8-2019

Developing an Interest in STEM Careers Through Integrated STEM Experiences

Megan Mullen
University of Nebraska-Lincoln, jumemullen3@gmail.com

DEVELOPING AN INTEREST IN STEM CAREERS THROUGH INTEGRATED STEM EXPERIENCES

by

Megan Mullen

A THESIS

Presented to the Faculty of

The Graduate College at the University of Nebraska

In Partial Fulfillment of Requirements

For the Degree of Master of Arts

Major: Teaching, Learning and Teacher Education

Under the Supervision of Professor Wendy Smith

Lincoln, Nebraska

August 2019

DEVELOPING AN INTEREST IN STEM CAREERS THROUGH INTEGRATED STEM EXPERIENCES

Megan Mullen, M.A.

University of Nebraska, 2019

Advisor: Wendy Smith

This study will investigate the effects of integrated STEM experiences on increasing student interest in STEM careers. A qualitative design was conducted. Two research questions were addressed in this study: *What happens to students' interest in STEM careers when I integrate STEM lessons into my classroom? What happens to students' interest in STEM subjects when I integrate STEM lessons into my classroom?* Participants included all students in grade 5 in a rural PK-12 school. Data were collected through student surveys conducted at the beginning and end of the study. Structured interviews were conducted of grade 5 students. Observations of STEM experiences were also documented.

Keywords: STEM careers, STEM interest, integrated STEM, elementary STEM

DEDICATION

I would like to dedicate this thesis to my husband and 3 daughters. They were so supportive throughout this process. My husband and oldest daughter went above and beyond to not only make it possible for me to complete multiple weeks of on-campus classes away from home, but also taking over tasks to allow me time and a quiet space to work. They were a driving force behind my completion and I couldn't have done it without their unwavering support. I would also like to thank my professors and advisors who have guided me and been amazing resources throughout this program. Finally, I would like to thank my 13 program classmates. There was constant support and collaboration from others working to accomplish the same tasks and cheering each other on, making this a group effort to reach our common goal.

GRANT INFORMATION

This material is based on work supported by the National Science Foundation under Grant No. 1758496. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

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CHAPTER 1: INTRODUCTION

Problem Statement

STEM education has quickly gained momentum. The National Research Council (2011) report identified 3 main goals of STEM education. These three goals are: (1) increase the number of students who pursue advanced degrees and careers in STEM fields; (2) expand and broaden the participation in the STEM workforce; (3) make STEM literacy for all students a reality (Johnson, 2013). It may be more difficult to reach these goals in the future as fewer students are choosing STEM related majors.

Reports from the Bureau of Labor Statistics (BLS) in 2005 and 2010 project that the U.S. will have a difficult time filling STEM careers that will be vacant due to retirements and a decrease in students' interest in STEM. The U.S labor statistics also project the development of nearly three million new jobs in science and technology by 2020, requiring capable individuals with educational backgrounds in STEM to fill these positions (BLS, 2010). Other reports indicate that the next generation is not prepared to respond either to current demands or to those of the future. (National Research Council [NRC], 2011).

Although, this STEM crisis is not agreed upon by all researchers. Some recent data (Anft, 2015) suggests that many areas of the STEM workforce are oversupplied which results in lower paying jobs. The U.S. Department of Labor (2015) suggests that some areas are oversupplied, however others in private industry have shortages. In the 21^{st} century as technology and computers become commonplace in all aspects of daily life, STEM will be a constant topic. There is also evidence that our country is driven by innovation. The U.S department of Commerce (2008) states that the country is 75%

wealthier in Gross Domestic Products than it was 3 years prior. Progressive innovation may be supported with quality STEM programs.

STEM education has become a national focus area as research points toward a need to increase 21^{st} century skills such as critical thinking, problem solving, communication, collaboration, creativity, and innovation (The partnership for 21^{st} century skills, 2011). In order to progress in our global economy, additional research is necessary to determine how best to engage our students in order to prepare them for the types of jobs that will be in high demand when they graduate. This study will investigate the effects of integrated STEM experiences on increasing student interest in STEM careers.

