guide student learning. Identifying existing student skill sets and interests may provide useful insight into educator goal-setting and fine-tuning of instructional interventions. While the need for both innovators and increased STEM education is evidenced in the research, this relationship should be investigated as it applies to any potential shift in instruction at the middle school level (National Science Board, 2010).

This literature review presents a number of influences on student learning with respect to skill building for the future. Several existing methods for classroom instruction of middle school students in math and science education, including the adoption of new national learning standards and different instructional practices, are shared. Societal need for innovators is explored with respect to services and skills provided by innovators and the role of formal education in supporting that need. Current themes of research regarding youth innovators are outlined, specifically with respect to the learning environment, faculty support, and youth leadership. STEM education is discussed as a current means to providing content-integrated inquiry and project-based learning opportunities for youth innovators. Lastly, two theories, Social Cognitive Career Theory
(SCCT) and Aptitude Treatment Interaction are considered with regard to what factors influence student career interests and support career interest actualization.

**Current Classroom Structures**

Classrooms are the front lines to influence students’ future successes. Educators, legislators, parents, and students alike know that what happens in a classroom can ignite or extinguish a desire to learn, create or destroy an opportunity to grow, and set off a chain of events that will influence a student’s future. Learning experiences intended to positively influence student achievement, help or hinder student learning, depending on a number of student variables such as need, preparation, and interests. To better prepare students for the workforce, educators must consider practices within the classroom they can implement to best fit the aforementioned student variables. The growing acceptance of new national standards in combination with corresponding instructional adaptations illustrate the importance of educator activity geared toward increasing youth innovator skills development.

**Shifts in Learning Standards**

Recently states throughout the United States adopted and began implementation of two new sets of learning standards, the Next Generation Science Standards (NGSS), and the Common Core State Standards (CCSS). The NGSS encompass science and engineering concepts and CCSS includes a structure for learning literacy, written communication, research, and mathematics directly and with respect to science (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010; National Science Board, 2010). The NGSS and CCSS offer many opportunities for connecting the two sets of standards, such as through activities that pair
content-rich texts with planning an investigation or designing a house to match environmental building codes (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010; National Science Board, 2010). By adopting these standards, states sent a message of expected conceptual integration to educators. These standards convey expected learning trajectories for current students and for future graduates.

**Next Generation Science Standards (NGSS).** The NGSS are one change to education expectations as a response to societal challenges to adequately prepare U.S. students for future endeavors. The standards are designed to overcome several failures of current science achievement (NGSS Lead States, 2015). Specifically, the U.S. is losing its competitive edge in innovation. Over half of patents filed in 2010 originated with foreign competitors and China far exceeded the U.S. in high-tech product exportation (National Science Board, 2012; U. S. Patent and Trademark Office, 2013). Further, achievement of U.S. Students is lagging with respect to its foreign counterparts. Assessments of student achievement in science literacy ranked U.S. students 23rd among global competitors (2012 ACT College Readiness Benchmarks Report, 2012). Sixty-nine percent of high school graduates did not meet readiness benchmark levels in science in a 2012 ACT report (2012 ACT College Readiness Benchmarks Report, 2012). Educators also identify a gap in what students are able to do and expectations for achievement. The NGSS are designed to create a rigorous classroom environment by requiring students to demonstrate and apply learned concepts (NGSS Lead States, 2015). Further, these standards are designed to stimulate and build interest in STEM (NGSS Lead States,
This organization of expectations presents a standardized guideline for educators in their efforts to raise the bar of US science, technology, and engineering achievement.

The standards cover K-12 learning expectations and are designed to create science competence to apply knowledge. Each standard consists of a list of multiple student demonstration expectations, corresponding science and engineering practices, disciplinary core ideas, cross-cutting concepts, vertical and horizontal connections to other standards, and connections to CCSS (NGSS Lead States, 2015). Additionally, several other successful aspects of international standards are echoed in the NGSS as a result of benchmarking (NGSS Lead States, 2015). Unifying overarching ideas, language geared toward assessment to focus on achievement, and presenting standards in a format structured as a useful reference tool also create a more effective guide to teaching science (Achieve, 2010; Dobson, Oostdyk, & Radtke, 2013). The ongoing progression of learning integrated with inquiry and demonstration processes add depth to science learning (Krajcik, 2013; Robelen, 2010). This instructional guideline is poised to influence students’ experiences and potentially their interests in the classroom.

The NGSS originated with 26 lead states and are gaining additional states during adoption processes (The Next Generation Science Standards, 2015). As states initiate implementation that includes a phasing out of state-created standards and corresponding assessments, some question the feasibility of the transition and the format of new assessments. Compared with many sets of prior standards, NGSS focus on student demonstrations of knowledge and assessments should follow the same trajectory. Dobson et al. (2013) suggest that prior attachments to highly structured assessments will need to be forgone in favor of more open-ended inquiry and copious opportunity for
conceptual exploration (Dobson et al., 2013). Others caution that a lack of a structured curriculum prior to building assessments will compromise measurements of student achievement and fail to actualize NGSS goals (Bybee, 2013; Krajcik, 2013). Several researchers agree that the inclusion of studying the nature of science, the constant relativity and localization of science concepts, enables future assessment formats to reflect responses personalized to the learner’s interactions with science (Dobson et al., 2013; Krajcik, 2013). Further, assessments should demonstrate to students themselves, in addition to educators, that science processes are more essential to science competence than memorization of content (Cooper, 2013). Responses to the rollout of standards call for systemic changes in education policy and classroom activity to match NGSS standards for learning (Cooper, 2013; Lee, Miller, & Januszyk, 2014). NGSS-based assessments have an opportunity to measure students’ abilities in STEM skill application, providing information regarding students’ growth and development.

In conjunction with science content and application, the NGSS seek to support science literacy for reasons beyond scholastic achievement. Inclusion of references to national standards regarding literacy and career readiness present a holistic framework for successful students. Whether students embark on careers of innovation or make decisions solely for their own livelihoods, the ability to read and comprehend material from the science genre and couple it with mathematics ability is a need for all citizens (The Next Generation Science Standards, 2014). The NGSS are designed to work with CCSS toward holistic education reform.

**Common Core State Standards (CCSS).** While primarily focused on English language arts/literacy and mathematics, the CCSS include standards for literacy and
writing in middle school science and technology classes. CCSS provide ten standards in line with the College and Career Readiness (CCR) anchor concepts with regard to science and technical literacy (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010). Students in middle grades must be able to locate key ideas and details in texts, understand the craft and structure of a piece of text, explain the integration of knowledge and ideas as presented in the text, and read with comprehension science and technical texts independently and proficiently (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010). For writing, students must be able to center arguments on discipline-specific content, craft expository texts such as inquiry procedures and technical processes, produce clear and coherent writing achieved through a developmental writing process, publish their work, research and present knowledge, and develop a range in writing applications (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010). In summary, students must be able to effectively obtain information from written texts, synthesize the material, and communicate new understandings and ideas through their writing and speech.

In one study, researchers made comparisons between students who experienced a literacy-enriched science class and those who did not (Fang & Wei, 2010). Specifically, students in several middle schools experienced a science classroom in which literacy was an integral part of instruction (Fang & Wei, 2010). The researchers found that students who experienced the literacy-enriched science class significantly outperformed the control group in literacy competency (Fang & Wei, 2010). This relationship supports the
CCSS directives for science learning. Specifically, students who experience science content with literacy support are more successful on literacy assessments.

CCSS do not directly reference innovation yet the standards are likely to support innovative practices (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010). Students able to read and research existing knowledge regarding a concept or product, locate supportive or idea illuminating material, and locate texts providing learning required to develop ideas formally build innovator skills (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010). Further, students who formally develop communication skills through writing are likely better prepared to share innovations (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010). Explaining how a given system works is a standard that unifies current and emerging technologies, a practice that can outline innovative paths of learning (Stohlman et al., 2011).

The inclusion of CCR considerations notes a concern of the CCSS to promote student development in light of post-secondary opportunities. The inclusion of scientific practices in the NGSS indicates a similar idea; students should practice skills applicable to workplaces. Future employment is unlikely to primarily consist of single activities as complexity grows to match industry needs (Friedman, 2013, March 30). Additionally, the NGSS and CCSS represent a shift toward students using a collection of skills, such as procedural writing and science inquiry, to complete learning activities. Preparing students for innovative activities in which they draw from a host of abilities to create something new is possible through integrated application of the new standards. Changes
in instructional activities are required to create an integrated learning environment. Practicing skills in isolation does not support task complexity (NGSS Lead States, 2015).

**Altering Instructional Practice**

Classroom activities and resources must evolve to support the education of innovators, STEM-centered learning, and a national transition to new learning standards. Instructional shifts have the potential to enable more students to participate in science and engineering practices, increasing their likelihood for achievement (Lee et al., 2014). Further, educators are responsible for instructional modification as a means to provide all students with access to the curriculum (Lee et al., 2014). Some of these modifications may include the installation of additional inquiry-driven learning opportunities (Wolfe & Fraser, 2008) and increasing interdisciplinary facets of those opportunities. Instruction could include designing possible solutions to a local environmental problem in which multiple organizations are stakeholders or determining the relationship among force, mass, and acceleration by creating a presentation to teach this relationship to older or younger children. This two-pronged approach supports the new learning standards, more closely matches students’ future professional problem-solving skill needs, and is likely to engage young minds in further learning.

**Inquiry-driven learning.** Inquiry-driven learning is an opportunity for students to use prior science learning to guide further science exploration (Germann, 1991). Examples of inquiry-driven learning in a classroom could include testing chemical mixtures to identify contents, assessing water quality of a stream, and observing animal behaviors. This practice enables students to probe situations for new information and cultivate new ideas based on an existing schema (Conrad & Dunek, 2012). This
customizable formatting enables a more learner-centered classroom, which is a supportive practice in science education (Harris & Rooks, 2010). Educational experiences centered on the learner also allow for a greater opportunity for student discourse (Hardman, Abd-Kadir, & Smith, 2008; Thompson, 2013). Benefits of inquiry-driven learning are amplified when learning experiences highlight discovery and lead to further inquiry (Arya & Maul, 2012). Prior frameworks for learning, such as following pre-determined procedures and assessing for expected results, do not necessarily enable students to explore new topics in science. Alterations to instructional practices may increase student discovery and exploration practices within classroom activities, prompting development of student interests.

The NGSS and CCSS place a greater emphasis on students determining what is needed to solve a given problem, locating the necessary content or practice, and demonstrating the process and results (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010; The Next Generation Science Standards, 2014). To meet the rigor of these new standards, students must become well versed in applying knowledge to model concepts and to solve problems (Pruitt, 2014). Classroom educators need to build in more demonstration-centered activities in which students use exploration of a concept to build new understandings and application of academic content (Tseng et al., 2011).

Applying learned skills and abilities can be an engaging activity in the classroom. Engaged students meet learning targets through a genuine interest in the work necessary to build new knowledge. Inquiry-based opportunities are rich tasks that encourage ownership of one’s learning and engender personalization of the learning experience.
(Conrad & Dunek, 2012). Engaging students promotes a climate of opportunity with greater achievement efficacy in schools that embrace this best practice (Oliveira et al., 2012). Further, using inquiry-based instructional practice engages students through a developmentally appropriate lens. Inquiry-driven learning can create an interest in the sciences at an age when many are at great risk of losing interest in science entirely (Rawot, Peirce, & Kanoy, 2011). In other words, early intervention is a key to maintaining science interest (Farenga & Joyce, 1999). Promoting the development of future innovators requires conscious retention of their innate drive to explore and engage with the world around them.

Inquiry is one approach to develop students’ science competencies (Pruitt, 2014). Further, inclusion of STEM project-based activities increases students’ interest in STEM fields (Tseng et al., 2011). Countries that use structured projects to reach a young audience and stimulate interest are more likely to create successful learning environments (Achieve, 2010). Inquiry is more than a process; it is an immersion in an actual or probable situation in which students are tasked with finding solutions and sense-making through discovery and use of a diverse skillset (Germann, 1991).

**Interdisciplinary experiences.** Current and future graduates entering the work force are unlikely to encounter employment opportunities that do not require a combination of skills (Friedman, 2013; Wagner, 2012). Overwhelmingly, students need to be well versed in applying interdisciplinary skill sets in both a proactive and reactive manner (President’s Council of Advisors on Science and Technology, 2012). Instructional practices should match this need and educators should provide more learning opportunities that require the development and use of interdisciplinary skills.
The NGSS and CCSS are performance-based rather than memorization- and recitation-based, and students must demonstrate competence with each standard (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010; The Next Generation Science Standards, 2014). For example, one NGSS standard for middle school requires students to construct a model to illustrate the function of a cell as a whole system and how organelles function as subsystems within (The Next Generation Science Standards, 2014). Students cannot achieve this standard through memorization and recitation of cell structures. Instead, they must consider cause and effect relationships, function, and proportionality, among other concepts, and finally communicate the product of that thinking in a comprehensible and cohesive manner.

Assessments of these standards require teachers to go beyond paper-and-pencil, multiple-choice exams. The national assessment environment should require students to demonstrate knowledge through application, rather than regurgitate catalogued information (NGSS Lead States, 2015).

Situation-based problem solving in the form of project-based learning is one example of how to authentically prepare students for future professional tasks (Chen, 2010). This method grounds student experiences in a context with which they may have some familiarity or experience. Exposing students to engineering activities also provides relevant opportunities to develop engineering design capabilities (Lee et al., 2014; Rawot et al., 2011). These activities can be similarly grounded through well-chosen contexts appropriate to the learners, including specific community connections. Educators further promote an interdisciplinary approach to learning through adding technology components to projects while building community partnerships between schools and organizations.
invested in encouraging such practices (Chen, 2010). Teachers can request materials, guest speakers, assessment resources, and other instructional supports from organizations interested in supporting their future job candidate pools.

Some existing educational programs provide examples of interdisciplinary means to strengthen innovator skill sets. Gateway to Technology is one effective interdisciplinary program in which students engage in tasks that require an application of STEM competencies to solve problems (Stohlman et al., 2011). The integrated curriculum has the potential to adequately prepare middle school students for future STEM applications through tasks such as cleaning up after an oil spill and the architecture of environmentally sustainable buildings (Project Lead the Way, 2014). Girls in Engineering, Mathematics, and Science (GEMS) is a second program structured to provide interdisciplinary learning opportunities (National Girls Collaborative Project, 2014). This program is successful in its ability to expose participants to STEM concepts, generate interest in application, and promote participant post-secondary achievement (Dubetz & Wilson, 2013). In both programs, students become versed in the engineering design process while using knowledge from other content areas to defend design choices (Dubetz & Wilson, 2013; Stohlman et al., 2011). While some formal programs exist, not all students have access. Additionally, some programs rely on resources that may not be available to all educators.

Whether formal or informal, interdisciplinary experiences are an engaging means for students to understand science and related learning as a repetitive practice, rather than an end result (Harris & Rooks, 2010). Such practices drive student interest in learning, interest in school, and create focus on personal achievement (Furner & Glasson, 2007).
Increasing youth engagement promotes interest in future career areas, providing avenues for introducing related career paths (Lee et al., 2014; Rawot et al., 2011; Schoof, 2006).

Learning initiatives are more likely to succeed with comprehensive adoption by educators (P. Thompson, 2013). Middle school models have the opportunity to influence student attitudes about science and related topics (Houtz, 1995). Student performance is based on cognitive abilities students develop as a result of intentionally instructed classroom experiences (Oliveira et al., 2012). Comprehensive initiatives may influence acculturation of these topics.

**Focus on Early Adolescent Learners**

Students attending middle school, early adolescent learners, are a unique population. This age group is challenged in forming self-concepts based on both their own interests and proclivities and those of adults in their environment (Arnold, 1980). Their “budding autonomy” explains a replacement of parental influence with social and other contexts (Suldo, Thalji-Raitano, Haseley, Gelley, & Hoy, 2012). Additionally, middle school students seek mature learning experiences, yet still benefit from support of educators (Palumbo & Sanacore, 2013). Early adolescent learners are on a precipice of independence, eager to explore their world through the lens of science and engineering practices yet still seeking guidance in implementation of those practices.

Specific to career and occupational preparation, age is related to career preparation maturity (Creed, Patton, & Prideaux, 2007; Luzzo, 1993; Patton & Creed, 2001; Rogers & Creed, 2011). Research regarding career paths of young people is often geared toward high school (Creed et al., 2007; Gushue, Clarke, Pantozer, & Scanlan, 2006; Lopez et al., 1997; Schneider et al., 2002; Schneider et al., 1999) and post-secondary
youth (Betz & Hackett, 1983; Ferry et al., 2000; Gainor & Lent, 1998; Lent et al., 2001; Lent et al., 2003; Luzzo, 1993). These age groups are generally accepted as times of future-minded exploration and planning (Navarro, Flores, & Worthington, 2007). However, an increasing quantity of research notes middle school as an influential time in which youth develop concepts regarding careers and make academic choices affecting their future (Erickson, 1963; Fouad & Smith, 1996; Navarro et al., 2007; Rogers & Creed, 2011; Super, 1990). Education leaders have an opportunity to influence the educational pathways these students choose and their development as young innovators.

**Societal Need for Innovators**

People with innovator skill sets are a human capital resource. A society that values innovators understands the necessity in supporting innovators, and likely accepts some responsibility for the identification and development of these skills (Benbow, 2012; Chell & Athayde, 2009a). Those equipped with the talent to innovate can only succeed through societal understanding, identification, and intentional support of innovator skill-building activities (Kell, 2013; President’s Council of Advisors on Science and Technology, 2012).

**Service of Innovators**

Innovators are needed to sustain and further develop the economy, both in business and social endeavors (Friedman, 2013). Specifically, the development of innovators benefits economies, which in turn creates a dependent relationship (Hira, 2007). For example, innovations in the technology industry will require a continuous flow of innovations to remain competitive (Thompson et al., 2012). Societies that value advances in technology, whether for economic benefits, societal welfare, or a
combination of the two, need innovators to grow technologies. Innovators need a society in which to diffuse their innovations, whether through intentional or accidental support by stakeholders (Rogers, 2003).

In addition to financial benefits, innovative activities also have social benefit. Innovators provide solutions to problems that compromise social development and can, in turn, further humanitarian efforts (Hira, 2007). Specifically, innovations can improve health, increase communication, and enable further innovation. The identification of the causes of cholera, the invention of laptop computers, and digital communication methods are examples of innovations with social benefit (Rogers, 2003).

Finally, as humans advance the production, technology, and efficiency of innovative industries, the existing job market will change. This new job market will require employees with innovator skills to continue this trajectory (Friedman, 2013, March 30; Zhao, 2012b). For example, as consultants and outsourcing supplant in-house operations, employers will increase the pool of candidates from which to fill their human capital needs (Gobble, 2013). Graduates seeking entrance into some industries should be ready for this type of economy, and promotion of relevant skills is essential in the continuation of that service.

**Economic development.** Citizens with innovator skills are in high demand by countries seeking financial sustainability and growth. If a country is home to individuals driven and able to create new assets, the country will benefit. Lubinski and Benbow highlight economically successful countries as those that developed their human capital (2006). Human capital is a resource and countries that maximize their resources are potentially better equipped to expand economic development. Further, education
resources directed toward talented persons can positively influence the rate of human capital development (Zhao, 2012a). As part of this development, individuals must be recognized early and be provided with opportunities to further develop innovator skill sets, investigate a variety of applications of those skills, and continue this cycle of growth (Lubinski & Benbow, 2006). The earlier a community can support this process for innovators, the more results are likely to manifest over time and positively affect economic success (Kell, 2013).

Global awareness of the direct relationship between economic prosperity and entrepreneurial citizenry causes some countries to reconsider their current developmental strategies. For example, Zhao (2012a) notes that Chinese officials are interested in changing their labor-based economy into one built on innovator talent. Room for innovation talent growth is evident in China. Specifically, while significant portions of goods are manufactured in China, these goods are not designed by Chinese people (Zhao, 2012a). Additionally, Singapore, among other countries like Japan and Korea, is seeking to alter its societal structures, such as access to human capital development opportunities, to enable the development of its citizens’ creativity (Kim, 2011; Zhao, 2012a). In other words, countries worldwide are looking to retain and grow their homegrown talent.

While some researchers note growth or a lack of growth of innovation in specific countries, others focus on the perceived decline of creativity as an inhibitor of innovation. Kim illustrated this point in research analyzing the Torrance Test of Creative Thinking scores of young children (2011). Kim discovered that since 1990, United States participants’ creativity scores have declined (Kim, 2011). Once considered a creative leader, the United States risks losing competitive creative edge, compromising its
economic standing (Kim, 2011). Failing to promote skills of innovators may negatively influence a country’s ability to graduate innovators ready for industries of interest.

**Social development.** Many innovations are created with service to humanity in mind. For example, 3D-printed skull pieces for transplants and portable water collection and filtration devices for populations in arid locations offer health benefits to populations in need (Andey, Lanjewar, Muduli, & Labhasetwar, 2011; Senthilingam, 2014). Some innovators seek these outlets to benefit the greater good, deriving a collective identity and purpose from this pursuit (Smith & Woodworth, 2012).

In the social sector, innovators have the opportunity to act as change agents, creating technologies to ease burdens and eradicate social barriers for present and future generations (Bronson & Merryman, 2010). Innovations for societal benefit carry accountability to a constituency, a mission, or a self-defined purpose for anticipated outcomes. In other words, they add value for a community (Dees, 1998; 2012). Dees argues that socially motivated innovators are needed to develop new models for coexistence, a concept that will only increase in applicability as the global population grows (Dees, 1998).

**Skills of an Innovator**

Innovators, however motivated, have skill sets that promote problem solving. A student’s demonstrated academic ability is often predictive of their future as an innovator, though exceptional intellect is not necessarily a requirement and certainly not the only key to successful innovations (Kell, 2013). In fact, some research suggests non-academic abilities, such as communication, are also essential in the process of innovation (Schneider, Paul, White, & Holcombe, 1999; Zhao, 2012a).
Several studies identify a variety of characteristics and attributes applicable to innovators. Schneider et al. (1999) noted that successful problem solvers are often skilled in interpersonal communication. People with strong interpersonal relatability are equipped to combine their skills with environmental constraints, are responsive to the given situations, and efficient in maximizing a project’s resources (Cawsey, Deszca, & Ingols, 2012). Additionally, initial problem solving skills, such as the understanding of constituents, resources, and the environment, are identified as important innovator skills (Cawsey et al., 2012; Rogers, 2003). Smith and Woodworth (2012) described an ideal innovator as mission-oriented, in constant pursuit of opportunities, a lifelong learner, and a risk-taker, all while demonstrating accountability to society. Bronson and Merryman stated that those who are able to first think divergently to uncover new possibilities and then converge original concepts into a workable reality are more likely to be innovators (2010). Bandura also believed that persons with a strong sense of self-efficacy are better able to construct ways to exert control over their environments and intentionally influence personal outcomes (Bandura, 1989b). In combination, these findings suggest innovators hold complex and varied skill sets which can be tuned toward problem solving in their respective fields. Innovators should be prepared to think through challenges, access skill sets to analyze problems, and design solutions. Rather than one skill in isolation, innovator skills are likely a combination of abilities.

Some research suggests that strength in reasoning ability in conjunction with science expertise influences innovator success and argues for educational practices to develop these skills. Students who are able to provide accurate explanations of science phenomena are more likely able to apply that process in future situations (Arya & Maul,
In support of this finding, some research argues for tailoring students’ education to their strengths in order to provide effective learning opportunities (Lubinski & Benbow, 2006). For example, tracking development of children over decades, one study followed the career choices and satisfaction of men and women with regard to childhood academic abilities and interests (Lubinski & Benbow, 2006). The study determined that rigorous academic experiences markedly influence success as an adult, and further, the experiences should be individualized as much as is possible (Lubinski & Benbow, 2006). The range of career accomplishments in conjunction with the quantity of successful participants prompted the conclusion that the learning environment is important (Lubinski & Benbow, 2006).

Supporting Young Innovators

Given the need for individuals with innovator skills and the school environment as a viable location for developing these skills, the focus of educators turns to growing this talent base. Studies highlight the ability and importance of identifying talent in young people, suggesting that one’s youth is the optimal time for innovation development (Schneider et al., 1999). Researchers find that early experiences, such as lessons in which students are tasked with a design challenge, contribute to later problem-solving efficacy in the workforce (Bloom, 1985; Campbell, Dunnette, Lawler, & Weick, 1970). Further, students’ leadership behavior, an innovator skill (Chell & Athayde, 2009), is evident to both peers and faculty as early as the high school level (Schneider et al., 1999). In fact, academic performance by youth as a strong indicator of future success can supersede the importance of collegiate programs (Lubinski, Benbow, Webb, & Bleske-Rechek, 2006). There is concern over a perceived shortage of individuals prepared to
enter the science and technology workforces, and waiting until post-secondary school to address this shortage is short-sighted (Business Roundtable, 2005; Council on Competitiveness, 2008). Identifying individuals for development of innovator skills should occur during the early years of formal education in conjunction with appropriate supportive interventions to increase students’ skill-building opportunities.

Identifying talented youth and environments that support their development is paramount to placing educational resources and processes in the right hands (Schneider et al., 1999). Students with interest in creating new technologies the tools to design, build, and test their ideas in an environment where the iterative path to discovery is understood and vilified. Further, there is room for countries to work collaboratively to foster young innovators (Zhao, 2012a; 2012b). In other words, countries seek each other’s citizens for employment purposes but fall short of solving the problem through partnerships.

**Educating Innovators**

Education systems are challenged to identify and encourage student innovators. The result of innovator-focused education should be a student’s desire to make a difference and a responsibility to do so (Smith & Woodworth, 2012). In the classroom, educators are tasked with encouraging student innovation, for students who show an inherent interest, as well as for those who appear less engaged in the innovation process. Further, the fields of science, technology, and engineering are in need of students with these traits and thus, teachers have potential influence on students’ interest in these fields.

Education content areas, such as math, are often first considered as opportunities to grow innovator skill sets. For example, science inquiry, the process of identifying a quandary, exploring related concepts, testing related hypotheses, and evaluating results to
inform one’s future work, is a process with extensive application for innovation 
(Germann, 1991). Science and mathematics teachers are tasked with encouraging 
students to answer questions and solve problems. Knowing on which subjects to focus 
instruction is an efficient use of instructional resources. Dempster and Lizzio (2007) 
indicated the importance of educators’ focus on students’ interests and experiences, rather 
than the adult educator’s idea about what a student should experience. Specifically, 
providing opportunities for students to witness their own leadership abilities may be the 
first step in promoting development of innovator skills (Dempster & Lizzio, 2007). 
Theory should be melded with practical application, allowing educators to engage 
students through classroom delivery of skill building opportunities (Chell & Athayde, 
2009a). Educators are tasked with considering influences on students’ classroom 
achievements and supporting instructional activities which have a positive affect on 
growth of desired skill sets.

Other studies considered extrinsic influences on student learning. Some studies 
noted the influence of educator inputs, such as the impact of teacher behaviors in the 
classroom, on academic success (Dempster & Lizzio, 2007; Schneider et al., 1999). 
While student aptitude influences learning outcomes (Cronbach & Snow, 1977), the 
learning environment, the persons and structures in place to provide instruction for 
students, can amplify these aptitude differences (Chell & Athayde, 2009a; Lent, Brown, 
Educators must consider the experiences of students as holistic opportunities for 
influence, identifying all possible opportunities for improving educational experiences.
Further studies discuss youths’ leadership traits as indicators of current and future success, highlighting opportunities to develop these traits (Chell & Athayde, 2009a). For example, one leadership program for female youths was developed to specifically encourage students’ interests in pursuing careers in science through increasing exposure to the sciences (Dubetz & Wilson, 2013). General instructional strategies also include the use of reflection to engage students in applying science findings, increasing awareness of science career opportunities and promoting the sciences as accessible careers (Cohen, Patterson, Kovarik, & Chowning, 2013). Regardless of origin or development of specific programming, the message is gaining strength. Specifically, students need the capacity to craft their future careers around solving problems. Further, students need lasting motivation to persevere through the iterative process of problem solving to create innovations (Friedman, 2013). In addition to student abilities, educators must also consider environmental influences on student achievement in this light.

**Learning Environment**

The learning environment is comprised of the structures surrounding a student’s educational experience. Structures include tangible facets, such as classrooms, and intangible facets, such as teaching style, that build a climate for learning. Several studies explore these facets of learning environments as they pertain to student achievement.

Fouts and Myers (1992) identify the classroom environment as an alterable variable in a child’s scholastic experience. Some environments are intentionally structured to promote student involvement, using a variety of pedagogical strategies, such as student work groups, to generate and sustain engagement through activities such as active discourse and investigation (Conrad & Dunek, 2012; Harris & Rooks, 2010). For
example, providing the opportunity to participate in science inquiry allows students the opportunity to engage in the practice of scientists, rather than solely read about the subject (Germann, 1991). A positive student response to classroom environments is necessary and desirable for academic achievement purposes (Fouts & Myers, 1992).

While Fouts and Myers’s (1992) study unveiled a variety of effective science learning environments, students’ attitudes were primarily positively related to two learning environments. Specifically, students identified classrooms with strong physical and normed behavior organization and varied teaching methods as positive science learning environments (Fouts and Myers, 1992). Fouts and Myers (1992) state that this empirical evidence provides a foothold for other research that could hone in on nuances in organization and pedagogy that could be manipulated by educators to further improve their classroom environment. Students are able to identify classroom characteristics that influence their ability to learn. Consequentially, educators should reflect and take action on those characteristics to maximize learning opportunities.

Wolf and Fraser (2008) also measured attitudes of science students as they relate to the learning environment and achievement. The study assessed the ways inquiry-based learning, defined as exploratory, student-driven science lessons, serves as an effective teaching model (Wolfe & Fraser, 2008). Inquiry-based learning requires student investigation in science concepts, high-level application of prior learning, cohesive understanding of tasks, and a strong relationship between teachers and students that promotes persistence through a process of learning (Wolfe & Fraser, 2008). The study’s results indicated that students in inquiry-based environments experienced significantly greater environmental cohesiveness and slightly greater content knowledge (Wolfe &
Fraser, 2008). In addition, the authors associate this type of learning environment and student outcomes of attitudes and achievement as somewhat dependent on gender, yet list assumptions (such as male predominance for physical interactions compared with female perseverance on classroom equity) not expressly measured or controlled, as supportive reasoning (Wolfe & Fraser, 2008).

Oliveira et al. (2013) also explored science classrooms through the lens of best practices for educators, defined as activities selected with reference to positive influence on student achievement. In addition to reviewing inquiry-based teaching, they used qualitative means to ascertain student engagement and students’ perceptions of school climates. Results corroborated those of Wolf and Fraser (2008) by noting that inquiry-based learning environments positively impact student achievement (Oliveira et al., 2013). The authors discuss additional learning environment factors, such as functionality of systems and subsystems within schools, identifying administrative activities as particularly influential (Oliveira et al., 2012). Further research on one of these several factors, such as specific administrative influence, may provide a more solid base from which to assert a causal relationship between the learning environment and levels of student achievement (Gerring, 2012).

**Faculty Support**

Some studies suggest that specific interpersonal aspects of the learning environment are the lynchpin to provide adequate, self-directed learning activities among students (Fouts & Myers, 2013; Mozhgan et al., 2011; Wentzel, 1997; Wolf & Fraser, 2008). One aspect for consideration is that of teacher support and caring for students’ learning. Some studies suggest educators’ actions influence student achievement
Specifically, educators’ behaviors that may influence achievement range from modeling positive attitudes to creating functional communication protocols in the classroom. For example, effective teachers might use formative assessments to check in with each student’s inquiry process steps on a frequent basis, regularly communicate with others about student progress, and craft classroom inquiries to reflect students’ current science interests (Germann, 1991; Marzano & Waters, 2009; Oliveira et al., 2012).

Students are aware of the diverse influences that may impact their academic achievement. Evidence of teacher concern, student motivation, and student achievement are strongly connected to students’ perceptions of their own success (Wentzel, 1997). For example, middle school students experience marked social and emotional changes during this period of early adolescence, and perceived supportive adult figures are critical for their well-being (Wentzel, 1997). Faculty support is one opportunity to facilitate individualized learning.

In one longitudinal study, students’ perceptions of caring teachers correlated significantly with their pro-social behavior, academic effort, and control beliefs (Wentzel, 1997). In other words, Wentzel (1997) attributed a difference in student motivation to students’ perceptions of being cared for and supported by teachers. While the study accounted for gender, distress, and control beliefs of participants over time, it did not address the potential developmental change in motivators between sixth and eighth graders (Wentzel, 1997). For example, eighth graders may be focused on the transition to high school, relying less on middle school faculty for guidance, and therefore perceive a lower level of faculty support. Students in the study also identified teacher characteristics
of caring as similar to parental characteristics. In short, positive adult models that have caring attitudes, are democratic in interactions, hold reasonable expectations, and give constructive feedback, are most ideal for positive relationships with students (Wentzel, 1997). The study queried student responses regarding teachers in general, not as individuals, and students’ perceptions of other adults in their lives, such as their parents, were not measured to provide a comparison.

Middle school students’ perceptions of pedagogical caring as displayed by teachers may be a factor also evaluated by secondary and post-secondary students. Mozhgan et al. (2011) also found that fostering student leadership is an essential role of a university and student-faculty interactions positively impact this development. Human interactions, a critical component of leadership, can be learned through the faculty-student relationship (Mozhgan et al., 2011). For example, Mozhgan et al. (2011) interviewed Iranian students as individuals and groups to determine the faculty’s influence on their abilities. Results from the study indicate the importance of strong relationships between teachers and students but did not provide specific measurements of these relationships (Mozhgan et al., 2011). Fouts and Myers (1992) also highlight that supportive relationships are specifically important to student achievement and leadership, as do Wolf and Fraser (2008). Faculty support positively correlated to student involvement, and students that perceived a greater level of teacher support identified a positive attitude toward learning (Fouts & Myers, 1992). Wolf and Fraser (2008) also noted an increase in student involvement and self-advocacy with respect to positive faculty influence during inquiry learning. This learning involved teacher facilitation of learning through probing questions rather than giving directives (Wolfè & Fraser, 2008).
In short, the benefit of faculty interactions with students may be an indicator of perceptions of self-efficacy and leadership.

Instructional strategies, chosen by educators, are only as effective as the outcomes regarding student learning goals. Identifying innovator skills in middle school students opens a door to future investigation regarding teachers’ opportunities for influencing achievement goals (Wolfe & Fraser, 2008). Understanding subject-matter is critical to teaching inquiry-based content. The possession of a greater understanding of youth innovator skills is essential for teachers who wish to create an environment of support and development, especially for young leaders (Marzano & Waters, 2009).

**Youth Leadership**

Leadership is perceived as an essential innovator skill (Chell & Athayde, 2009). Leadership traits are observable aspects of a person that positively impact the ability to lead (Rath & Conchie, 2008). These traits displayed in youth may indicate future success as a leader, as well as an opportunity to develop and sustain these traits over time. For example, students who seek understanding of science concepts through effective questioning should be equipped to use these skills when assessing logistics in a future professional endeavor. Skills learned in the classroom should also be transferable to outside the classroom. Students who are comfortable identifying variables and accessing prior knowledge before embarking on an experiment are more likely to solve problems in their future workplace, and further, guide others toward the same goals (Freidman, 2013). Students with this ability are well poised to lead others towards solving problems. Three studies begin to uncover the relationship between student skills in leadership and those students’ efficacy as learners.
Noting a lack of existing research about early adolescent leadership, Karnes and McGinnis investigated sixth through tenth grade students’ leadership attributes with regard to leadership skills, self-actualization, and locus of control (1996). Self-actualization, or the fulfillment of one’s goals, is an important objective for young students (Maslow, 1968). Students with a strong identification with self-actualization are more likely to pursue achievement, leading students who require greater support and direction. Locus of control, the perception of causal connections between human behaviors and rewards, defines situational or chance outcomes as external rewards, and chosen activities or characteristics of the individual as an internal drive or reward (Rotter, 1954). A greater internal locus of control, intentionally selecting one’s experiences to reach desired outcomes, may positively influence students’ leadership abilities. Students with this control may be more likely to persevere in problem solving situations to achieve anticipated outcomes. The combination of a strong concept of self-actualization and locus of control in a student may indicate an innovative leader in a future workplace (Freidman, 2013; Karnes & McGinnis, 1996). Innovators are only as effective as their ability to overcome tangible and intangible barriers to create innovations where others may not yet see opportunity; serving as leaders in their respective industries.

Karnes and McGinnis (1996) found a correlation between leadership traits, self-actualization and locus of control, with regard to ages of students. Specifically, they found that older students scored significantly higher on leadership fundamentals, communication skills, values clarification, and decision-making abilities (Karnes & McGinnis, 1996). Further study of leadership skills, locus of control, and self-actualization may reveal ideal leadership development opportunities for different grade-
levels among adolescent students. There is also the potential to influence student leadership capabilities prior to tenth grade through intentional instruction of leadership skills (Karnes & McGinnis, 1996).

Schneider et al. (1999) conducted a multi-phase research program exploring early displays of leadership behaviors in students in order to help identify experiences likely to promote leadership skill acquisition and assist in selection of responsive interventions. The first phase of study investigated teachers’ predictions of leadership behaviors for specific students. Schneider et al. (1999) shared that a student’s personality, interests, behaviors, skills and abilities are predictors of youth leadership. Data indicated that teachers’ perceptions of student behaviors likely serve as a parallel to a supervisor’s perceptions in the workplace (Schneider et al., 1999). This research design mimics future assessments by workplace leaders evaluating employees, where students are most likely to display leadership qualities as adults.

The authors used a variety of assessments to explore possible relationships among student attributes (Schneider et al., 1999). Results indicated that students skilled and interested in interpersonal relationships are concerned with the impact of their behavior on others (Schneider et al., 1999). Further, while academic ability positively correlated with leadership abilities, it did not necessarily influence faculty ratings of student attributes (Schneider et al., 1999). The authors suggest that leadership is more than academic achievement though perhaps faculty measurements have some limitations (Schneider et al., 1999). The study also found that student leaders have the ability to adjust to the situation and early leadership practice activities may influence success in their future workplaces (Schneider et al., 1999). Exploring students’ early experiences,
such as participating in a leadership program specific to science, might further support this data, as well as the inclusion of peer perceptions.

In phase two of the study, Schneider, Ehrhart, and Ehrhart (2002) addressed youth leadership as viewed by peers to create a model of coworkers’ perception of leaders in the workplace. Collecting peer data is a means to corroborate data collected by faculty regarding students in the leadership program. Teacher and peer ratings of leadership attributes correlated, as did peer ratings of leadership and popularity (Schneider, Ehrhart, & Ehrhart, 2002). Peers and faculty identify student leaders similarly, indicating that one’s leadership abilities are observable from multiple levels of academic relationships.

The aforementioned studies promote the concept that leadership traits are developed at an early age, recognizable by both teachers and peers. The use of trait identification may provide an opportunity to increase science leadership experiences, promote the development of leadership traits, and positively influence work place interactions. Further, Schneider et al. (1999) presented strong correlations between several assessments, highlighting relevance, yet designed the study to require further data support. These studies provide a strong argument for the identification of innovator skills, such as leadership, through the use of instruments and peer and/or faculty ratings.

**STEM Education**

Science, Technology, Engineering, and Mathematics (STEM) education is the use of integrated core content subjects to create inquiry-based experiences for students. This method of combining multiple subjects is an engaging way to involve students in answering questions and solving problems while developing skill sets for future applications, a pathway to innovation (Dubetz & Wilson, 2013; Stohlman, Moore,
Students with an interest in and competency with STEM can enter relevant careers if made aware of appropriate opportunities and necessary resources (National Science Board, 2010; White House Office of Science and Technology Policy, 2014).

To support the increase of STEM career candidates, STEM education is under national and global attention as education stakeholders investigate ways to increase student access to STEM content. Educators, business leaders, legislators, and community members alike seek exploratory experiences that will ignite a spark of interest in young people and build relevant skills (Craig, Thomas, Hou, & Mathur, 2011; White House Office of Science and Technology Policy, 2014). The perceptions of waning talent pools of qualified STEM graduates motivates some employers to draw STEM-competent individuals from outside the United States’ borders to fill jobs. On the other hand, there is a movement in the United States to also bolster STEM experiences for youth to decrease this reliance on foreign talent. This shift requires a systemic change to education in which STEM education access is increased in order to better identify and support students.

**Enhanced Learning Opportunities**

STEM education is intentionally designed to positively affect students’ learning experiences of mathematics, science, engineering, and technology learning through an integrated approach. Educators providing STEM learning experiences allow for a holistic, exploratory development and application of content areas (Dubetz & Wilson, 2013; O'Neill et al., 2012). Students learn by doing, redoing, and communicating about activities, processes, and next steps (Billiar, Hubelbank, Oliva, & Camesano, 2014;
Tseng, Chang, Lou, & Chen, 2011). Classroom activities should involve many opportunities to practice that iterative process. Supporting enhanced learning opportunities allows educators and leaders to influence the caliber of student exposure and interaction with STEM concepts and literacy. Altering student experiences with STEM has extended application to student development of innovator skill sets and their future career choices.