Purpose and Research Questions

Interest in STEM is defined as an individual's positive attitudes toward, science, technology, engineering, and mathematics subjects. This interest becomes a stimulus for them to pursue any of the STEM subjects in their future career (Buxton, 2001). A variety of reports suggest reasons why students may hesitate to pursue STEM courses and careers, including a lack of quality preparation in mathematics and science in K-12 education, lack of access to money and technology, lack of guidance from adults who are knowledgeable of or affiliated with STEM careers, psychological barriers, and lack of role models in the fields. (National Academy of Science, Global Affairs, & Institute of Medicine 2011; Scott and Martin, 2012). The purpose of this study is to investigate the effects of integrated STEM experiences on increasing student interest in STEM careers. The specific research questions for this study are:

1. What happens to students' interest in STEM careers when I integrate STEM lessons into my classroom?

2. What happens to students' interest in STEM subjects when I integrate STEM lessons into my classroom?

Methods Overview

In this study, I will use qualitative methods to gather evidence of classroom STEM lessons and strategies that may contribute to developing and sustaining students' interest in STEM subjects and STEM careers. Data sources include student work samples, student surveys, student interviews, and teacher observations.

Definition of Key Terms

STEM: The purposeful integration of science, technology, engineering, and mathematics as used in solving real-world problems. (Labov, Reid, & Yamamoto, 2010; Sanders, 2009)

Project-based learning (PBL): approach is one that focuses on organizing self-learning in an empirical project

CHAPTER 2: LITERATURE REVIEW

Overview

Researchers indicate the challenges the United States could face in the future if a significant number of graduating seniors do not develop and maintain an interest in pursuing a STEM career (Maltese & Tai, 2011). Studies have identified useful strategies for fostering an interest in STEM subjects and STEM careers in elementary grades, as well as useful tools for assessing student perceptions of STEM subjects and careers (Kier, Blanchard, Osborne, & Albert, 2013; Nugent et al., 2015; Wyss, Heulskamp, & Siebert, 2012) Related articles were found using a keyword search on Google Scholar. Keywords searched included STEM careers, and interest development. The major themes of this research are interest development, assessing STEM interest and STEM learning experiences.

Interest Development

A person's interest has been found to be a powerful influence on learning, thus creating the basis for developing a four-phase model of interest development. (Hidi & Renninger 2006). This model describes the development of interest through triggered situational interest, maintained situational interest, emerging individual interest, and well-developed individual interest. Triggered situational interest refers to a psychological state of interest that results from short-term changes in affective and cognitive processing (Hidi & Baird, 1986, 1988; Mitchell, 1993) An example of this would be hearing surprising information or something of personal relevance that triggers an interest. Triggered situational interest is typically externally supported (Bloom, 1985; Sadoski, 2001; Sloboda, 1990). Maintained situational interest refers to a psychological state of interest that is subsequent to a triggered state, involves focused attention and persistence over an extended episode in time, and /or reoccurs and again persists (Hidi & Baird, 1986, 1988; Mitchell, 1993). An example of this would be continuing to hold one's interest through repeated tasks. Emerging Individual interest refers to the psychological state of interest as well as to the beginning phases of a relatively enduring predisposition to see repeated reengagement with particular classes of content over time (Hidi & Baird, 1986, 1988; Mitchell, 1993). Examples of this would be the student seeking out opportunities to reengage in tasks related to a particular interest. A well-developed individual interest refers to the psychological state of interest as well as to a relatively enduring predisposition to reengage with particular classes of content over time (Hidi & Baird, 1986, 1988; Mitchell, 1993). An example of this would a student seeking out opportunities to answer their curious questions about a topic of interest. Students tend to be more resourceful and willing to persist through long-term projects of their choosing. The four-phase model of interest development was linked to case illustrations. One such case illustration describes Julia who sees an article at a doctor's office on an engineer, she had not finished the article when she was called back to be seen by the doctor, however, once she finished with her appointment, she located the magazine and sat down to finish the article. This demonstrates triggered and maintained situational interest. (Hidi & Renninger, 2006). Hidi and Renninger (2006) further state that there is no data suggesting that individual interest emerges without first being experienced as a situational interest. Hidi and Renninger's (2006) study then continues through alternate approaches to interest development, all of which have similarities to their four phase model.