**Engaging student interests.** Student engagement is a result of the educational environment. Students connected with learning experiences will experience more success than those disengaged (Marzano, Pickering, & Heflebower, 2011). The educational environment consists of elements constructed to provide student interactions with academic material. Several studies highlight the ability of STEM education to engage student interest and therefore increase the likelihood of subsequent original work and entrance into STEM careers.

Weinberg, Basile, and Albright (2011) focused on how to engage and motivate students in mathematics and sciences, noting that student choices, reflective of investment in the subject areas, determine students’ academic choices post-secondary school. The study examined student attitudes toward math and science after an academic intervention program and noted significant increases in student engagement in content areas post program (Weinberg et al., 2011). While the study is limited by the specificity of program parameters and longitudinal application, results suggest that an intervention program stimulates changes in student engagement in mathematics and science.

Another project identified the ability of STEM education to influence students’ future career choices (Benbow, 2012). The study indicated that schools can produce
STEM-skilled students through recognition of student abilities and the introduction of a formal school STEM program to further develop those abilities (Benbow, 2012). Schools can implement STEM programs as an organizational change in order to influence student outcomes, such as academic ability.

**Application for innovators.** STEM education focuses on academic experiences and environments to set a framework for innovator skill building. Inquiry-based opportunities provide students with means to practice innovator skill sets, positively affecting attitude toward and achievement in academics (Moos & Honkomp, 2011; Wolfe & Fraser, 2008). Inquiry-based activities include experiences in which students are presented with a prompt or challenge and must use or locate resources to complete the activity. Participating in inquiry-based activities aids students in establishing effective processes for learning and future problem solving application (Beisser & Gillespie, 2003). While students explore STEM-focused prompts, educators can support this practice by encouraging students to construct solutions to given problems using unique methods, (Valas & Solvik, 1993). In short, STEM provides opportunities for building skills of innovators for future application.

**Increasing STEM career awareness.** One side effect of STEM education is the increase in student awareness of related career fields. Exposing students to relevant academic experiences and subsequent career possibilities connects students with the global need for STEM-literate graduates who are prepared to innovate (National Science Board, 2010). Students’ high school course choices shape later career paths so if students are not aware of all course choices, such as advanced or application-based science and math classes, they are ill equipped to meet societal expectations (Weinberg et al., 2011).
Cohen, Patterson, Kovarik, and Chowning (2013) suggest increasing STEM career awareness is the responsibility of schools and communities. Through learning connections, career explorations, and classroom community building practices, teachers can influence student career awareness while communities provide coordinated support through policy changes and by providing resources to students (Cohen et al., 2013). Educating students about these opportunities cannot exist solely in or outside schools. There must be a collaborative effort, though schools are the most likely organized location from which to start.

**Social Interest and Advocacy**

In line with supporting young innovators, there is an interest in graduating students prepared to embark on careers involving combinations of sciences, technology, engineering, and mathematics. There is a call to graduate significantly more STEM industry-oriented students each year to fill a shortage of over one million positions in related industries (President’s Council of Advisors on Science and Technology, 2012). In support of increased innovation potential, there is a concurrent drive to specifically support STEM education in primary and secondary schools. Students with experience in solving problems through an integrated application of subject matter may be better equipped to direct future organizational needs.

**Growing the talent pool.** Countries motivated to support innovation seek talented STEM-oriented individuals to fill positions in many industries such as bioengineering, environmental restoration, and architecture (President’s Council of Advisors on Science and Technology, 2012). According to Craig, Thomas, Hou, and Mathur (2011), there is a mismatch between some countries’ existing talent base and
STEM talent, the result of which is organizations extending candidate searches to outside countries. The National Science Board further highlighted a United States reliance on foreign-born talent to fill job positions because current college graduates do not meet the industry’s employment needs (2010). Many countries are engaged in producing significant quantities of STEM industry graduates willing to relocate for work (Craig et al., 2011). In fact, students from other countries are outperforming top students from the United States in mathematics and science (Baldi, Jin, Skemer, Green, & Herget, 2007). This dissonance is between what industries want in graduate abilities and what graduates currently bring to the industries. This gap will likely be filled from outside the country if there is not a conscious effort to cultivate it from within the United States.

**Need for systemic change.** Changing the educational environment requires a systemic, cohesive alteration of student experiences. The National Science Board is part of a national campaign to improve awareness of and access to STEM education opportunities for all students (2010). Students are historically underrepresented in careers for reasons such as academic skill, gender, and ethnicity (Benbow, 2012; National Science Board, 2010). As schools implement broad, programmatic changes to increase STEM exposure and assessment, it is increasingly important to consider students’ interests and abilities. While academic success is helpful in STEM career achievement, it is not a sole or excluding indicator of said achievement (Benbow, 2012). Increasing STEM experiences for all students should shift the spotlight from academics to a greater focus on a student’s ability and drive.

As Weinbergh, Basile, and Albright (2011) noted, youths’ academic choices affect their career achievements. Abilities associated with STEM success can be
developed, and schools are a reasonable location for this development. At school, students interact with multiple subjects, learning formats, and teaching styles, as well as foster interpersonal relationships, all of which may influence a student's academic abilities. Further, if STEM innovators can be identified and therefore supported as youth, it becomes the role of education systems to enable these activities as general and expected practices (Benbow, 2012). National Science Board recommendations include creating more opportunities for STEM learning, improve assessments of students with strong related potential and abilities, and foster a cohesive environment of learning support for students in STEM disciplines (2011). In short, creating and delivering an effective STEM curriculum is the responsibility of schools in preparing students for success in an innovation-driven, global society.

Theoretical Frameworks

Two theories provide a framework for the current study. Social Cognitive Career Theory (SCCT) and Aptitude-Treatment Interaction (ATI) each outline a potential lens through which we might view young innovators, STEM education, and future careers of early adolescents.

Social Cognitive Career Theory (SCCT)

SCCT stems from the application of Social Cognitive Theory (SCT) to the development and outcomes of one’s occupation. SCT illustrates the relationships among a person’s behavior, thought processes, and external environment (Bandura, 1989a; 1989b). In short, these relationships assist in explaining actualization of or deviation from expected outcomes. Within the constructs of SCT, Bandura highlighted self-
efficacy as a specific link to motivation as a thought process that influences individuals’ behaviors (Bandura, 1986; 1989a; 1989b).

Lent, Brown, and Hackett (1994) utilized concepts from Bandura’s SCT into a model for connecting individuals’ career interests, career choices and career outcomes. The theory states that people with strong self-efficacy and positive outcome expectations regarding a given career interest will retain interests in career-related activities to a greater extent than those with lower self-efficacy and more negative outcome expectations (Lent et al., 1994). The theory applies to those considering career paths with respect to their perceived academic experiences with self-efficacy and career planning (Gibbons, 2004; Lent et al., 1994; 2000). SCCT attempts to outline the effect of an individual’s internal and external influences on career goal setting and outcomes (Lent et al., 1994; Lent, Brown, & Hackett, 2000). Some of these influences include cognitive ability, personal beliefs, gender, age, ethnicity, and environmental factors. These factors serve as contextual variables; they take the form of supports or barriers to the actualization of career goals (Lent et al., 1994; Rogers & Creed, 2011). For example, students who have more than one barrier, such as low socioeconomic status and who live in a rural location are likely to be more challenged in career goal actualization than students with one or no barriers. Likewise, a student with learning disabilities may find greater career goal actualization attending a school with a learning support program. In SCCT, the individual is both a product and producer of his or her environment.

Research findings provide some insight into the application of SCCT in education settings for the purpose of explaining young people’s occupational intentions and outcomes. Students’ learning experiences influence their perceptions of self-efficacy and
outcome expectations with regard to planning their occupational futures (M. N. Thompson & Dahling, 2012). Students who are confident and motivated are more likely to plan for their future whereas students with low perceptions of self-efficacy and outcome expectations are likely to avoid planning for secondary and post-secondary opportunities (Rogers & Creed, 2011). Creating more positive supports for young people with regard to their career goal setting and actualization can have a positive affect on their career successes (Lent et al., 2008).

SCCT appears to play a part in guiding young people toward innovator-oriented and STEM careers. With regard to SCCT, STEM-related self-efficacy is shown to influence STEM interests and performance (Ferry, Fouad, & Smith, 2000; Fouad & Smith, 1996; Gainor & Lent, 1998; Lent et al., 2001; Lent et al., 2003; Lopez, Lent, Brown, & Gore, 1997). Additionally, several studies have illuminated a direct relationship between students with math and science beliefs and experiences and their likelihood of choosing a STEM career (Fouad & Smith, 1996; Gainor & Lent, 1998; Lent et al., 2001; Lent et al., 2005; Lent, Lopez, & Bieschke, 1993). Other studies determined the SCCT model to also be a predictor of engineering interests and outcomes (Inda, Rodriguez, & Peña, 2013; Lent et al., 2003; Lent et al., 2005) and direction toward and success within technology occupations (Lent et al., 2008).

The theoretical framework of SCCT is appropriate in the present study as it investigates student innovator skills, STEM education, and occupational intentions. Innovator skills are a potential influence on a young person’s occupational outcome as are STEM education interests and experiences. SCCT provides that these variables,
whether in a formal education setting or otherwise, likely influence future career outcomes for the individual.

**Aptitude-Treatment Interaction (ATI)**

The ATI model also seeks to explain differences in individuals planned outcomes compared with actualization of said outcomes, and like SCCT, is applicable to career outcomes. The theory states that the efficacy of chosen instructional treatments, or learning opportunities presented to students will differ depending on the abilities of students (Cronbach & Snow, 1977; Snow, 1989). In addition to a relationship between aptitude and outcomes, the researchers also found a positive relationship between highly structured instructional environments and achievement of students with lower academic abilities and a positive relationship between less structured learning environments and highly capable students (Cronbach & Snow, 1977). Characteristics, deemed aptitudes, may include factors such as gender, cognitive ability, grade level, and experiences (Cronbach & Snow, 1977). Additionally, students will perform differently in educational settings depending on the instructional support (Peterson, 1988; Snow, 1989). Innovator skills and STEM interests fall under the definition of aptitudes for the purposes of this study. Further, educators’ instructional choices geared toward developing innovator skills and STEM interests may vary in efficacy based on the aforementioned aptitudes.

In education settings, ATI outlines a means to influence outcomes of teachers and educational leaders’ educational choices. Investigating student aptitudes is a means to determine the most appropriate instructional activities to maximize student learning (Peterson, 1988). Educators must select and deliver instructional activities with the most accessible and appropriate to their learners (Becker, 1970; Peterson, 1988). Further, once
a collective understanding of students’ aptitudes is known, educators can choose instructional activities that most directly apply to individuals, groups, or entire classes as necessary (Peterson, 1988).

Creating more personalized learning experiences with reference to students’ aptitudes is an effective instructional model for educators. Personalized learning experiences positively affect educational outcomes (Garn & Jolly, 2014). Further, adaptive instruction can be used to develop some career-applicable aptitudes of students (Corno, 1988). In turn, students’ motivation can be positively influenced by personalized learning experiences (Garn & Jolly, 2014), potentially supporting a cycle of positive outcomes tied to increasing motivation from perceived self-efficacy (Bandura, 1986, 1989a, 1989b; M. N. Thompson & Dahling, 2012).

This framework is appropriate for consideration as the current study explores the aptitudes of students with regard to innovator skills, STEM interests and experiences, and intended career paths. These aptitudes and resulting outcomes may be influenced by participants’ education experiences, such as targeted innovator skill building opportunities during STEM lessons, treatments received during middle school years. Examining the results of the current study with an eye toward instructional decision-making may illuminate further application of this framework.

Summary

The previous section drew attention to how students’ experiences in school affect their career outcomes as adults. Education systems are adjusting learning standards and classroom practices in response to industry needs. Middle schools are a crucial stop in
the journey students’ development as they consider academic pathways in secondary and post-secondary school.

Economic development and significant growth rely on people to create new products and processes that will revolutionize industries, sustaining and expanding current economic standings. Further, social entrepreneurs, innovators focused on developments to better communities, are needed in the positive development of humanitarian action. Innovator skills are malleable and can be directed toward these needs both reactively and with an eye toward the future. School experiences, including the learning environment, interactions with adults, and leadership opportunities, influence students’ academic and career outcomes.

STEM education is one desirable method for developing innovator skills through an interdisciplinary approach in which students practice the design process. Globally, STEM graduates are in high demand, and relevant education methods are gaining empirical support. Providing increased access to STEM education may be an influential means to developing innovators who solve problems of the future.

While external motivators should positively impact achievement, the foci for the greatest controllable influence could lie in application of the design process of creation in which they use skills to create, test, and refine new products or processes. Educators have the opportunity to identify and influence these skills and subsequent interests through intentional instructional choices. Students who exhibit innovator skills, are sufficiently familiar with the process, and intrinsically motivated to participate should consistently identify as innovators. This achievement is likely to create a habitual process for addressing challenges that will serve students as adults in future careers.
Finally, two theories, SCCT and ATI serve as frameworks for evaluating how students gain or fail to gain, awareness of career fields, preparatory skill sets, and suggest how student choices are influenced and made.
CHAPTER THREE: METHODOLOGY

Introduction

The purpose of this quantitative survey study was to explore the relationship between middle school students’ reported innovator skill levels and their perceptions of STEM education and careers at a suburban middle school in the Pacific Northwest. This research sought evidence to support education systems’ teaching of innovator skills, provide information about middle school students, and present data useful in evaluating STEM education.

Method Rationale

This cross-sectional, quantitative survey study explored a potential relationship between participants’ self-identified innovator skills and STEM interests. Two existing surveys were used to collect data at one point in time. Surveys are appropriate for use when researchers seek to identify trends in data (Creswell, 2011).

This quantitative design was chosen to collect information from a fairly large group of middle school students. Collecting a greater quantity of data is useful in looking for broad patterns among a population (Gerring, 2012). As STEM education is often delivered to whole classrooms or schools of children rather than as a program for individual students (Dubetz & Wilson, 2013; Stohlman et al., 2011), collecting and examining aggregate data regarding student skills and interests is appropriate. Considering the perceptions of a large sample of students could add clarity to the relationship between innovator skill building and STEM experiences. Additionally, examining perceptions of students, the intended recipients of academic interventions, is important in determining an educational program’s efficacy.
Description of Participants

The population sample for this study included 6th through 8th grade students at one suburban middle school in southwestern Washington State. The school is located in a middle-to-lower-middle class suburban city with a population of approximately 165,000 people. According to the Washington State Report Card, in 2014 the school served approximately 886 students. Forty-eight percent of students were female and 52% were male. The ethnicity of students was 58% white, 23% Hispanic/Latino, 6% Asian, 2% Native Hawaiian/Other Pacific Islander, 4% Black, 1% American Indian/Alaskan Native, and 6% two or more races. At the time of the study, there were 51 classroom teachers, 75% of which had at least a Master’s degree and averaged 11.2 years of experience. One hundred percent of teachers at the school were considered highly qualified to teach their assignment by state and national requirements. Approximately 59% of the student body received free or reduced-price meals, 8% were transitional bilingual, and 16% of students qualified for specialized education services.

The study sample included students who are in full year science and math classes in the general education setting. Some students received formal STEM project experiences prior to the study either in general education classroom settings, STEM summer camps, and/or technology or engineering elective coursework. Participants receiving specialized education services in addition to the general education setting were not identified in the data collection process.

Three hundred twenty-six students elected to take home a packet of study information, including a study invitation in the form of a letter home, presented in Appendix A, Parent Permission form (Appendix B), Participant Assent Form for
Participants Aged 11 Years or Younger (Appendix C), and Participant Assent Form for Participants Aged 12 to 15 (Appendix D). One hundred eighty-seven students returned signed permission and assent forms, approximately 21% of the school population. After receipt of the signed forms, the researcher provided students and families copies of the signed forms. All 187 students with returned forms received an opportunity to complete the instruments. Fourteen students were not present during their teacher’s initial elected time and were given the instruments on their next present school day. Within the 187 participants, 83 were male and 104 were female. Forty-three participants were in sixth grade, 46 in seventh, and 98 in eighth grade in September 2014.

Convenience sampling was used because participants were minors and required permission to participate from parents or guardians (Creswell, 2011). Convenience sampling is based on participants’ availability. This method does not allow control over the representation of the sample but was necessary given the study’s population. This study sought to recruit the largest number of participants possible as a larger sample size may improve population representation and reduce statistical variance and errors (Creswell, 2011).

**Instrumentation**

Participants took three surveys as part of this study. The first was a demographic survey and asked respondents to identify their gender (male or female), age (10, 11, 12, 13, 14, or 15), and grade level (6th, 7th, or 8th). See Appendix E for the demographic survey. Two existing survey instruments were also used to collect data in addition to demographic information, the Youth Innovator Skills Measurement Tool (YISMT) and
Middle and High School STEM-Student Survey (S-STEM) (Chell & Athayde, 2009b; Friday Institute for Educational Innovation, 2012a).

Chell and Athayde’s (2009a) objective in creating the YISMT was to assist in youth personal development, evaluate educational initiatives using the instrument as a benchmark, and to compare learning environments through youth self-assessment of innovator skills. The tool as used in this study included 51 questions for which students assessed their level of agreement with each statement. Chell and Athayde (2009) identify five sub scales in the instrument that describe youth’s innovator skill sets: leadership, self-efficacy, creativity, risk, and energy of participant. Responses require participants to read each question and respond using a seven-point Likert-type scale that ranged from “Strongly Disagree” to “Strongly Agree”. Rating a statement as “Strongly Disagree” indicates a low-level of agreement with the statement while a rating of “Strongly Agree” indicates a high level of agreement with the statement. See Appendix F for the YISMT.

The Friday Institute for Educational Innovation (2012b) created the S-STEM to measure student attitudes. The instrument includes statements regarding STEM content areas, 21st century learning skills, and interest in STEM careers for educational purposes (Friday Institute for Educational Innovation, 2012a). For the purpose of this study, only a portion of the S-STEM was used for analysis though participants completed the instrument in its entirety. Specifically, the 37 items regarding STEM content areas of math, science, engineering, technology, and 21st century learning required participant responses using a five-point Likert type scale ranging from “Strongly Disagree” to “Strongly Agree”. Rating a statement as “Strongly Disagree” indicates a low-level of agreement with the statement while a rating of “Strongly Agree” indicates a high level of
agreement with the statement. The next 12 items describe 12 STEM career areas to which respondents rated their interest on a four-point Likert type scale ranging from “Not at all Interested” to “Very Interested”. Rating a career area as “Not at all Interested” indicated a low level of interest in studying and/or working in that field while a rating of “Very Interested” indicated a high level of interest in studying and/or working in that field. The last item asked participants to select either “yes”, “no”, or “not sure”, as to whether they plan to go to college. See Appendix G for the S-STEM.

**Variables**

**Independent Variable**

Participants’ self-identification of innovator behaviors, as measured by the YISMT serves as the independent variable.

**Dependent Variables**

1. Participants’ self-identified attitudes and interests towards STEM education and careers, as measured by the S-STEM.

2. Participant plans for post-secondary school including collegiate intentions.

**Controlled Variables**

1. School at which the study occurs.

2. Delivery method of study materials.

3. Time allotment for participant responses.

**Data Collection Procedures**

On the first or second day of school in September 2014, all students at the school were given an invitation letter (Appendix A), parent permission form (Appendix B), and age-appropriate assent form (Appendix C and D) in their science class. The letter
introduced the study and provided students and families details about the information to be collected, method of collection, and intended use of results. The researcher assured students and families that neither their personal identity nor the identity of the school would be released in the dissertation, publications, or reports, nor would students’ academic records be affected. Students who were interested in participation and whose parent or guardian granted permission to participate returned the signed permission slip to their science teacher prior to the end of the second week of September 2014. The researcher stored permission and assent forms were stored in a locked storage drawer, separate from the instruments at all times.

The YISMT, S-STEM, and demographic instruments were administered in one science class period during either the third or fourth week of September. Science teachers selected a date during the two-week time period for students to take the instruments. The researcher delivered the instruments to the participants on the mutually agreed upon date. No identifying material was collected. Students who did not have parental or guardian consent were not permitted to participate and were not given any study materials. Instead, these students were provided with an in-class activity that required approximately equal time and effort, so they did not feel excluded from participation. The supplementary activity varied by teacher as mutually agreed upon by each teacher and the researcher prior to the chosen date of data collection. There was no established time limit for completing the instruments and completion time was not tracked. All participants were given sufficient time to complete the surveys. The researcher collected completed instruments from participants.
Ethical Considerations

Ethical considerations in quantitative survey research arise in collecting data, evaluating results, and presenting findings (Creswell, 2011). As this study involved a vulnerable population, middle school students, particular attention to ethics was required (Schenk & Williamson, 2005). Vulnerable populations require protective measures in addition to a thorough evaluation by the institutional board (IRB) (Creswell, 2011).

Several measures were taken for IRB approval. Students and their parents/guardians were informed of the study’s intent, and presented a copy of their participation rights, including the option to withdraw participation at any time (Appendix I). Parent or guardian permission was required to protect the interests of potential participants. Students were given an age-appropriate assent form. All students who returned signed permission and assent forms had the opportunity to participate in the study. Response sheets collected from the surveys were stored separately in a locked cabinet during the study and maintained there after the study was completed. No subsets of data were or will be released that will disclose the identity of specific individuals. Results of the study are only reported with respect to data trends among respondents as an aggregate group. IRB approval was granted for this study (Appendix H).

Further, as this study happened at the place of employment for the researcher, it was imperative that the bias of the researcher be minimized. Participants took the surveys under the supervision of another teacher in addition to the researcher to limit any unintended researcher influence on responses as some participants were current or former students of the researcher. Information regarding any prior academic relationships to the researcher was not collected from participants.
No harm or direct benefit to individual participants was anticipated as a result of taking these surveys. Students reported existing interests, opinions, and attitudes and did not experience an experimental treatment as part of the study. Participants’ academic and behavioral records were not be affected by the study. Further, participants were not given any incentives or consequences as a result of taking or not taking the surveys. Likewise, students could elect to stop participation at any time without penalty. No participants withdrew assent nor was any parental permission withdrawn during the study.

Summary

This quantitative study collected data from 187 middle school students. Participants responded to three printed surveys: a demographic survey, the YISMT, and the S-STEM. The data collected in these surveys identified participant innovator skill sets, attitudes toward STEM content, interest in STEM careers, and post-secondary plans in addition to demographic information. Data was gathered at one middle school from students with parental or guardian permission to participate. Data was collected through a procedure designed to keep participants anonymous with regard to their responses before, during, and after the study. Data was analyzed to explore the relationships among data from the group as a whole and results may be used to positively affect student experiences with related educational content or experiences.
CHAPTER FOUR: FINDINGS

Introduction

This study explored the relationship between middle school students’ innovator skills and their interest in STEM. Existing literature suggests a need for future innovators and a deeper understanding of the factors influencing the education of future innovators. This study sought to investigate these relationships. The following chapter reports on the findings of the research study. Specifically, this chapter briefly reviews the study’s methodology, provides an overview of the data analysis procedures, and finally presents findings organized by each hypothesis.

Review of Methodology

This researcher collected data using three instruments presented to participants in printed format. Demographics questions asked about participant age, grade, and gender. The S-STEM collected information on attitudes toward STEM content, interest in STEM careers fields, and post-secondary plans (Friday Institute for Educational Innovation, 2012a). The YISMT collected information about participants’ innovator skill sets (Chell & Athayde, 2009b). The study collected data from 187 participants from a Pacific Northwest middle school.

Data Analysis

Participants provided responses on printed survey instruments. Responses were transferred to an Excel spreadsheet using a code number as participant number. No identifiers connected a code number to a participant by name. The Excel sheet was then uploaded into Statistical Analysis Software (SAS) for analysis. All analyses reported in this chapter were conducted using SAS.
Scale Creation and Reliabilities

The following section provides a description of the scale creation for each survey and provides reliabilities for the YISMT and S-STEM.

YISMT

Participants received a printed version of the YISMT (Chell & Athayde, 2009b). The YISMT consisted of 51 Likert-style questions using a seven-point scale ranging from 1 (Strongly Disagree) to 7 (Strongly Agree). Select items from the full YISMT were reverse-coded in accordance with the measure’s scoring scheme. The following section describes these subscales in detail.

Subscales. The authors of the YISMT identify five subscales of the YISMT: Leadership, Self-Efficacy, Creativity, Risk, and Energy. Individual item scores were summed to create a composite score for each of five innovator skill categories and subscales were created as follows:

- **Leadership** subscale was created using items 1-9.
- **Self-Efficacy** subscale was created using items 10-21, with item 16 reverse-coded.
- **Creativity** subscale was created using items 22-32, with items 22, 28, and 30 reverse-coded.
- **Risk-Propensity** subscale was created using items 33-41, with items 34-35, 37, and 39-40 reverse-coded.
- **Energy** subscale was created using items 42-51, with items 42-43, 45, and 49 reverse-coded.

See Table 1 for a summary of the means and standard deviations of the YISMT individual items and subscales.
Table 1

YISMT Means and Standard Deviations

<table>
<thead>
<tr>
<th>YISMT Scale and Item</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Leadership</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. I really like being leader of a group</td>
<td>5.04</td>
<td>1.61</td>
</tr>
<tr>
<td>2. I am often chosen to be the team leader or captain</td>
<td>4.38</td>
<td>1.73</td>
</tr>
<tr>
<td>3. It would be good to have a leadership role when I leave college and get a job</td>
<td>5.21</td>
<td>1.58</td>
</tr>
<tr>
<td>4. I enjoy persuading others to follow my lead</td>
<td>4.75</td>
<td>1.70</td>
</tr>
<tr>
<td>5. I like organizing other people</td>
<td>4.61</td>
<td>1.84</td>
</tr>
<tr>
<td>6. When working on a group project, I do my best to persuade others</td>
<td>4.82</td>
<td>1.67</td>
</tr>
<tr>
<td>7. Project work gives me a chance to take a leading role in the group</td>
<td>4.64</td>
<td>1.70</td>
</tr>
<tr>
<td>8. I am usually the one who takes the initiative in the group</td>
<td>4.50</td>
<td>1.75</td>
</tr>
<tr>
<td>9. I feel quite comfortable telling other people what to do</td>
<td>4.50</td>
<td>1.97</td>
</tr>
<tr>
<td><strong>Self-Efficacy</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. I like to get things done</td>
<td>5.48</td>
<td>1.48</td>
</tr>
<tr>
<td>11. I am often chosen to represent others</td>
<td>5.84</td>
<td>1.36</td>
</tr>
<tr>
<td>12. I like the feeling of accomplishing difficult tasks</td>
<td>4.83</td>
<td>1.59</td>
</tr>
<tr>
<td>13. I enjoy doing things well</td>
<td>4.98</td>
<td>1.64</td>
</tr>
<tr>
<td>14. Feeling inspired makes me work harder at what I’m doing</td>
<td>4.99</td>
<td>1.63</td>
</tr>
<tr>
<td>15. I feel a sense of accomplishment when I master a new skill</td>
<td>4.93</td>
<td>1.50</td>
</tr>
<tr>
<td>16. I feel that a lack of confidence sometimes hinders my progress</td>
<td>2.96</td>
<td>1.27</td>
</tr>
<tr>
<td>17. People think that I am very confident</td>
<td>5.32</td>
<td>1.35</td>
</tr>
<tr>
<td>18. I like tasks that present me with a challenge</td>
<td>5.31</td>
<td>1.36</td>
</tr>
<tr>
<td>19. If my friends give up on something I’ll see it through</td>
<td>5.17</td>
<td>1.47</td>
</tr>
<tr>
<td>20. I believe I am self-assured</td>
<td>5.02</td>
<td>1.50</td>
</tr>
<tr>
<td>21. I usually feel confident that I can do what is asked of me</td>
<td>5.15</td>
<td>1.34</td>
</tr>
<tr>
<td><strong>Creativity</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22. I would not say that I am a creative person</td>
<td>3.05</td>
<td>1.22</td>
</tr>
<tr>
<td>23. Given my interests, I would always choose creative work beyond college</td>
<td>4.97</td>
<td>1.67</td>
</tr>
<tr>
<td>24. People turn to me when we need ideas in class</td>
<td>4.51</td>
<td>1.58</td>
</tr>
<tr>
<td>25. I have a strong imagination</td>
<td>5.49</td>
<td>1.64</td>
</tr>
<tr>
<td>26. The subjects I’ve chosen at school/college require imagination</td>
<td>4.81</td>
<td>1.55</td>
</tr>
<tr>
<td>27. I like putting ideas together to come up with something new</td>
<td>5.58</td>
<td>1.31</td>
</tr>
<tr>
<td>28. I dislike subjects that don’t give me scope to express my ideas</td>
<td>5.06</td>
<td>1.36</td>
</tr>
<tr>
<td>29. I see myself as a practical, down-to-earth person</td>
<td>2.52</td>
<td>1.13</td>
</tr>
<tr>
<td>30. I do not often day-dream but try to be realistic</td>
<td>2.52</td>
<td>1.22</td>
</tr>
<tr>
<td>31. I am good at having ideas</td>
<td>5.30</td>
<td>1.21</td>
</tr>
<tr>
<td>32. I sometimes surprise myself and others with the ideas I suggest</td>
<td>5.32</td>
<td>1.24</td>
</tr>
<tr>
<td><strong>Risk-Propensity</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>33. I don’t worry about risk if I am involved in something interesting</td>
<td>4.80</td>
<td>1.49</td>
</tr>
<tr>
<td>34. I tend not to give my opinion in front of others in case I’m wrong</td>
<td>3.30</td>
<td>1.43</td>
</tr>
</tbody>
</table>
No job is risk-free, but on balance I’d prefer one that offered few risks.

I see myself taking a variety of jobs to explore my potential.

I see myself as taking a job and pursuing a career that I’ll stick with.

I wouldn’t see it as risky to move between jobs.

I think I am a rather cautious person really.

I’d describe myself as a risk-taker.

I often lose focus before I get to the end of a task.

I usually feel I could have done more at the end of the day.

People often describe me as energetic.

Very often I can’t be bothered to get things done.

I feel frustrated if I haven’t the time to complete the tasks set.

I feel that I have more energy than many of my friends.

I get irritated with friends that give up on things.

I often put off things that I know I ought to do.

I like having a lot of things on the go.

I often put off things that I know I ought to do.

Reliabilities. Internal consistency within YISMT responses is presented in Table 2 using Cronbach’s alpha. Cronbach’s alpha, a determinant of relation of items within a define group, has an acceptable measure of internal consistency when greater than .70 (Institute for Digital Research and Education, 2014a). In a 2008 study of reliability of the YISMT, Cronbach’s alpha for the innovator skill subscale areas of Leadership, Self-Efficacy, Creativity, Risk-Propensity, and Energy were shared as .77, .70, .79, .58, and .76, respectively (Chell & Athayde, 2009a). The Cronbach’s alpha values for this study are .91 for Leadership, .92 for Self-Efficacy, .66 for Creativity, .68 for Risk-Propensity, and .74 for Energy. Three of the five Cronbach values YISMT subscales in this study
surpass the acceptable threshold of .70, while Creativity and Risk-Propensity do not. For Creativity, removal of item 29 would produce $\alpha = .70$. For Risk-Propensity, removal of item 34 would produce $\alpha = .73$. However, the researcher opted to include all items in the sub-scales as the original authors of the YISMT intended to allow for more direct comparisons between the original authors’ findings and the current study’s results.

Table 2

Reliability of Scales

<table>
<thead>
<tr>
<th>Scale</th>
<th>Cronbach’s $\alpha$</th>
</tr>
</thead>
<tbody>
<tr>
<td>YISMT Leadership</td>
<td>.91</td>
</tr>
<tr>
<td>YISMT Self-Efficacy</td>
<td>.92</td>
</tr>
<tr>
<td>YISMT Creativity</td>
<td>.66</td>
</tr>
<tr>
<td>YISMT Risk-Propensity</td>
<td>.68</td>
</tr>
<tr>
<td>YISMT Energy</td>
<td>.74</td>
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<tr>
<td>S-STEM Math</td>
<td>.90</td>
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<tr>
<td>S-STEM Science</td>
<td>.83</td>
</tr>
<tr>
<td>S-STEM Engineering and Technology</td>
<td>.86</td>
</tr>
<tr>
<td>S-STEM STEM Careers</td>
<td>.76</td>
</tr>
</tbody>
</table>

Subscales within the YISMT are highly inter-correlated as presented in Table 3.
Table 3

*Bivariate Correlations Among Instrument Totals and Scales*

<table>
<thead>
<tr>
<th>Measure</th>
<th>1.</th>
<th>2.</th>
<th>3.</th>
<th>4.</th>
<th>5.</th>
<th>6.</th>
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<th>8.</th>
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<th>10.</th>
<th>11.</th>
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<tbody>
<tr>
<td>YISMT TOTAL</td>
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<td>YISMT</td>
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<td>YISMT Self</td>
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<td>Efficacy</td>
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<td>YISMT</td>
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<td>Creativity</td>
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<td>YISMT Risk-Propensity</td>
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<tr>
<td>S-STEM Math</td>
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<td>S-STEM Science</td>
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<tr>
<td>S-STEM Engineering and</td>
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<tr>
<td>Technology</td>
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</tr>
<tr>
<td>S-STEM STEM Careers</td>
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</tr>
</tbody>
</table>

*Note.* Correlations marked with an asterisk (*) are significant at $p < .05$. 
S-STEM

Participants received a printed version of the S-STEM (Friday Institute for Educational Innovation, 2012b). The S-STEM consisted of 63 items: 37 Likert-style statements using a five-point scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree), 12 Likert-style statements using a four-point scale ranging from 1 (Not at All Interested) to 4 (Very Interested), one question using a Likert-type scale ranging from 1 (Very Well) to 3 (Not Very Well), four multiple choice items, three short answer items, and one item requiring students to select “yes”, “no”, or “not sure” as a response. Select items from the full S-STEM were reverse-coded during data analysis in accordance with the measure’s scoring scheme. The following section describes the subscales used in this study in detail.

Subscales. Four of the subscales identified by the authors of the S-STEM were used in this study: Math, Science, Engineering and Technology, and STEM Careers. Individual item scores were summed to create a composite score for each subscale as follows:

Math subscale was created using items 1-8 in the Math section, with items 1, 3, and 5 reverse-coded.

Science subscale was created using items 9-17 in the Science section, with item 16 reverse-coded.

Engineering and Technology subscale was created using items 18-26 in the Engineering and Technology section.

STEM Careers subscale was created using items 1-12 in the Your Future section.
Item number two in the About Yourself section was used to measure a participant’s plans for attending post-secondary school. Responses for this item were collected as “yes”, “no”, and “not sure”, as written on the instrument. For the purposes of analysis, answers were then grouped into two categories, “yes” and “not yes”. See Table 4 for a summary of the means and standard deviations of the S-STEM individual items and subscales.

Table 4

**S-STEM Means and Standard Deviations**

<table>
<thead>
<tr>
<th>S-STEM Scale and Item</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Math</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S-STEM Q1 Math has been my worst subject.</td>
<td>2.43</td>
<td>1.24</td>
</tr>
<tr>
<td>S-STEM Q2 I would consider choosing a career that uses</td>
<td>2.99</td>
<td>1.13</td>
</tr>
<tr>
<td>math.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S-STEM Q3 Math is hard for me.</td>
<td>2.68</td>
<td>1.18</td>
</tr>
<tr>
<td>S-STEM Q4 I am the type of student to do well in math.</td>
<td>3.55</td>
<td>1.05</td>
</tr>
<tr>
<td>S-STEM Q5 I can handle most subjects well, but I cannot do a good job with math.</td>
<td>2.43</td>
<td>1.08</td>
</tr>
<tr>
<td>S-STEM Q6 I am sure I could do advanced work in math.</td>
<td>3.18</td>
<td>1.29</td>
</tr>
<tr>
<td>S-STEM Q7 I can get good grades in math.</td>
<td>4.01</td>
<td>.89</td>
</tr>
<tr>
<td>S-STEM Q8 I am good at math.</td>
<td>3.76</td>
<td>1.05</td>
</tr>
<tr>
<td><strong>Science</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S-STEM Q9 I am sure of myself when I do science.</td>
<td>3.65</td>
<td>.84</td>
</tr>
<tr>
<td>S-STEM Q10 I would consider a career in science.</td>
<td>3.25</td>
<td>1.07</td>
</tr>
<tr>
<td>S-STEM Q11 I expect to use science when I get out of school.</td>
<td>3.41</td>
<td>1.00</td>
</tr>
<tr>
<td>S-STEM Q12 Knowing science will help me earn a living.</td>
<td>3.57</td>
<td>.92</td>
</tr>
<tr>
<td>S-STEM Q13 I will need science for my future work.</td>
<td>3.29</td>
<td>1.00</td>
</tr>
<tr>
<td>S-STEM Q14 I know I can do well in science. Science will be important to me in my life’s work.</td>
<td>3.89</td>
<td>.83</td>
</tr>
<tr>
<td>S-STEM Q15 I can handle most subjects well, but I cannot do a good job with science.</td>
<td>3.30</td>
<td>.99</td>
</tr>
<tr>
<td>S-STEM Q16 I am sure I could do advanced work in science.</td>
<td>3.30</td>
<td>1.17</td>
</tr>
<tr>
<td><strong>Engineering and Technology</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S-STEM Q18 I like to imagine creating new products.</td>
<td>3.84</td>
<td>.91</td>
</tr>
<tr>
<td>S-STEM Q19 If I learn engineering, then I can improve things that people use every day.</td>
<td>3.79</td>
<td>.89</td>
</tr>
</tbody>
</table>
### STEM Careers

**S-STEM Q1**  
Physics: is the study of basic laws governing the motion, energy, structure, and interactions of matter. This can include studying the nature of the universe. (aviation engineer, alternative energy technician, lab technician, physicist, astronomer)  

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>STEM Q1</td>
<td>Physics</td>
<td>2.45</td>
<td>.83</td>
</tr>
</tbody>
</table>

**S-STEM Q2**  
Environmental Work: involves learning about physical and biological processes that govern nature and working to improve the environment. This includes finding and designing solutions to problems like pollution, reusing waste and recycling. (pollution control analyst, environmental engineer or scientist, erosion control specialist, energy systems engineer and maintenance technician)  

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>STEM Q2</td>
<td>Environmental Work</td>
<td>2.39</td>
<td>.89</td>
</tr>
</tbody>
</table>

**S-STEM Q3**  
Biology and Zoology: involve the study of living organisms (such as plants and animals) and the processes of life. This includes working with farm animals and in areas like nutrition and breeding. (biological technician, biological scientist, plant breeder, crop lab technician, animal scientist, geneticist, zoologist)  

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>STEM Q3</td>
<td>Biology and Zoology</td>
<td>2.70</td>
<td>1.05</td>
</tr>
</tbody>
</table>

**S-STEM Q4**  
Veterinary Work: involves the science of preventing or treating disease in animals. (veterinary assistant, veterinarian, livestock producer, animal caretaker)  

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>STEM Q4</td>
<td>Veterinary Work</td>
<td>2.63</td>
<td>1.05</td>
</tr>
</tbody>
</table>

**S-STEM Q5**  
Mathematics: is the science of numbers and their operations. It involves computation, algorithms and theory used to solve problems and summarize data. (accountant, applied mathematician, economist, financial analyst, mathematician, statistician, market researcher, stock market analyst)  

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>STEM Q5</td>
<td>Mathematics</td>
<td>2.36</td>
<td>.99</td>
</tr>
</tbody>
</table>
S-STEM Q6  Medicine: involves maintaining health and preventing and treating disease. (physician’s assistant, nurse, doctor, nutritionist, emergency medical technician, physical therapist, dentist)

2.52  1.00

S-STEM Q7  Earth Science: is the study of earth, including the air, land, and ocean. (geologist, weather forecaster, archaeologist, geoscientist)

2.39  .89

S-STEM Q8  Computer Science: consists of the development and testing of computer systems, designing new programs and helping others to use computers. (computer support specialist, computer programmer, computer and network technician, gaming designer, computer software engineer, information technology specialist)

2.65  1.03

S-STEM Q9  Medical Science: involves researching human disease and working to find new solutions to human health problems. (clinical laboratory technologist, medical scientist, biomedical engineer, epidemiologist, pharmacologist)

2.44  1.00

S-STEM Q10  Chemistry: uses math and experiments to search for new chemicals, and to study the structure of matter and how it behaves. (chemical technician, chemist, chemical engineer)

2.56  .91

S-STEM Q11  Energy: involves the study and generation of power, such as heat or electricity. (electrician, electrical engineer, heating, ventilation, and air conditioning (HVAC) technician, nuclear engineer, systems engineer, alternative energy systems installer or technician)

2.35  .92

S-STEM Q12  Engineering: involves designing, testing, and manufacturing new products (like machines, bridges, buildings, and electronics) through the use of math, science, and computers. (civil, industrial, agricultural, or mechanical engineers, welder, auto-mechanic, engineering technician, construction manager)

2.71  .95

Subscales
S-STEM Math  27.95  6.90
S-STEM Science  31.35  5.83
S-STEM Engineering and Technology  32.23  6.17
S-STEM Careers  30.13  6.06
Reliabilities. Internal consistency for each S-STEM subscale is presented in Table 2 using Cronbach’s alpha. For example, Cronbach’s alpha for items in the STEM content area of Math (items #1-8, with 1, 3, and 5 reverse-coded) was used to evaluate how closely these items are related when considered as a single construct (Friday Institute for Educational Innovation, 2012b).