The four phase model of interest development is relevant to this research study since it suggests that the psychological process that develops interest relies upon the topic being introduced in a way that piques curiosity, but through continued opportunities to interact with the topic, students may choose to continue to seek out opportunities on the topic. Hidi and Renninger (2006) found that a learning environment that involves project-based learning and cooperative groups contributes to continued situational interest, which then leads to the development of individual interest. Hidi and Renninger (2006) also state that external support that is contextualized in content is critical for early phases of interest development, helping students to have positive feelings toward the content. Positive feelings for content may come from choice in tasks and promoting a sense of autonomy.

The project-based learning (PBL) approach is one that focuses on organizing self-learning in an empirical project. Through practical activities, interactive discussions, independent operation and/or team cooperation, students reach the planned target and establish their own know-how (Tseng, Chang, Lou, & Chen; 2013). This definition of Project-based learning suggests that student opportunities to take the lead and be creative in their learning may contribute to an increased development of interest in a particular topic. Many STEM activities are very collaborative and open-ended. Since research suggests that these types of activities contribute to increasing student interest, this research study can explore the impact of STEM activities on interest in STEM subjects and careers.

Additional findings indicate that a person needs to be exposed to content in order for an interest to be triggered (Hidi & Renninger; 2006). Additional instruction or opportunities relevant to the activity will then need to take place in order for interest to develop further. (Hidi & Renninger; 2006). This is an important finding to drive my research study, because in my rural school, students are not exposed to many STEM careers. Not having an interest in particular STEM subjects and careers may be due to a lack of opportunities for exposure to them in order to develop through the phases of interest. The four-phase model provides a framework to use within my study to determine if participants are developing an interest in STEM careers and subjects.

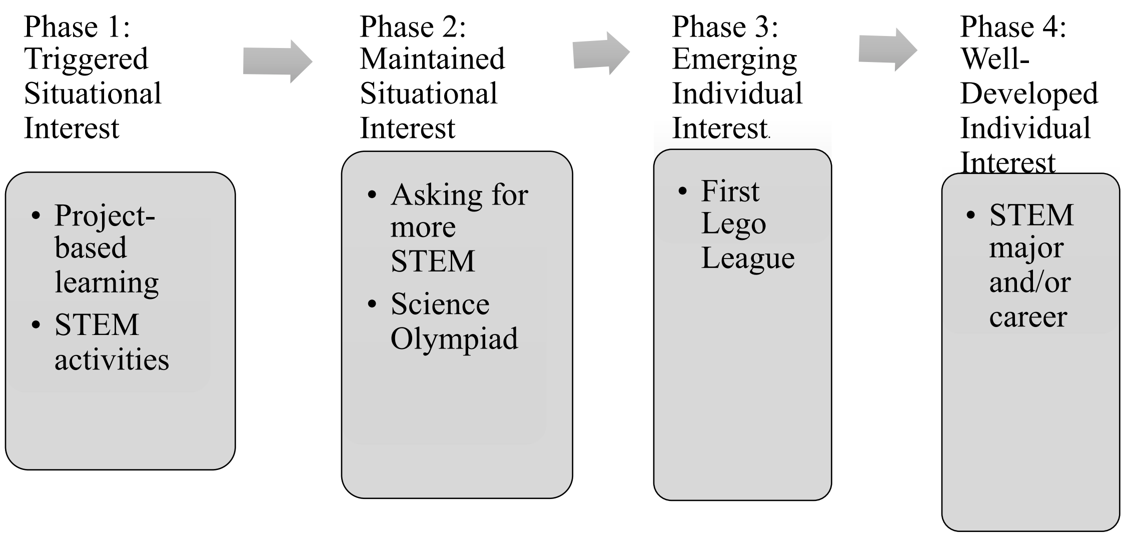

Figure 1. The four-phase model of interest development (Hidi & Renninger, 2006) in context of this study.