Authors of the S-STEM reported Cronbach’s alpha for the content areas Math, Science, Engineering and Technology as .90, .89, and .89, respectively (Friday Institute for Educational Innovation, 2012b). The Cronbach’s alpha values for this study are .90 for Math, .83 for Science, and .86 for Engineering and Technology. All three Cronbach values for STEM content area in this study are above the acceptable value. Documentation of Cronbach’s alpha for STEM Careers could not be obtained from the instrument’s author. This study determined a Cronbach’s value of .76, above the acceptable standard, for the subscale of STEM Careers. See Table 2 for a summary of the measure’s reliabilities in this study. Subscales within the S-STEM are highly intercorrelated and are presented in Table 3.

Hypotheses Analyses

The following section presents the study’s findings organized by hypothesis. For each hypothesis, variables, tests, and results are described.

Innovator Skills and STEM Content Interest

The first hypothesis considered the relationship between student innovator skills and attitudes toward STEM content areas. Specifically, the researcher hypothesized that students who possess greater innovator skills are more likely than students who possess fewer innovator skills to have positive attitudes toward STEM education content. For the
purposes of this hypothesis, subscales for each of the innovator skill sets on the YISMT, YISMT total score, subscales for each content area in the S-STEM, and S-STEM total score were used for analyses. Correlation tests were conducted between each total score and subscale of the YISMT and with the S-STEM total score and subscales. When determining significance levels for correlations, an alpha level for significance must be set (Creswell, 2011). For the purposes of this study, \( p \)-values of less than or equal to .05 are considered significant. Further, correlation coefficients between .7 and .9 are considered strong, between .4 and .6 are considered moderate, and between .1 and .3 are considered weak within this study (Dancy & Reidy, 2004). Table 3 displays a correlation matrix for the variables.

**YISMT total and S-STEM total.** To explore the relationship between the YISMT total score and the S-STEM total score, the researcher computed the correlation value. The researcher found a moderate, positive relationship between the YISMT total score and the S-STEM total score \( (r = .44, p < .0001) \). See Table 3 for these correlation statistics.

**YISMT total and S-STEM content subscales.** To explore the relationship between the YISMT total score and each S-STEM content subscale, the researcher performed a series of correlations. The researcher found significant, positive relationships between the YISMT total score and the S-STEM Math subscale \( (r = .22, p < .01) \), S-STEM Science subscale \( (r = .31, p < .001) \), and a moderate, positive correlation between the YISMT total and the S-STEM Engineering and Technology subscale \( (r = .43, p < .001) \). In other words, as students YISMT total score increased, their interest in
STEM Content subjects increased as well. See Table 3 for a summary of these correlation statistics.

**S-STEM total and YISMT subscales.** To explore the relationship between the S-STEM total score and YISMT subscale scores the researcher performed a series of correlations. The researcher found significant, albeit weak, positive correlations between the S-STEM total score and the YISMT Leadership subscale ($r = .24, p < .001$), YISMT Creativity ($r = .29, p < .001$), YISMT Risk-Propensity subscale ($r = .23, p = .001$), and YISMT Energy subscale ($r = .31, p < .001$). There is a moderate positive correlation between the S-STEM total score and the YISMT Self-Efficacy subscale ($r = .50, p < .001$). That is to say the higher the S-STEM total score, the higher the participant score on Self-Sufficiency. See Table 3 for a summary of these correlation statistics.

**YISMT subscales and S-STEM Content subscales.** To explore the relationship between the YISMT subscales and each S-STEM content subscale, the researcher performed a series of correlations. The researcher found significant, albeit weak, positive relationships between the YISMT Leadership subscale and S-STEM Science subscale ($r = .19, p < .05$) and the YISMT Leadership subscale and S-STEM Engineering and Technology subscale ($r = .23, p = .001$). In other words, students who scored higher on the YISMT Leadership subscale also scored higher on the S-STEM Science and S-STEM Engineering and Technology subscales. There were also significant, weak correlations between the YISMT Self-Efficacy subscale and S-STEM Math subscale ($r = .32, p < .001$), YISMT Self-Efficacy and S-STEM Science subscale ($r = .35, p < .001$), and the YISMT Self-Efficacy subscale and S-STEM Engineering and Technology subscale ($r = .39, p < .001$). The YISMT Creativity subscale and S-STEM Science subscale ($r = .18, p$
= .01), and YISMT Creativity subscale and S-STEM Engineering and Technology subscale ($r = .36, p < .001$) were also significantly correlated. Further, there were significant correlations between the YISMT Risk-Propensity subscale and S-STEM Engineering and Technology subscale ($r = .31, p < .001$), YISMT Energy subscale and S-STEM Math subscale ($r = .15, p < .05$), YISMT Energy subscale and S-STEM Science subscale ($r = .28, p < .01$) and the YISMT Energy subscale and S-STEM Engineering and Technology subscale ($r = .30, p < .001$). As participants’ Energy scores increased, STEM Content interest scores increased as well.

The relationship between the YISMT Leadership subscale and the S-STEM Math subscale ($r = .10, p = n.s.$), YISMT Creativity subscale and S-STEM Math subscale ($r = .09, p = n.s.$), YISMT Risk-Propensity subscale and S-STEM Math subscale ($r = .05, p = n.s.$), and the YISMT Risk-Propensity subscale and S-STEM Science subscale ($r = .28, p = n.s.$) were not significant. See Table 3 for these correlation statistics.

**Innovator Skills and STEM Career Interest**

The second hypothesis considered the relationship between students’ innovator skills and attitudes toward STEM careers. Specifically, the researcher hypothesized that students who possess greater innovator skills are more likely to have positive attitudes toward STEM career areas. To test this hypothesis, subscales for the YISMT as well as the YISMT total score were correlated with the S-STEM Career subscale.

Each of the correlations between the YISMT subscales and the S-STEM Career subscale were significant except for Creativity and S-STEM Careers ($r = .12, p = n.s.$), which was not significant. Specifically, the correlations between Leadership and S-STEM Careers ($r = .17, p < .05$), Self-Efficacy and S-STEM Careers ($r = .27, p < .001$),
Risk-Propensity and S-STEM Careers \( r = .24, p = .001 \) and Energy and S-STEM Careers \( r = .22, p < .01 \) were significant with a weak correlation. Likewise, the YISMT Total score and S-STEM Careers subscale were correlated \( r = .28, p < .001 \). Table 3 displays a summary of the correlation results.

**Innovator Skills and Post-Secondary Plans**

The third hypothesis considered the relationship between student innovator skills and plans for attending post-secondary school. Specifically, the researcher hypothesized that students with greater innovator skills are more likely to have plans to attend post-secondary school. The researcher performed a series of t-tests to determine whether students’ intention to attend post-secondary school is related to their YISMT total score or the YISMT subscales. Participants chose between three responses to the question “Do you plan to go to college?” One hundred seventy one (91%) of students replied yes, 14 responded not sure, and two responded no. Due to the small percentage of participants who noted they do not intend to attend college, the researcher created a dichotomous variable by dividing the responses into a “yes” category \( n = 171 \) and “not yes” category \( n = 16 \), by combining responses of “not sure” and “no”. The researcher ran a series of t-tests with this intention to attend post-secondary school variable as the independent variable, with each of the YISMT subscales and total score as the dependent variables.

For a majority of the t-tests on each of the dependent measures, participants planning to attend post-secondary school scored significantly higher on innovator interests than those who were unsure or did not plan to attend post-secondary education. Specifically, participants who plan to attend post-secondary school \( M = 256.82, SD = 33.17 \) reported significantly higher scores on the YISMT total scale than those who
reported “not” or “not sure” ($M = 221.88$, $SD = 43.85$), $t(185) = 3.91$, $p < .001$. Participants choosing “yes” ($M = 43.46$, $SD = 11.44$) reported significantly higher scores on the YISMT Leadership subscale than participants who chose “not yes” ($M = 31.81$, $SD = 11.62$), $t(185) = 3.89$, $p < .001$. Participants choosing “yes” ($M = 62.96$, $SD = 12.20$) reported significantly higher scores on the YISMT Self-Efficacy subscale than participants who chose “not yes” ($M = 52.38$, $SD = 14.52$), $t(185) = 3.26$, $p < .001$. Likewise, participants who chose “yes” ($M = 57.51$, $SD = 6.80$) reported significantly higher scores on the YISMT Creativity subscale than participants who chose “not yes” ($M = 50.88$, $SD = 9.57$), $t(185) = 3.60$, $p < .001$. Participants who chose “yes” ($M = 51.34$, $SD = 8.28$) reported significantly higher scores on the YISMT Energy subscale than participants who chose “not yes” ($M = 46.81$, $SD = 8.67$), $t(185) = 2.08$, $p < .05$. Participants who plan to attend post-secondary education ($M = 41.55$, $SD = 7.21$) and those who do not plan to attend or are unsure whether they plan to attend post-secondary education ($M = 40.00$, $SD = 7.69$) did not differ significantly on the YISMT Risk-Propensity subscale, $t(185) = .82$, $p = n.s$. T-test score results are displayed in Table 5.

Due to the small number of participants who noted that they do not plan to attend post-secondary education, or are uncertain whether they plan to attend post-secondary education, the above results should be interpreted with caution because of the unequal sample sizes on the independent variable.
Table 5

Innovator Skills, STEM Content Areas, and Post-Secondary Plans

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Yes</th>
<th></th>
<th>No</th>
<th></th>
<th>M diff</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>YISMT Total</td>
<td>256.82</td>
<td>33.17</td>
<td>221.88</td>
<td>43.85</td>
<td>34.95</td>
<td>3.91</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Leadership</td>
<td>43.46</td>
<td>11.44</td>
<td>31.81</td>
<td>11.62</td>
<td>11.64</td>
<td>3.89</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>YISMT Self-Efficacy</td>
<td>62.96</td>
<td>12.20</td>
<td>52.38</td>
<td>14.52</td>
<td>10.59</td>
<td>3.26</td>
<td>.001</td>
</tr>
<tr>
<td>Creativity</td>
<td>57.51</td>
<td>6.80</td>
<td>50.88</td>
<td>9.57</td>
<td>6.64</td>
<td>3.60</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>YISMT Risk-Propensity</td>
<td>41.55</td>
<td>7.21</td>
<td>40.00</td>
<td>7.69</td>
<td>1.55</td>
<td>.82</td>
<td>.42</td>
</tr>
<tr>
<td>Energy</td>
<td>51.34</td>
<td>8.28</td>
<td>46.81</td>
<td>8.67</td>
<td>4.53</td>
<td>2.08</td>
<td>&lt; .05</td>
</tr>
<tr>
<td>S-STEM Total</td>
<td>92.32</td>
<td>13.23</td>
<td>83.06</td>
<td>11.81</td>
<td>9.25</td>
<td>2.71</td>
<td>.01</td>
</tr>
<tr>
<td>S-STEM Math</td>
<td>28.33</td>
<td>6.95</td>
<td>23.81</td>
<td>4.89</td>
<td>4.52</td>
<td>2.54</td>
<td>.01</td>
</tr>
<tr>
<td>S-STEM Science</td>
<td>31.49</td>
<td>5.99</td>
<td>29.81</td>
<td>3.49</td>
<td>1.68</td>
<td>1.10</td>
<td>.27</td>
</tr>
<tr>
<td>S-STEM Engineering and Technology</td>
<td>32.49</td>
<td>6.11</td>
<td>29.44</td>
<td>6.27</td>
<td>3.05</td>
<td>1.91</td>
<td>.06</td>
</tr>
</tbody>
</table>

*Note.* Degrees of freedom for above statistics = 185.
STEM Content Interests and Post-Secondary Plans

The fourth hypothesis considered the relationship between participant attitudes toward STEM content areas and plans for attending post-secondary school. Specifically, the researcher hypothesized that participants with greater positive attitudes toward STEM content areas are more likely to have plans to attend post-secondary school. The researcher performed a series of t-tests to determine whether students’ intention to attend post-secondary school is related to their S-STEM content area total score or the S-STEM content area subscales. The researcher ran a series of t-tests with this intention to attend post-secondary school variable as the independent variable, with each of the S-STEM content subscales and total score as the dependent variables.

For the majority of t-tests on each of the dependent measures, participants planning to attend post-secondary school scored significantly higher on S-STEM total and subscales than did those who did not plan to attend or were uncertain of attendance. Specifically, participants who plan to attend post-secondary education ($M = 92.32, SD = 13.23$) reported significantly higher scores on the S-STEM total scale than participants who reported “no” or “not sure” ($M = 83.06, SD = 11.81$), $t(185) = 2.70, p < .01$. Likewise, participants choosing “yes” ($M = 28.33, SD = 9.95$) reported significantly higher scores on the S-STEM Math subscale than participants who chose “not yes” ($M = 23.81, SD = 4.89$), $t(185) = 2.54, p < .05$. Participants who chose “yes” ($M = 31.49, SD = 5.99$) and those who chose “not yes” ($M = 29.81, SD = 3.49$) categories did not differ significantly in Science, $t(185) = 1.10, p = n.s$. Additionally, participants who chose “yes” ($M = 32.49, SD = 6.11$) and those who chose “not yes” ($M = 29.44, SD = 6.27$)
categories did not differ significantly in Engineering and Technology, \( t(185) = 1.91, p = \text{n.s.} \). T-test score results are displayed in Table 5.

Due to the small number of participants who noted that they do not plan to attend post-secondary education, or are uncertain whether they plan to attend post-secondary education, the above results should be interpreted with caution because of the unequal sample sizes on the independent variable.

**Exploratory Analyses**

Participant gender and grade level were collected for exploratory purposes in this study. While the focus of this study is not driven by participant demographics, the researcher anticipated some potentially interesting findings related to this information. Research suggests an influence of grade level on development of skills and interests (Creed et al., 2007; Navarro et al., 2007; Rogers & Creed, 2011). Specifically, some research suggests there is a difference between males and females with regard to innovator skills, STEM interests, and access to STEM education (Farenga & Joyce, 1999; Fouad et al., 2010; Inda et al., 2013; Navarro et al., 2007; Tokar, Thompson, Plaufcan, & Williams, 2007). These are timely considerations given the call to support diversity in future generations of innovators (President’s Council of Advisors on Science and Technology, 2012). Table 6 displays frequency of participant gender and grade level. The following sections present data analyses for gender and grade level for a number of the dependent variables in this study.
Table 6

*Participants’ Gender and Grade Level*

<table>
<thead>
<tr>
<th>Grade</th>
<th>Gender</th>
<th>Female</th>
<th>Male</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>Female</td>
<td>22 (51%)</td>
<td>21 (49%)</td>
<td>43</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Female</td>
<td>30 (65%)</td>
<td>16 (35%)</td>
<td>46</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Female</td>
<td>52 (53%)</td>
<td>46 (47%)</td>
<td>98</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>104 (56%)</td>
<td>83 (44%)</td>
<td>187</td>
</tr>
</tbody>
</table>

**Gender.** The researcher ran a series of analyses exploring the relationship between the dichotomous gender variable (male v. female) and each of the study’s dependent variables. Specifically, the researcher considered participant gender with respect to the YISMT total and subscales, the S-STEM total and subscales, and plans to attend post-secondary school.

**Gender differences for YISMT scales and S-STEM scales.** Table 7 displays the results of a series of t-tests for the YISMT scales and S-STEM scales with respect to participants’ gender. There were significant gender differences for two of the dependent variables. Specifically, male participants (*M* = 42.64, *SD* = 7.07) reported significantly higher scores on the YISMT Risk-Propensity subscale than female participants (*M* = 40.44, *SD* = 7.27), *t*(185) = -2.08, *p* < .05. Male participants (*M* = 34.13, *SD* = 6.32) also reported significantly higher scores on the S-STEM Engineering and Technology subscale than female participants (*M* = 30.71, *SD* = 5.63), *t*(185) = -3.91, *p* < .001.

There were no significant gender differences on any of the other dependent variables. Specifically, male participants (*M* = 254.43, *SD* = 34.00) and female participants (*M* = 253.36, *SD* = 36.72) did not differ significantly in the YISMT total scale, *t*(185) = -0.21, *p* = n.s. Likewise, male participants (*M* = 42.11, *SD* = 11.94) and
female participants ($M = 42.74, SD = 11.89$) did not differ significantly in the YISMT Leadership subscale, $t(185) = .36, p = \text{n.s.}$, nor did male participants ($M = 62.04, SD = 12.40$) and female participants ($M = 62.08, SD = 13.04$) differ significantly in the YISMT Self-Efficacy subscale, $t(185) = .02, p = \text{n.s.}$ Male participants ($M = 57.19, SD = 7.80$) and female participants ($M = 56.75, SD = 6.88$) did not differ significantly in the YISMT Creativity subscale, $t(185) = -0.41, p = \text{n.s.}$ With regard to the YISMT Energy subscale, $t(185) = .72, p = \text{n.s.}$, male participants ($M = 50.46, SD = 8.16$) and female participants ($M = 51.35, SD = 8.58$) also did not differ significantly. Male participants ($M = 92.77, SD = 14.43$) and female participants ($M = 90.53, SD = 12.39$) also did not differ significantly in the S-STEM total scale, $t(185) = -1.14, p = \text{n.s.}$, nor did male participants ($M = 27.55, SD = 7.64$) and female participants ($M = 28.26, SD = 6.28$) differ significantly in the S-STEM Math subscale, $t(185) = .69, p = \text{n.s.}$ Male participants ($M = 31.08, SD = 5.98$) and female participants ($M = 31.56, SD = 5.73$) did not differ significantly in the S-STEM Science subscale, $t(185) = .55, p = \text{n.s.}$ Finally, male participants ($M = 29.34, SD = 6.58$) and female participants ($M = 30.77, SD = 5.57$) did not differ significantly in the S-STEM Careers subscale, $t(185) = 1.61, p = \text{n.s.}$ See Table 7 for a summary of these results.
Table 7

Innovator Skills, STEM Content, and Gender

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Gender</th>
<th></th>
<th></th>
<th></th>
<th>M diff</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Female</td>
<td>Male</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>YISMT TOTAL</td>
<td>253.36</td>
<td>254.43</td>
<td>-1.08</td>
<td>-2.21</td>
<td>.83</td>
<td></td>
<td></td>
</tr>
<tr>
<td>YISMT</td>
<td>42.74</td>
<td>42.11</td>
<td>.63</td>
<td>.36</td>
<td>.72</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leadership</td>
<td>62.08</td>
<td>62.04</td>
<td>.04</td>
<td>.02</td>
<td>.98</td>
<td></td>
<td></td>
</tr>
<tr>
<td>YISMT Self Efficacy</td>
<td>56.75</td>
<td>57.19</td>
<td>-.44</td>
<td>-.41</td>
<td>.68</td>
<td></td>
<td></td>
</tr>
<tr>
<td>YISMT Creativity</td>
<td>40.44</td>
<td>42.64</td>
<td>-2.20</td>
<td>-2.08</td>
<td>&lt; .05</td>
<td></td>
<td></td>
</tr>
<tr>
<td>YISMT Risk-Propensity</td>
<td>51.35</td>
<td>50.46</td>
<td>.89</td>
<td>0.72</td>
<td>.47</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S-STEM Total</td>
<td>90.53</td>
<td>92.77</td>
<td>-2.24</td>
<td>-1.14</td>
<td>.26</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S-STEM Math</td>
<td>28.26</td>
<td>27.55</td>
<td>.71</td>
<td>.69</td>
<td>.49</td>
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<tr>
<td>S-STEM Science</td>
<td>31.56</td>
<td>31.08</td>
<td>.47</td>
<td>.55</td>
<td>.58</td>
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<tr>
<td>Engineering and Technology</td>
<td>30.71</td>
<td>34.13</td>
<td>-3.42</td>
<td>-3.91</td>
<td>&lt; .001</td>
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<tr>
<td>S-STEM Careers</td>
<td>30.77</td>
<td>29.34</td>
<td>1.43</td>
<td>1.61</td>
<td>.11</td>
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</table>

Note. Degrees of freedom for above statistics = 185.

**Gender differences for post-secondary school plans.** The relationship between gender and post-secondary plans was explored using a Chi-square test. Chi-square tests are appropriate for comparing variables when each variable compared is categorical (Creswell, 2011). Ninety-seven of female participants selected yes for plans to attend post-secondary school while seven did not select yes. Seventy-four male participants selected yes for plans to attend post-secondary school while nine did not select yes. The percentage of participants reporting plans to attend post-secondary school did not differ by gender, $\chi^2 (1, N = 187) = .99, p = n.s.$

**Grade level.** The researcher also explored middle school grade level as an independent variable. Specifically, the researcher considered participant grade level with
respect to the YISMT total and subscales, S-STEM total and subscales, and plans to attend post-secondary school.

**Grade level differences for YISMT scales and S-STEM scales.** A series of between-groups ANOVAs were used to examine each grade level with respect to the dependent variables. ANOVAs are used for group comparisons when the independent variable includes more than two levels and the dependent variable is a continuous variable (Creswell, 2011). Post-hoc Tukey multiple comparisons were used to identify which, if any, grades differed on each of the dependent variables.

The researcher first compared the grade levels among the YISMT total and subscale scores and found a main effect of grade level for the YISMT total scale, $F(2, 184) = 7.41, p < .001$. Specifically, sixth ($M = 241.14, SD = 39.74$) and seventh graders ($M = 246.46, SD = 33.48$) reported significantly lower YISMT total scale scores than did eighth graders ($M = 262.87, SD = 32.04$). A main effect of grade level was found for the YISMT Leadership subscale, $F(2, 184) = 3.31, p < .05$. Seventh graders ($M = 39.41, SD = 10.48$) reported significantly lower Leadership scores than eighth graders ($M = 44.49, SD = 12.03$). A main effect of grade level was also found for the YISMT Self-Efficacy subscale, $F(2, 184) = 4.87, p < .01$. Sixth graders ($M = 57.14, SD = 15.83$) reported significantly lower Self-Efficacy scores than did eighth graders ($M = 64.26, SD = 11.10$). A main effect of grade level was also found for the YISMT Creativity subscale, $F(2, 184) = 4.96, p < .01$, whereby sixth graders ($M = 55.09, SD = 8.15$) and seventh graders ($M = 55.35, SD = 6.56$) reported significantly lower Creativity scores than did eighth graders ($M = 58.51, SD = 6.92$). A main effect of grade level was found for Risk-Propensity, $F(2, 184) = 3.95, p < .05$. Sixth graders ($M = 39.35, SD = 5.58$) also reported significantly
lower Risk-Propensity scores than did eighth graders \((M = 42.77, SD = 7.31)\). Finally, a main effect of grade level was found for YISMT Energy subscale, \(F(2, 184) = 5.62, p < .01\). Sixth \((M = 48.47, SD = 7.36)\) and seventh graders \((M = 49.24, SD = 8.28)\) reported significantly lower Energy scores than did eighth graders \((M = 52.85, SD = 8.48)\).

The researcher then compared the grade levels for the S-STEM total and subscales and found a main effect of grade level for the S-STEM total scale, \(F(2, 184) = 5.43, p < .01\). Specifically, sixth \((M = 87.74, SD = 10.43)\) and seventh graders \((M = 88.72, SD = 13.08)\) reported significantly lower S-STEM total scores than did eighth graders \((M = 94.50, SD = 14.00)\). A main effect of grade level was also found for the S-STEM Math subscale, \(F(2, 184) = 5.21, p < .01\). Sixth graders \((M = 25.60, SD = 6.10)\) also reported significantly lower Math subscale scores than did eighth graders \((M = 29.39, SD = 7.22)\).

The main effect of grade level with the S-STEM Science subscale was not significant, \(F(2, 184) = 2.66, p = n.s.\) The main effect of grade with the S-STEM Engineering and Technology subscale was not significant, \(F(2, 184) = 1.03, p = n.s.\) The main effect of grade level with the S-STEM Careers subscale was not significant, \(F(2, 184) = 1.2, p = n.s.\) See Table 8 for a summary of the ANOVA analyses and Table 9 for means and standard deviations for each dependent measure by grade level.
Table 8

ANOVA Results for Grade Organized by Dependent Variable

<table>
<thead>
<tr>
<th>Dependent Measure</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>YISMT TOTAL</td>
<td>17430.01</td>
<td>8715.00</td>
<td>7.41</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>YISMT Leadership</td>
<td>911.18</td>
<td>455.59</td>
<td>3.31</td>
<td>&lt;.05</td>
</tr>
<tr>
<td>YISMT Self Efficacy</td>
<td>1513.59</td>
<td>756.79</td>
<td>4.87</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>YISMT Creativity</td>
<td>504.91</td>
<td>252.46</td>
<td>4.96</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>YISMT Risk-Propensity</td>
<td>402.62</td>
<td>201.31</td>
<td>3.95</td>
<td>&lt;.05</td>
</tr>
<tr>
<td>YISMT Energy</td>
<td>752.80</td>
<td>376.40</td>
<td>5.62</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>S-STEM Total</td>
<td>1844.63</td>
<td>922.31</td>
<td>5.43</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>S-STEM Math</td>
<td>475.12</td>
<td>237.56</td>
<td>5.21</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>S-STEM Science</td>
<td>177.70</td>
<td>88.85</td>
<td>2.66</td>
<td>.07</td>
</tr>
<tr>
<td>S-STEM Engineering and Technology</td>
<td>78.58</td>
<td>39.29</td>
<td>1.03</td>
<td>.36</td>
</tr>
<tr>
<td>S-STEM Careers</td>
<td>88.04</td>
<td>44.02</td>
<td>1.20</td>
<td>.30</td>
</tr>
</tbody>
</table>

*Note.* The degrees of freedom for each analysis above. (2, 184).

Table 9

YISMT and S-STEM Means by Grade Level

<table>
<thead>
<tr>
<th>Measure</th>
<th>Grade Level</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>6</td>
<td>7</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>YISMT TOTAL</td>
<td>M</td>
<td>241.14</td>
<td>246.46</td>
<td>262.87</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>39.74</td>
<td>33.48</td>
<td>32.04</td>
<td></td>
</tr>
<tr>
<td>YISMT Leadership</td>
<td>M</td>
<td>41.09</td>
<td>39.41</td>
<td>44.49</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>12.31</td>
<td>10.48</td>
<td>12.03</td>
<td></td>
</tr>
<tr>
<td>YISMT Self Efficacy</td>
<td>M</td>
<td>57.14</td>
<td>61.98</td>
<td>64.26</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>15.83</td>
<td>11.66</td>
<td>11.10</td>
<td></td>
</tr>
<tr>
<td>YISMT Creativity</td>
<td>M</td>
<td>55.09</td>
<td>55.35</td>
<td>58.51</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>8.15</td>
<td>6.56</td>
<td>6.92</td>
<td></td>
</tr>
<tr>
<td>YISMT Risk-Propensity</td>
<td>M</td>
<td>39.35</td>
<td>40.48</td>
<td>42.77</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>5.58</td>
<td>7.99</td>
<td>7.31</td>
<td></td>
</tr>
<tr>
<td>YISMT Energy</td>
<td>M</td>
<td>48.47</td>
<td>49.24</td>
<td>52.85</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>7.36</td>
<td>8.28</td>
<td>8.48</td>
<td></td>
</tr>
<tr>
<td>S-STEM Total</td>
<td>M</td>
<td>87.74</td>
<td>88.72</td>
<td>94.50</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>10.43</td>
<td>13.08</td>
<td>14.00</td>
<td></td>
</tr>
<tr>
<td>S-STEM Math</td>
<td>M</td>
<td>25.60</td>
<td>27.07</td>
<td>29.39</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>6.10</td>
<td>6.28</td>
<td>7.22</td>
<td></td>
</tr>
<tr>
<td>S-STEM Science</td>
<td>M</td>
<td>30.40</td>
<td>30.26</td>
<td>32.28</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>4.45</td>
<td>6.69</td>
<td>5.84</td>
<td></td>
</tr>
<tr>
<td>S-STEM Engineering and Technology</td>
<td>M</td>
<td>31.74</td>
<td>31.39</td>
<td>32.84</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>5.96</td>
<td>6.02</td>
<td>6.31</td>
<td></td>
</tr>
<tr>
<td>S-STEM Careers</td>
<td>M</td>
<td>30.84</td>
<td>28.98</td>
<td>30.37</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>5.97</td>
<td>6.51</td>
<td>5.88</td>
<td></td>
</tr>
</tbody>
</table>
**Grade level differences for post-secondary school plans.** The researcher planned to use Chi-square tests to examine differences between grades with regard to post-secondary plans. Ninety-one eighth graders, 44 seventh graders and 36 sixth graders selected yes for plans to attend post-secondary school. Seven eighth graders, two seventh graders, and seven sixth graders did not select yes. However, Fisher’s Exact Test was identified as a more appropriate test as 33% of expected values in the Chi-square test were less than five.

Fisher’s Exact Test was appropriate in this case as the test does not assume a minimum frequency (Institute for Digital Research and Education, 2014b). The Fisher’s Exact Test determined no association between grade level and plans for post-secondary education, $P = .01, p = n.s.$

**Summary**

The quantitative data in this study consisted of participant responses on three instruments: a demographic survey, the YISMT, and the S-STEM. The YISMT and the S-STEM were examined for relationships between and among variables for each hypothesis. Some important correlations exist between innovator skills and STEM content areas. Likewise, correlations also exist between innovator skills and interest in STEM careers. The majority of participants also have plans to attend post-secondary school, with no statistical difference between gender or grade in this regard. There are also some relationships with regard to students planning to attend post-secondary school and their interest in STEM careers and innovator skill sets.

In addition to hypotheses presented in this study, participant responses were further explored with regard to gender and grade level in school. There are also
significant relationships between grade levels and the dependent variables, with mean
differences as predominantly higher when comparing eighth graders to the other grades.

The results of the study identify some significant relationships between student
innovator skills, STEM interests, and plans for post-secondary education. In addition, the
exploratory phase of this research did not distinguish among relationships with regard to
gender, yet indicated grade level as an important independent variable. The results of the
data support connections among the study research questions.
CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS

Introduction

The purpose of this study was to explore the relationship between youth innovator skills and STEM interests. This chapter will summarize the study and present the major findings from the research. These findings are discussed in light of the current research presented in the second chapter. Lastly, study limitations, implications for action, and recommendations for further research are discussed. While it is clear that there is a relationship between innovator skills and STEM education and careers, further research is needed to create a comprehensive pedagogical plan to foster these interests.

Summary of the Study

The primary purpose of this quantitative study was to explore the relationships between innovator skills, STEM content interests, and STEM career orientation within a population of middle school students at one Pacific Northwest school. There is limited research about young innovators and their skill level and interest in innovation. The current study examined the relationship between students’ self-assessments of five innovator skill sets as measured by the Youth Innovation Skills Measurement Tool and interests in STEM content and career areas as measured by the Middle and High School STEM Survey. In an additional exploratory phase, these variables were considered with respect to participants’ genders and grade levels. The conclusions from this study reflect a broad context of education as preparation for future careers and the opportunity for learning experiences to influence that trajectory. Educators may consider findings from this study for instructional, programming, or resource-allocation decision making for middle school students.
Summary of the Findings

The overarching research question in this study was whether students with strong innovator skill sets are also highly oriented toward STEM disciplines. In addition, the study asked students about their intention to attend post-secondary school. To explore these questions, the researcher tested four hypotheses about the relationship between innovator skills and STEM interests, as well as several exploratory hypotheses about how these interests relate to participant gender and grade level. The following section describes these relationships.

Innovator Skills and STEM Content Interest

The study hypothesized that students who possess greater innovator skills are more likely to have positive attitudes towards STEM education content. The researcher found support for this hypothesis through a series of significant correlations between innovator skills and STEM content interests. With the exception of the relationship between Math on the S-STEM and Creativity and Risk-Propensity on the YISMT, there was a significant, positive relationship between all other youth innovator skills and STEM content areas, as well as a moderate, positive relationship between total scores on the YISMT and S-STEM. In other words, a significant relationship exists between students who exhibit a wide variety of innovator skills and a wide range of interests in STEM content areas, particularly when considered as a set of skills and interests. Further, the positive, moderate correlation between the YISMT total score and Engineering and Technology may suggest that as students identify greater innovator skills, they identify greater success in Engineering and Technology activities. These outcomes support the findings of several researchers who found that inquiry-based, skill-
building activities influence students’ attitudes toward corresponding STEM content areas (Moos & Honkomp, 2011; Tseng et al., 2011; Wolfe & Fraser, 2008). Further, it may indicate a reciprocal relationship whereby innovator skills promote interest in STEM learning that in turn provide increased opportunity for innovator skill-building.

The lack of a relationship between Math with Creativity and Risk-Propensity raises further questions about middle school student experiences. Mathematics curricula, emotional, mental, and social development are some factors that may preclude a relationship among these variables. For example, mathematics instruction models at middle schools may not emphasize creativity and risk-taking in the curriculum, or math content taught in middle school may not be conducive for growing student skills in these areas. These results are not in support of the hypothesis, yet are potentially useful for further investigation.

**Innovator Skills and STEM Career Interest**

The study also hypothesized a positive relationship between students’ innovator skills and their attitudes toward STEM careers. The researcher found support for this hypothesis through significant correlations between participants’ innovator skills, both individual skills and as a set, and participants’ interests in STEM career fields. Middle school students self-identifying as innovators are likely to find interest in future occupations in which they are able to use these skills. These findings suggest either an existing academic connection, or opportunity for an academic connection, between middle school students’ innovator skills and STEM interests. This is consistent with research highlighting an opportunity for educators to influence young peoples’ innovator
skills and interests (Bloom, 1985; Campbell et al., 1970; Lubinski et al., 2006; Schneider et al., 1999).

Several researchers also highlight the potential benefit of identifying specific student skills to use in planning instruction (Cronbach & Snow, 1977; Schneider et al., 1999; Snow, 1989). For example, educators seeking to teach robotics to students interested in the biomedical fields would prefer building robotic prosthetics rather than building Mars rovers. Lubinski et al. (2006) also noted that people who attend well-regarded, rigorous mathematics, science, and engineering graduate programs achieve similar levels of success as those born with exceptional intelligence. The researchers suggest exposure to rigorous academic experiences that provide effective learning opportunities has the ability to influence students’ future outcomes (Lubinski et al., 2006). Educators have an opportunity to craft interest-based learning experiences that can positively affect student achievement, promote STEM fields, and support young innovators.

However, the current study did not determine the participants’ awareness about STEM career fields prior to taking the S-STEM. Specifically, some participants may not have previously known about occupational options within STEM fields, but after reading the descriptions on the S-STEM, subsequently identified an interest in these areas. As supported by the literature, young people with an appropriate ability and desire to enter STEM fields may need only be made aware of potential STEM occupations to foster an interest and professional direction in these occupations (Ali & Menke, 2014; Gushue et al., 2006; Lent et al., 1994). In other words, providing opportunities for STEM career
exposure during the middle school years may positively influence young people’s occupational decision making.

Interestingly, as in the previous hypothesis, Creativity was not significantly related to interest in fields containing a strong reliance on math, science, engineering, and technology. With creativity on the decline in the United States (Kim, 2011; Zhao, 2012a, 2012b) there is a need to develop creativity alongside innovator skills (Bronson & Merryman, 2010; Chell & Athayde, 2009a; Schneider et al., 1999). This study’s findings highlight a potential opportunity for further investigation about the skill of creativity among middle school students. On the other hand, perhaps creativity is not an essential component of STEM interests, although it remains an integral part of development and success in innovation.

**Innovator Skills and Post-Secondary Plans**

The majority of participants have plans to attend post-secondary school. As hypothesized, participants without plans to do so had comparatively lower innovator skill set scores overall. Specifically, students who planned to attend post-secondary education scored significantly higher in the innovator areas of leadership, self-efficacy, creativity, and energy compared to those who do not have plans to attend post-secondary school or are uncertain about whether they plan to attend post-secondary school. However, as most of the sample had plans for post-secondary school, these findings should be interpreted with caution because of the unequal sample sizes between those who planned to attend post-secondary school and those who did not or were uncertain. Participants may have limited exposure to post-secondary options, limited access to influential adults in their lives, or have other extrinsic motivators guiding their current planning about post-
secondary education. Additionally, the sample size \( n = 187 \), approximately one-fifth the
student body, may have limited application to other student groups, both within the
school and beyond. However, the large percentage of participants planning to attend post-
secondary school was a positive finding overall.

Participants did not differ in their Risk-Propensity scores, regardless of whether
they had plans for post-secondary education. While some may consider attending college
a risk, (e.g. financial, academic), students may not yet associate risk calculation with an
activity that is four or more years away at this stage in their development. This lack of a
significant difference between students with post-secondary plans and those without may
be due to the nature of career planning, comprehension of collegiate activity, or students’
focus on other skills.

**STEM Content Interests and Post-Secondary Plans**

As the researcher hypothesized, participants without plans to attend post-
secondary school had comparatively lower STEM content interest scores. Specifically,
students who planned to attend post-secondary education scored significantly higher on
the overall STEM content scale and on the Math subscale compared to those who do not
have plans to attend post-secondary school or are uncertain of attendance. As in the
above section, these findings should be interpreted with caution because of the unequal
sample sizes between those who planned to attend post-secondary school and those who
did not or were uncertain.

Participants did not differ in their Science or Engineering and Technology scores,
regardless of whether they had plans for post-secondary education. This may indicate
greater exposure to mathematics at this stage in academic development or less academic
exposure to science, engineering, and/or technology concepts. Not all students receive the same contact time with these core subject areas (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010). With NGSS learning expectations (NGSS Lead States, 2015), longitudinal data collected after full implementation of the new standards may provide additional insights into relationships among STEM content areas. Cross-cutting concepts are a significant aspect of the NGSS (NGSS Lead States, 2015), and further research may highlight whether the integrated nature of the standards creates a more equal interest level for each content area.

**Exploratory Analyses**

The researcher also included a number of analyses involving participant gender and age. Though not part of the research questions or hypotheses, these variables may indicate directions for future research.

**Gender.** The findings identified a difference between male participants’ responses on the Risk-Propensity section from the YISMT and the STEM content area of Engineering and Technology from the S-STEM. Specifically, males scored significantly higher than females on these subscales. This propensity for higher scores by males on the Engineering and Technology subscale may be a consequence of exposure to these constructs. Farenga and Joyce (1999) suggest that perceptions of gender-appropriateness with regard to educational content areas may influence interests and/or chosen courses of study. With regard to differences on the Engineering and Technology subscale, SCCT theory may suggest that exposure to these concepts may influence females’ associations with this STEM content (Lent et al., 1994). Application of SCCT suggests influences possible within school structures, such as intentional instruction in engineering and
Identifying Pioneers of Tomorrow

Technology practices, career exploration within these fields, and confidence in STEM content overall may positively affect the quantity of females who seek employment in STEM career fields (Lent et al., 1994; Lent et al., 2003; Lent et al., 2005; Lent et al., 2008). Fouad et al. (2010) also note that while some gains seem to have been made in balancing STEM interests between genders, students may perceive other barriers that prevent them from obtaining careers in STEM fields. Further exploration of gender influences on STEM interests may provide a greater understanding with regard to student interests in STEM fields into STEM careers. Regarding risk-propensity, one meta-analysis suggests that males and females differed greatly in intellectual risk-taking (Byrnes, Miller, & Schafer, 1999). Internal or external influences may create this difference, though causality cannot be determined from this study. Research also suggests that the gender gap between males and females is shrinking over time (Byrnes et al, 1999). This sample of middle school males and females may be an example of that decrease in the gap as in most measures, males and females did not differ regard to innovator skills and STEM interest.

**Grade level.** Overall, eighth graders tended to score higher on the YISMT and the S-STEM, than did sixth and seventh graders. These findings illustrate that eighth graders reported higher levels of innovator skills than both sixth and seventh graders on the YISMT total score, the YISMT Creativity and Energy subscales, and higher S-STEM total scores. Additionally, eighth graders scored significantly higher than sixth graders on the YISMT Self-Efficacy and Risk-Propensity subscales, as well as the S-STEM Math subscale. Finally, eighth graders scored significantly higher than seventh graders on the YISMT Leadership subscale.
In the district from which the sample population was chosen, these students enter high school for ninth grade. Eighth graders may, in their relatively advanced academic position, be more oriented toward high school subject matter and career choice-making than their sixth grade counterparts. In line with SCCT (Lent et al., 1994), sixth graders, who recently graduated from elementary school, have not yet been as exposed to the same content, careers, and opportunities for personal development as the eighth graders. The fact that there were more differences between eighth and sixth graders than eighth and seventh graders is interesting and may indicate additional support for this idea, though findings are too limited in this study to make a definitive conclusion. Further exploration within the middle school grades may lead to an identification of factors that influence students’ orientation toward innovator skill building, STEM interests, and post-secondary planning.

**Theoretical Implications**

Results from this study further illuminate the theoretical frameworks outlined in the second chapter, namely the relationships between innovator skills, STEM interests, and post-secondary plans. While this study’s design did not strictly adhere to either the SCCT or ATI constructs, the findings support further consideration of each theory in light of the innovator characteristics and STEM interests of middle school students.

Further research in SCCT (Lent et al., 1994) as it relates to students’ innovator interests may stem from this study’s findings, specifically with regard to self-efficacy. This study identified relationships between Self-Efficacy subscale scores and each of the other innovator skill subscales, all STEM content areas, STEM career interests, and post-secondary plans. Among the correlations, there was a moderately strong positive
correlation between scores on the Self-Efficacy subscale and the S-STEM total scores. While males and females did not differ significantly in their assessment of their self-efficacy, eighth graders scored significantly higher than did sixth graders. These scores may indicate a skill of particular interest for researchers interested in influencing student interests and career outcomes.

Self-efficacy is one of three main tenets in SCCT (Lent et al., 1994) that affects career choice exploration and actualization. While goal setting and outcome expectations, the other two tenets of the SCCT (Lent et al., 1994) were not specifically explored in this study, the study did inquire as to which STEM career areas interested participants and whether participants plan to attend post-secondary school. This study’s findings highlight a relationship between the YISMT Self-Efficacy subscale and the S-STEM Careers subscale, and participants planning to attend post-secondary school scored higher on the YISMT Self-Efficacy subscale. This study suggests an opportunity for further research about SCCT with regard to middle school students. Additionally, this study may be of interest to researchers as a platform from which to build a further understanding of early adolescent learners’ internal and external influences on career exploration and actualization. Relationships identified within the data suggest innovator skill sets and STEM interests may influence career interests and post-secondary plans in early adolescence. Educators seeking to support young innovators may gain awareness about what supports to provide or barriers to remove to help students reach their educational and career goals.

Researchers investigating the application of ATI (Cronbach & Snow, 1977) in innovator-centered and/or STEM classrooms may note the relationships found in this
study as an opportunity to seek specific interactions that influence innovator skills, STEM content, and STEM career choices in early adolescent learners. For example, the inclusion of leadership coursework for middle school students may positively influence students’ leadership abilities as they enter the adult workforce (Schneider et al., 1999). In short, this study’s findings indicate potential educational opportunities for positively influencing students’ abilities and interests in support of graduating a greater number of innovation- and STEM-ready adults.

**Practical Implications**

**Support for New Learning Standards**

This study suggests a link between the development of student innovator skill sets and students’ interests in STEM content areas and careers, and provides one avenue for educators to make pedagogical reform. The CCSS and NGSS set expectations that middle school students be able to demonstrate abilities in applied situations, such as citing research used to influence experimental designs and using knowledge of engineering processes to create a solution to a given problem (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010; NGSS Lead States, 2015). Increasing the quantity of inquiry or project-based learning activities can provide students with additional opportunities for practicing innovator skills within STEM content areas (Conrad & Dunek, 2012; Germann, 1991; National Girls Collaborative Project, 2014; Project Lead the Way, 2014; Tseng et al., 2011; Wolfe & Fraser, 2008).

In his 2011 report, President Obama called for systemic changes to education in support of student readiness for STEM career promotion (Obama, 2011). The researcher urges educators and those in education policy to expedite the integration of new national
standards for STEM content areas, through actions such as providing STEM courses for
students, training for teachers in support of innovator skill-building classroom activities,
and advocating for resources to support this transition. These standards outline an
opportunity and expectation to increase integration of innovator skill set building and
STEM practices into daily curriculum (2012 ACT College Readiness Benchmarks
Report, 2012; Lee, Quinn, & Valdes, 2013; National Governors Association Center for
Ensuring a smooth transition to the new standards through appropriate resource allocation
may allow educators to more quickly integrate the new standards into classrooms.
Implementation of innovation- or STEM-centered learning must bridge demographic
barriers, ensuring that all students receive equivocal experiences and opportunities (Ali &
Menke, 2014). This will likely have a positive effect on the number of STEM graduates.
Stakeholders should also work diligently to identify and remove or mitigate tangible and
intangible barriers throughout implementation of these changes.

**Middle School Programming**

Results of this study suggest a relationship among middle school students’
innovator skills and STEM interests. Middle school math, science, engineering, and
technical programs have the opportunity to support further development through
integration of the new standards along with the opportunity for content integration into
STEM coursework. Education leaders can integrate desired student outcomes through
adjusting or replacing existing educational programs to include STEM activity. Teachers
of math, science, and other content areas can be encouraged to collaborate on curriculum,
providing students with learning opportunities that apply knowledge from multiple
content areas. For example, students may be tasked with building a school garden that best utilizes available resources and presenting the idea to the school board. Minimum alterations could occur through increased STEM classroom experiences, or the addition of stand-alone classes, such as STEM electives. Innovation-focused districts might be served in forming STEM charter middle schools (Judson, 2014). The alteration of the middle school model to include formal structures in support of innovation and/or STEM activities may positively influence STEM graduates.

**Implications for Leadership**

Leaders in education are tasked with providing effective, quality learning environments rich in instruction for a diverse body of students. Effective education leadership holds measurable influence on student achievement (Marzano & Waters, 2009). Findings from this study should assist those seeking to build schools and systems geared toward the promotion of youth innovators and STEM education.

Highlighting the relationships between innovator skills and STEM content, careers, and plans for post-secondary school should serve as a call to action for those contemplating and choosing instructional guidelines for 21st century learning. Leaders working to prepare students for innovation-oriented careers and seeking to train STEM graduates should first investigate instructional models, identifying ways in which students receive these influences and opportunities for growth. Next, leaders can create and adopt policies promoting student access to innovator-skill building opportunities, STEM content, and STEM careers, such as to new national standards. This may require instructional adaptations, a creation of new curricula, training staff members, education of community members, and a reallocation of resources.
In support of these activities, leaders in innovation and STEM fields should be invited into discussions regarding education policy as well as into classrooms. While policy makers are not necessarily educators nor are teachers necessarily politicians, establishing common ground may allow more effective information gathering and provide opportunities for further collaboration. Legislation informed by education structures may receive greater community support and organization of district operations should reflect government resource allocations. Collaborative planning and goal-setting with all stakeholders, including STEM industry leaders, is an effective leadership tool (Freire, 1970; Goodlad, 1995; Johnson, 2012; Marzano & Waters, 2009). Further, industry professionals can serve as mentors to students whether through classroom presentations, internships at these organizations, or one-on-one mentoring with career-focused students. Collaboration can positively influence the scope of systemic implementation of innovator skill development activities by active collaboration with these stakeholders.

Most importantly, educators’ day-to-day decisions can reflect desired societal outcomes, theories, and relationships between innovator skills and STEM education, as identified in this study. While many teachers already espouse this goal, it should be further honed to include student interests and abilities in innovation and STEM. Increasing technology in classrooms (Hani, 2014; Hill, 1998; Robinson, 2014), further promotion of STEM curricula (Cohen et al., 2013; Tseng et al., 2011), and providing an opportunity for innovation practices will educate future innovators by design, rather than by accident (Wagner, 2012; Zhao, 2012b). In short, educators will mobilize a population of young innovators. Collectively, this academic shift may expand STEM education to
formally include innovator education practices or create a new branch of instructional expectations altogether.

**Limitations**

**Sample Population**

There were several limitations of this study. First, the sample population came from one school in one area of the country. For that reason, participant demographics and study size may be too limited for generalizations about the population of middle school students as a whole. Further, the sample population also required participant assent and parental permission, limiting interested participants to those with a parent willing and able to grant permission. It is possible that parents interested in the study, innovators, STEM education, and/or the influence of any of the aforementioned topics on their child’s education were more likely to provide permission for participation. Along the same lines, it is likely that students interested in participating were more likely to seek parent permission, creating a self-selection bias.

Additionally, prior exposure to lessons promoting innovator skills, STEM education, and other prior instructional influences were not strictly controlled. However, this limitation was minimally controlled through the use of students from a single school who are likely to have similar instructional experiences in the same environment. Lastly, the researcher is a staff member at the school. While the researcher provided a consistent data collection environment for all participants, as a teacher for some participants within the sample, potential bias is a limitation for this study. For example, students might have participated based on an academic relationship with the researcher or responded to instruments using assumed interests of the researcher. Further research with more
controlled variables is warranted prior to making generalizations about innovations and
STEM education activities for middle school students.

**Instrumentation**

There are also several limitations related to the study’s data collection
instruments. The YISMT is intended for 14-19 year-old youths and only seven percent of
the sample was 14 at the time of the study (Chell & Athayde, 2009b). Participants may
not have been academically able to fully comprehend and appropriately respond to the
survey items. Further, the five skills represented in the instrument, leadership, creativity,
self-efficacy, risk propensity and energy, may not be inclusive of measurable innovator
skills. While the S-STEM is appropriate for middle and high school students (Friday
Institute for Educational Innovation, 2012a), comprehension support was not provided for
participants so the researcher cannot guarantee that all students fully comprehended each
question. Additionally, no instrument modifications, nor accommodations, were provided
for participants with limited English proficiency or other learning limitations, such as
reading comprehension, beyond those required in their education plans as designated by
school personnel. Further, the S-STEM combines Engineering with Technology for
instrument purposes when a division may have influenced data results. Some students
may perceive and/or prefer engineering or technology as independent content areas and
this perception may have affected responses to this subscale. Finally, this study did not
employ a true experimental design. While the researcher can confidently draw
conclusions about the correlational relationships between students’ innovator skills and
STEM interests within the sample, any assumptions about the cause and effect-
relationships between these variables would be inappropriate. Consequently,
additional studies will add to the limited body of research on young innovators and promote scholarly development in this field.

**Recommendations for Further Research**

**Longitudinal Data**

This study was a temporal snapshot of a sample population of middle school students. Further study should include a longitudinal measurement of students’ self-assessments of innovator skills and STEM interests throughout their middle school experience. This structure would assess participant responses over time, providing multiple data points for consideration (Creswell, 2011). This study found some differences on the dependent variables between student grade levels, particularly the eighth graders, and skills and interests as measured by the study instruments. Particular attention toward identifying optimum influential opportunities for supplemental learning experiences across middle school years is important.

**Expanded Population**

Expanding geographical and demographical characteristics of future sample populations would support further research about youth innovator skills and STEM interests. Broad generalizations within K-12 education require an extensive sample and may facilitate comparisons among demographics not accessible within this study. While this study highlights relationships between innovator skills and STEM interests at the middle school level, there may be opportunities for similar research in additional middle schools in other geographical regions as well as working with youth in elementary schools or early education programs. Attention to location, age, socioeconomic status, race, academic achievement, and exposure to curriculum relevant to the study, along with
a formal investigation of gender and grade level, may provide further insight regarding young innovators.

**Teacher Perceptions**

This study included students’ self-reported assessments of their own abilities and interests. Future research should include teachers’ perceptions of students’ abilities and interests. Rather than specific commentary about individual participants, teachers could provide insight about their students’ ability to communicate innovator skills and interests, existing access to skill-building activities, STEM content, STEM careers, available resources, and their interpretation of the call for developing young innovators. Further, instruments for participants could be expanded to include student perceptions of teachers’ influence on student abilities and interests.

**Summary**

Insights from this study may be beneficial to educators and education leaders as they work to support young innovators. Students with innovator skills are turned into STEM academics and candidates for careers in STEM fields. There is an opportunity in middle schools to influence students’ innovator skills and interests and career-readiness in preparation for secondary and post-secondary opportunities in STEM. Further research regarding specific academic opportunities, longitudinal studies of student interests, and other internal and external influences on middle school youth are warranted. Education is a solid foundation on which to buttress our future innovators.

Prescience in education occurs when examining learning inputs for a given student body and hypothesizing career outputs. Instructional strategies matter; considering students within the classroom should be an essential first step in planning
instruction regarding innovators and STEM. Selecting from strategies geared toward supporting innovators and their STEM interests, such as use of the iterative design processes (Hill, 1998), will provide meaningful classroom experiences that translate into career-applicable skills. Education leaders must also support these classroom activities with appropriate and adequate resources. Our actions must at minimum, match our desires for a positive experience for our students, and further, promote their hopes for extraordinary future. If society wants innovators to change the world, we must place the necessary tools in their hands from an early age and clear the path for them to reach their full academic potential.
References


science: Gender and educational level differences. *Journal of Vocational Behavior*, 77, 361-373. doi: 10.1016/j.jvb.2010.06.004


Appendix A

Invitation Letter to Parents and Families

September 3, 2014

Dear Students and Families,

Welcome to the new school year. I am an 8th grade science teacher at Wy’east and am starting a study this month as part of my doctoral program. I am studying the skills, attitudes and interests of students with regard to science, technology, math, and engineering. I am interested in surveying middle school students with the goal of helping teacher planning and instruction.

This study is voluntary. Choosing to be in the study will not impact grades or class standing. Participant identification will remain confidential. Participants will take two short surveys during their science classes that will not interfere with classwork. The data gained may help students and teachers in the future.

More information can be found on the attached consent form and I can answer any questions you may have about the study. Please feel free to contact me through calling or send me an email for more information. Permission slips should be turned in by September 12th.

I hope you will consider being a part of the study.

Sincerely,

Erin Lark

Email: cel20165@creighton.edu

Phone: 360-604-6400
Appendix B

Parental Permission for a Minor Child to Participate in a Research Study

IRB Study #
Consent Form Version Date: June 12, 2014

Title of Study: Youth innovators and STEM: A quantitative study of skills, interests, and attitudes

Principal Investigator: Courtney Erin Lark
Email Address: cel20165@creighton.edu
Faculty Advisor: Dr. Leah Georges
Funding Source: Private

Study Contact telephone number: 360-604-6400
Study Contact email: cel20165@creighton.edu

Things you should know
You are being asked to allow your child to participate in a research study. The results of the study will be used in a doctoral research project. The researcher is a science teacher at your child’s school.

Details about the study are below. It is important that you understand the details so you and your child can make an informed choice.

You will be given a signed copy of this form.

Freedom to Refuse or Withdraw
The study is voluntary. You may also withdraw permission for your child to participate, for any reason, at any time. Your child may withdraw participation for any reason, at any time. Withdrawing from the study for any reason will not result in a penalty. Your child can also refuse to participate in the study. Refusing to participate will not result in a penalty.

The purpose of this study
The purpose is to research a relationship between student’s skills and interests in STEM (science, technology, engineering, and mathematics) and STEM careers.

Criteria for participation:
-Current student at Wy’east
-Student is willing to participate
-Student returns a signed permission slip

Amount of students who will take part in the study
200 students
Length of study
2 months

What will happen
Participants will complete three surveys. The first survey asks for gender, grade level, and age. The second survey is about their skills in creating new ideas and solving problems. The third survey is about their interests in STEM. Students may choose not to answer any question. The surveys will not impact grades or class standing.

Time required
Surveys will take approximately 25-40 minutes to complete.

Risks
There are no known risks or discomforts as a result of this study.

Benefits
Research studies are designed to obtain new knowledge. This new knowledge may help students in the future. Your child may not receive any direct benefit from being in the research study.

Your child’s privacy
Names of participants will be coded. As soon as responses are entered, response sheets will be destroyed. Only group results will be reported. Participants will not be identified by name in any report or publication. Records for this study will be kept in a locked cabinet and will only be seen by the investigator. Records will be stored for no longer than two years after the study is complete.

Will your child receive anything for being in this study?
No.

Will it cost you anything for your child to be in this study?
No.

Questions about this study
You and your child have the right to ask any questions about this research prior to giving permission and at any time during the study. If you have questions or concerns about the study, please contact Ms. Lark. If you have any questions about your rights as a participant in this study that have not been answered by the investigator, you may contact the Institutional Review Board at (402) 280-2126.

Rights as a research participant
Research on human volunteers is reviewed by a committee. That committee works to protect your child’s rights and welfare. If you or your child has questions or concerns you may contact:
Erin Lark, at cel20165@creighton.edu or (360) 604-6400
Dr. Leah Georges, at LeahGeorges@creighton.edu or (402) 280-3414

Parent/Guardian Consent Agreement:

I have read and understand the information provided above. I have asked the questions I have at this time. I voluntarily give permission to allow my child to participate in this research study.

____________________________________________________
Printed Name of Research Participant  (Child)

____________________________________________________
Signature of Parent/Guardian

____________________________________________________
Printed Name of Parent/Guardian

____________________________________________________
Date
Appendix C

CREIGHTON UNIVERSITY ASSENT FOR CHILDREN AGE 11

Protocol Title Dissertation: Survey of Youth Innovators and STEM
Protocol Number 631687-1

Principal Investigator: Courtney Erin Lark

Email Address: cel20165@creighton.edu

Faculty Advisor: Dr. Leah Georges

Study Contact telephone number: 360-604-6400 x 7583 Study Contact email: cel20165@creighton.edu

INVITATION

We would like you to join in a research study about your skills, interests, and opinions about Science, Technology, Engineering, and Mathematics (STEM) and innovating. You can ask a question at any time and you can say no anytime you want to. We will talk to your parents or legal guardian first. We will ask your parents or legal guardian if it is OK for you to be in this study.

BASIC ELEMENTS

The purpose is to research a relationship between student’s skills and interests in STEM (science, technology, engineering, and mathematics), innovating, and STEM careers. To participate, students must attend Wy’east, be willing to participate, and return a signed parent/guardian permission form and an assent form. Two hundred students will take part in the study.

Participants will complete three short surveys during one science class period. One survey is about their skills in creating new ideas and solving problems. The other
survey is about their interests in STEM. One survey asks their grade, age, and gender.
Participants will not be asked to put their names on their surveys.

1. **Can anything good happen to me?**
   - You will not likely receive any benefits.
   - The new knowledge from the study may help students and teachers in the future.

2. **Can anything bad happen to me?**
   - No more risk than you would have in everyday life is expected.
   - Your grades will not change.
   - Your academic standing will not change.
   - Your relationship with your teacher(s) will not change.

3. **Do I have other choices?**
   Students who do not take the study will be given a different assignment of equal time and effort to work. Your grades, academic standing, and your relationships with your teacher(s) will not change if you choose not to participate.

4. **Will anyone know I am in the study?**
   Only those people involved in the study will know that you are in it.

5. **Will I be paid?** No

6. **Who can I talk to about the study?**
   If you have any questions or concerns about this study, please contact either Ms. Lark or her faculty supervisor, Dr. Leah Georges, at LeahGeorges@creighton.edu or 402-280-3414. You can also talk to your parent or guardian, too.
SIGNATURE CLAUSE

You do not have to be in this study. You can stop being in the study at any time and no one will be mad at you. Do you want to be in the study?

_____Yes, I want to be in the study _____No, I do not want to be in the study

___________________________________________
Name of Child (Print)

___________________________________________
Signature of Child

___________________________________________
Name(s) of Parent(s)/Legal Guardian(s) (Print)

__________________
Date of Birth

__________________
Date

__________________
Relationship to Child

For the Research Investigator—I have discussed with this subject the procedure(s) described above and the risks involved; I believe he/she understands the contents of the assent document.

___________________________________________
Investigator’s Signature
Appendix D

CREIGHTON UNIVERSITY ASSENT FOR CHILDREN AGE 12-15

Protocol Title: Dissertation: Survey of Youth Innovators and STEM Protocol Number 631687-1

Principal Investigator: Courtney Erin Lark

Email Address: cel20165@creighton.edu

Faculty Advisor: Dr. Leah Georges

Study Contact telephone number: 360-604-6400 x 7583 Study Contact email: cel20165@creighton.edu

INTRODUCTORY STATEMENT (INVITATION)

We would like you to join in a research study about your skills, interests, and opinions about Science, Technology, Engineering, and Mathematics (STEM) and innovating. You can ask a question at any time and you can say no anytime you want to. We will talk to your parents or legal guardian first. We will ask your parents or legal guardian if it is OK for you to be in this study.

BASIC ELEMENTS

1. What is this study about?

The purpose is to research a relationship between student’s skills and interests in STEM (science, technology, engineering, and mathematics), innovating, and STEM careers. To participate, students must attend Wy’east, be willing to participate, and return a signed parent/guardian permission form and an assent form. Two hundred students will take part in the study.
Participants will complete three short surveys during one science class period. One survey is about their skills in creating new ideas and solving problems. The other survey is about their interests in STEM. One survey asks their grade, age, and gender. Participants will not be asked to put their names on their surveys.

2. **What are the possible benefits to me or others?**

Research studies are designed to obtain new knowledge. This new knowledge may help teachers and students in the future. You may not receive any direct benefit from being in the research study.

3. **What are the risks and discomforts you could have?**

No more risk than is encountered in everyday life is expected. Your grades will not be affected. Your academic standing will not be affected. Your relationship with your teacher(s) will not be affected.

4. **What if I decide not to participate?**

Students who do not choose to participate will be given an alternative activity of requiring relatively equal time and effort to complete. Your grades, academic standing, and your relationship with your teacher(s) will not be affected in any way if you choose not to participate.

5. **Will anyone know I am in the study?**

We will do everything we can to keep your records confidential. However, it cannot be guaranteed. We may need to report certain information to agencies as required by law.

Both records that identify you and this consent form signed by you may be looked at by others. The list of people who may look at you research records are:
The investigator and her Supervisor

The Creighton University Institutional Review Board (IRB) and other internal departments that provide support and oversight at Creighton University

We may present the research findings at professional meetings or publish the results of this research study in relevant journals. However, we will always keep your name, address, or other identifying information private.

6. Will I be paid?

You will not receive any payment for participating.

7. Who can I talk to about the study?

If you have any questions or concerns about this study, please contact either Ms. Lark or her faculty supervisor, Dr. Leah Georges, at LeahGeorges@creighton.edu or 402-280-3414

8. Consequences of Subject’s Decision to Withdraw

There are no consequences of choosing to withdraw from the study. Student’s grades, academic standing, and relationships with their teacher(s) will not change.

SIGNATURE CLAUSE

You do not have to be in this study. You can stop being in the study at any time and no one will be mad at you. If you decide not to be in this study, you will continue to receive necessary medical treatment from your doctors who are taking care of you.

My signature below indicates that all my questions have been answered. I agree to participate in the project as described above.
Name of Adolescent (Print)

___________________________________________

Signature of Adolescent

___________________________________________

Name(s) of Parent(s)/Legal Guardian(s) (Print)

___________________________________________

Date of Birth

___________________________________________

Date

___________________________________________

Relationship to Child

A copy of this form has been given to me. ___________ Subject’s Initials

For the Research Investigator—I have discussed with this subject the procedure(s) described above and the risks involved; I believe he/she understands the contents of the assent document.

___________________________________________

Investigator’s Signature

We would appreciate your feedback on your experience as a research participant at Creighton University; please fill out our survey at

http://www.creighton.edu/participantsurvey

Bill of Rights for Research Participants

As a participant in a research study, you have the right:
1. To have enough time to decide whether or not to be in the research study, and to make that decision without any pressure from the people who are conducting the research.

2. To refuse to be in the study at all, or to stop participating at any time after you begin the study.

3. To be told what the study is trying to find out, what will happen to you, and what you will be asked to do if you are in the study.

4. To be told about the reasonably foreseeable risks of being in the study.

5. To be told about the possible benefits of being in the study.

6. To be told whether there are any costs associated with being in the study and whether you will be compensated for participating in the study.

7. To be told who will have access to information collected about you and how your confidentiality will be protected.

8. To be told whom to contact with questions about the research, about research-related injury, and about your rights as a research subject.

9. If the study involves treatment or therapy:
   a. To be told about the other non-research treatment choices you have.
   b. To be told where treatment is available should you have a research-related injury, and who will pay for research-related treatment.
Appendix E

Demographic Survey

Please circle the answer under each category that applies to you.

1. Gender

Male   Female

2. Grade Level

6\textsuperscript{th}   7\textsuperscript{th}   8\textsuperscript{th}

3. Age in Years

10   11   12   13   14   15
### Youth Innovative Skills Measurement Tool (YISMT)
Statements Categorized by Subscale

<table>
<thead>
<tr>
<th>LEADERSHIP</th>
</tr>
</thead>
<tbody>
<tr>
<td>I really like being leader of a group.</td>
</tr>
<tr>
<td>I am often chosen to be the team leader or captain.</td>
</tr>
<tr>
<td>It would be good to have a leadership role when I leave college and get a job.</td>
</tr>
<tr>
<td>I enjoy persuading others to follow my lead.</td>
</tr>
<tr>
<td>I like organizing other people.</td>
</tr>
<tr>
<td>When working on a group project, I do my best to persuade others to take up my ideas.</td>
</tr>
<tr>
<td>Project work gives me a chance to take a leading role in the group.</td>
</tr>
<tr>
<td>I am usually the one who takes the initiative in the group.</td>
</tr>
<tr>
<td>I feel quite comfortable telling other people what to do.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SELF-EFFICACY</th>
</tr>
</thead>
<tbody>
<tr>
<td>I like to get things done.</td>
</tr>
<tr>
<td>I am often chosen to represent others.</td>
</tr>
<tr>
<td>I like the feeling of accomplishing difficult tasks.</td>
</tr>
<tr>
<td>I enjoy doing things well.</td>
</tr>
<tr>
<td>Feeling inspired makes me work harder at what I’m doing.</td>
</tr>
<tr>
<td>I feel a sense of accomplishment when I master a new skill.</td>
</tr>
<tr>
<td>I feel that a lack of confidence sometimes hinders my progress.</td>
</tr>
<tr>
<td>People think that I am very confident.</td>
</tr>
</tbody>
</table>
I like tasks that present me with a challenge.

If my friends give up on something I’ll see it through.

I believe I am self-assured.

I usually feel confident that I can do what is asked of me.

**CREATIVITY**

I would not say that I am a creative person.

Given my interests, I would always choose creative work beyond college.

People turn to me when we need ideas in class.

I have a strong imagination.

The subjects I’ve chosen at school/college require imagination.

I like putting ideas together to come up with something new.

I dislike subjects that don’t give me scope to express my ideas.

I see myself as a practical, down-to-earth person.

I do not often day-dream but try to be realistic.

I am good at having ideas.

I sometimes surprise myself and others with the ideas I suggest.

**RISK-PROPENSITY**

I don’t worry about risk if I am involved in something interesting.

I tend not to give my opinion in front of others in case I’m wrong.

No job is risk-free, but on balance I’d prefer one that offered few risks.
| I see myself taking a variety of jobs to explore my potential. |
| I see myself as taking a job and pursuing a career that I’ll stick with. |
| I wouldn’t see it as risky to move between jobs. |
| I think I am a rather cautious person really . |
| I tend to avoid taking part in sports that involve an element of danger. |
| I’d describe myself as a risk-taker. |

**ENERGY**

| I often lose focus before I get to the end of a task. |
| I usually feel I could have done more at the end of the day. |
| People often describe me as energetic. |
| Very often I can’t be bothered to get things done. |
| I feel frustrated if I haven’t the time to complete the tasks set. |
| I feel that I have more energy than many of my friends. |
| I get irritated with friends that give up on things. |
| I often put off things that I know I ought to do. |
| I like having a lot of things on the go. |
| I have a huge amount of drive. |
Appendix G

Student Attitudes toward STEM Survey (S-STEM)

Middle and High School (6-12th)

Last Updated October 2012

Appropriate Use
The Middle/High School (6-12th) S-STEM Survey is intended to measure changes in students’ confidence and efficacy in STEM subjects, 21st century learning skills, and interest in STEM careers. The survey is available to help program coordinators make decisions about possible improvements to their program.

The Friday Institute grants you permission to use these instruments for educational, non-commercial purposes only. You may use an instrument as is, or modify it to suit your needs, but in either case you must credit its original source. By using this instrument you agree to allow the Friday Institute to use the data collected for additional validity and reliability analysis. The Friday Institute will take appropriate measures to maintain the confidentiality of all data.

Recommended citation for this survey:

The development of this survey was partially supported by the National Science Foundation under Grant No. 1038154 and by the Golden LEAF foundation.

The framework for part of this survey was developed from the following sources:


DIRECTIONS:

There are lists of statements on the following pages. Please mark your answer sheets by marking how you feel about each statement. For example:

<table>
<thead>
<tr>
<th>Example 1:</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neither Agree nor Disagree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
</table>
As you read the sentence, you will know whether you agree or disagree. Fill in the circle that describes how much you agree or disagree.

_Even though some statements are very similar, please answer each statement. This is not timed; work fast, but carefully._

There are no "right" or "wrong" answers! The only correct responses are those that are true for you. Whenever possible, let the things that have happened to you help you make a choice.

**PLEASE FILL IN ONLY ONE ANSWER PER QUESTION.**
## Math

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neither Agree nor Disagree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Math has been my worst subject.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>2. I would consider choosing a career that uses math.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>3. Math is hard for me.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>4. I am the type of student to do well in math.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>5. I can handle most subjects well, but I cannot do a good job with math.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>6. I am sure I could do advanced work in math.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>7. I can get good grades in math.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>8. I am good at math.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

## Science

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neither Agree nor Disagree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>9. I am sure of myself when I do science.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>10. I would consider a career in science.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>11. I expect to use science when I get out of school.</td>
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<td>○</td>
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<tr>
<td>12. Knowing science will help me earn a living.</td>
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<td>13. I will need science for my future work.</td>
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<td>14. I know I can do well in science.</td>
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<td>15. Science will be important to me in my life’s work.</td>
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<td>16. I can handle most subjects well, but I cannot do a good job with science.</td>
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<td>17. I am sure I could do advanced work in science.</td>
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Engineers use math, science, and creativity to research and solve problems that improve everyone’s life and to invent new products. There are many different types of engineering, such as chemical, electrical, computer, mechanical, civil, environmental, and biomedical. Engineers design and improve things like bridges, cars, fabrics, foods, and virtual reality amusement parks. Technologists implement the designs that engineers develop; they build, test, and maintain products and processes.
### 21st Century Learning

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neither Agree nor Disagree</th>
<th>Agree</th>
<th>Strongly Agree</th>
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</table>
Your Future

Here are descriptions of subject areas that involve math, science, engineering and/or technology, and lists of jobs connected to each subject area. As you read the list below, you will know how interested you are in the subject and the jobs. Fill in the circle that relates to how interested you are.

There are no “right” or “wrong” answers. The only correct responses are those that are true for you.

<table>
<thead>
<tr>
<th>Subject Area</th>
<th>Not at all Interested</th>
<th>Not So Interested</th>
<th>Interested</th>
<th>Very Interested</th>
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<tbody>
<tr>
<td>Physics:</td>
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<tr>
<td>Is the study of basic laws governing the motion, energy, structure, and interactions of matter. This can include studying the nature of the universe. (aviation engineer, alternative energy technician, lab technician, physicist, astronomer)</td>
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<tr>
<td>Environmental Work:</td>
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<tr>
<td>Involves learning about physical and biological processes that govern nature and working to improve the environment. This includes finding and designing solutions to problems like pollution, reusing waste and recycling. (pollution control analyst, environmental engineer or scientist, erosion control specialist, energy systems engineer and maintenance technician)</td>
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<tr>
<td>Biology and Zoology:</td>
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<tr>
<td>Involve the study of living organisms (such as plants and animals) and the processes of life. This includes working with farm animals and in areas like nutrition and breeding. (biological technician, biological scientist, plant breeder, crop lab technician, animal scientist, geneticist, zoologist)</td>
<td>○</td>
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<tr>
<td>Veterinary Work:</td>
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<td>Involves the science of preventing or treating disease in animals. (veterinary assistant, veterinarian, livestock producer, animal caretaker)</td>
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<tr>
<td>Mathematics:</td>
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<tr>
<td>Is the science of numbers and their operations. It involves computation, algorithms and theory used to solve problems and summarize data. (accountant, applied mathematician, economist, financial analyst, mathematician, statistician, market researcher, stock market analyst)</td>
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<tr>
<td>Medicine:</td>
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<tr>
<td>Involves maintaining health and preventing and treating disease. (physician’s assistant, nurse, doctor, nutritionist, emergency</td>
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<tr>
<td>7. <strong>Earth Science:</strong> is the study of earth, including the air, land, and ocean. <em>(geologist, weather forecaster, archaeologist, geoscientist)</em></td>
<td>Not at all Interested</td>
<td>Not So Interested</td>
<td>Interested</td>
<td>Very Interested</td>
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<tr>
<th>8. <strong>Computer Science:</strong> consists of the development and testing of computer systems, designing new programs and helping others to use computers. <em>(computer support specialist, computer programmer, computer and network technician, gaming designer, computer software engineer, information technology specialist)</em></th>
<th>Not at all Interested</th>
<th>Not So Interested</th>
<th>Interested</th>
<th>Very Interested</th>
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<tr>
<th>9. <strong>Medical Science:</strong> involves researching human disease and working to find new solutions to human health problems. <em>(clinical laboratory technologist, medical scientist, biomedical engineer, epidemiologist, pharmacologist)</em></th>
<th>Not at all Interested</th>
<th>Not So Interested</th>
<th>Interested</th>
<th>Very Interested</th>
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<tr>
<th>10. <strong>Chemistry:</strong> uses math and experiments to search for new chemicals, and to study the structure of matter and how it behaves. <em>(chemical technician, chemist, chemical engineer)</em></th>
<th>Not at all Interested</th>
<th>Not So Interested</th>
<th>Interested</th>
<th>Very Interested</th>
</tr>
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<tr>
<th>11. <strong>Energy:</strong> involves the study and generation of power, such as heat or electricity. <em>(electrician, electrical engineer, heating, ventilation, and air conditioning (HVAC) technician, nuclear engineer, systems engineer, alternative energy systems installer or technician)</em></th>
<th>Not at all Interested</th>
<th>Not So Interested</th>
<th>Interested</th>
<th>Very Interested</th>
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<tr>
<th>12. <strong>Engineering:</strong> involves designing, testing, and manufacturing new products (like machines, bridges, buildings, and electronics) through the use of math, science, and computers. <em>(civil, industrial, agricultural, or mechanical engineers, welder, auto-mechanic, engineering technician, construction manager)</em></th>
<th>Not at all Interested</th>
<th>Not So Interested</th>
<th>Interested</th>
<th>Very Interested</th>
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</table>
About Yourself

DIRECTIONS: In the following series of questions, you will skip certain questions
based on how you answered previous questions. Make sure to read the directions in bold
that tell you about which questions to skip based on your answers.

1. How well do you expect to do this year in your:

<table>
<thead>
<tr>
<th>Class</th>
<th>Not Very Well</th>
<th>OK/Pretty Well</th>
<th>Very Well</th>
</tr>
</thead>
<tbody>
<tr>
<td>English/Language Arts Class?</td>
<td>○</td>
<td>○</td>
<td>○</td>
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<tr>
<td>Math Class?</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Science Class?</td>
<td>○</td>
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</tbody>
</table>

2. Do you plan to go to college?
   - [ ] Yes
   - [ ] No
   - [ ] Not Sure

Please only answer Question 3 if your answer to Question 2 was “No.”

3. Are you planning on:
   - [ ] Enlisting in the Military
   - [ ] Finding a Job
   - [ ] Other (Please List) ____________________________________________

Please only answer Question 4 if your answer to Question 2 was “Yes.”

4. Are you planning on going to a community college or four-year college/university first?
   - [ ] Community College
   - [ ] Four-year College

Please only answer Question 5 if your answer to Question 2 was “Yes” and your answer to
Question 3 was “Community College.”

5. Are you planning to attend a four-year college after you go to community college?
   - [ ] Yes
   - [ ] No

Please only answer Question 6 if your answer to Question 2 was “Yes.”

6. Please list up to three colleges you are interested in attending.
   - College 1: __________________________________________
   - College 2: __________________________________________
   - College 3: __________________________________________

Please only answer Question 7 if your answer to Question 2 was “Yes.”

7. Please list up to three areas (or college majors) you are interested in studying in college.
   - Area 1: __________________________________________
8. Please list any other science, mathematics, engineering, or technology-oriented camps, clubs, or activities you have been involved in:
________________________________________________________________________
________________________________________________________________________

9.

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
<th>Not Sure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do you know any adults who work as scientists?</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Do you know any adults who work as engineers?</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Do you know any adults who work as mathematicians?</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Do you know any adults who work as technologists?</td>
<td>○</td>
<td>○</td>
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</tr>
</tbody>
</table>

Thank you for taking this survey! This is the end
IDENTIFYING PIONEERS OF TOMORROW

Appendix H
IRB Approval Letter

Creighton University
Social Behavioral and Biomedical Institutional Review Board
2500 California Plaza • Omaha, Nebraska 68178
phone: 402.280.2126 • fax: 402.280.4766 • email: irb@creighton.edu

DATE: July 18, 2014
TO: Courtney Lark
FROM: Creighton University IRB-02 Social Behavioral
PROJECT TITLE: [831687-2] Dissertation: Survey of Youth Innovators and STEM Orientation
SUBMISSION TYPE: Response/Follow-Up
ACTION: APPROVED
APPROVAL DATE: JULY 16, 2014
EXPIRATION DATE: JULY 15, 2015
REVIEW TYPE: EXPEDITED
REVIEW CATEGORY: Expedited category # 9

Thank you for your submission of Response/Follow-Up materials for this project.

The following items were reviewed in this submission:

- Application Form - Application for Response to IRB Requests (UPDATED: 07/16/2014)
- Child Assent - Assent for Age 12-15 (tracked changes) (UPDATED: 07/16/2014)
- Child Assent - Assent Age 12-15 (clean version) (UPDATED: 07/16/2014)
- Child Assent - Assent for Children Age 11 (tracked changes) (UPDATED: 07/16/2014)
- Child Assent - Assent for Children Age 11 (clean version) (UPDATED: 07/16/2014)
- Letter - Invitation Letter for Participants (tracked changes) (UPDATED: 07/16/2014)
- Letter - Invitation Letter to Participants (clean version) (UPDATED: 07/16/2014)
- Parental Permission Form - Parental Permission Form (tracked changes) (UPDATED: 07/16/2014)
- Parental Permission Form - Parental Permission Form (clean version) (UPDATED: 07/16/2014)

The Creighton University IRB-02 Social Behavioral has APPROVED your submission. This approval is based on an appropriate risk/benefit ratio and a project design wherein the risks have been minimized. All research must be conducted in accordance with this approved submission.

The two assents and parental permission form are stamped dated July 18, 2014. Only copies of these stamped dated permission and assents may be used when enrolling subjects in this project.

Please remember that informed consent is a process beginning with a description of the project and insurance of participant understanding followed by a signed consent form. Informed consent must continue throughout the project via a dialogue between the researcher and research participant. Federal regulations require that each participant receives a copy of the consent document.

Please note that any revision to previously approved materials must be approved by this committee prior to initiation. Please use the Application for Modification of Approved Research for this procedure.
All UNANTICIPATED PROBLEMS involving risks to subjects or others (UIRSEs) and SERIOUS and UNEXPECTED adverse events must be reported promptly to this office. All NON-COMPLIANCE issues or COMPLAINTS regarding this project must be reported promptly to this office. Please use the New Information Reporting application for this procedure. All FDA and sponsor reporting requirements should also be followed.

Advertisements, letters, internet postings, any other media for subject recruitment, and information given to subjects for use in this study require approval before posting or distribution. Please use the Request for Review of Supplemental Documents form when requesting review for supplemental documents.

This project has been determined to be a minimal risk project. Based on the risks, this project requires continuing review by this committee on an annual basis. Please use the Reporting Form for Continuing Review/Project Termination for this procedure. Your documentation for continuing review must be received with sufficient time for review and continued approval before the expiration date. If you complete this project within the year, you are required to close the study and submit a final report before the expiration date.

If you have any questions, please contact Christine Scheuring at 402-280-3384 or christinescheuring@creighton.edu. Please include your project title and reference number in all correspondence with this committee.

This letter has been electronically signed in accordance with all applicable regulations, and a copy is retained within Creighton University IRB-02 Social Behavioral's records.
Appendix I

Bill of Rights for Research Participants

As a participant in a research study, you have the right:

1. To have enough time to decide whether or not to be in the research study, and to make that decision without any pressure from the people who are conducting the research.

2. To refuse to be in the study at all, or to stop participating at any time after you begin the study.

3. To be told what the study is trying to find out, what will happen to you, and what you will be asked to do if you are in the study.

4. To be told about the reasonably foreseeable risks of being in the study.

5. To be told about the possible benefits of being in the study.

6. To be told whether there are any costs associated with being in the study and whether you will be compensated for participating in the study.

7. To be told who will have access to information collected about you and how your confidentiality will be protected.

8. To be told whom to contact with questions about the research, about research-related injury, and about your rights as a research subject.

9. If the study involves treatment or therapy:
   a. To be told about the other non-research treatment choices you have.
   b. To be told where treatment is available should you have a research-related injury, and who will pay for research-related treatment.