Assessing STEM interest

In addition to understanding how interest develops, it is important to have a valid tool for assessing the changes in student interest in a content area. Kier, Blanchard, Osborne, & Albert (2013) conducted a study to develop a survey with sub-scales in science, technology, engineering, and mathematics. The purpose of their study is to effectively measure interest in STEM classes and careers in middle school students. The social cognitive career theory was used to develop a forty-four question survey that was administered to over 1000 middle school students to test for reliability and psychometric properties. The STEM-CIS (STEM-Career Interest Survey) used a 6 stage process to develop and validate as a reliable survey for determining student interest in STEM. (Kier et al., 2013).

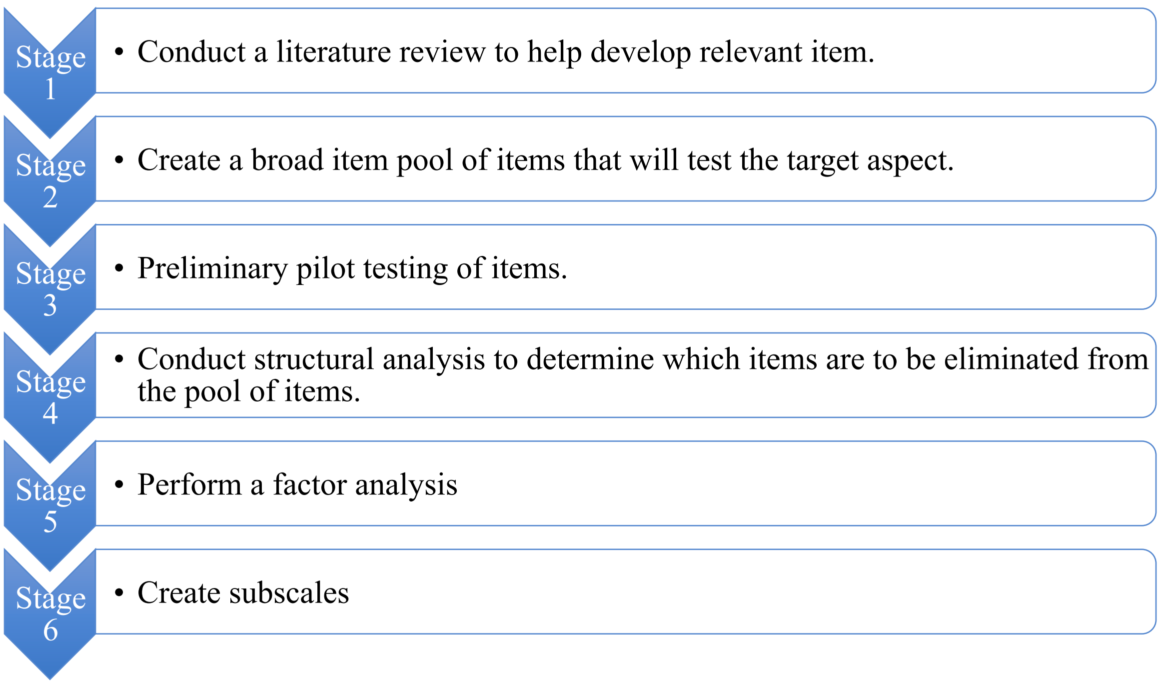

Figure 2. Six stages of the STEM-CIS (Kier et al., 2013).

Questions were developed for the STEM-CIS (STEM-Career Interest Survey) based on self-efficacy, outcome expectation, personal inputs, and contextual supports and barriers. The STEM-CIS was developed within a STEM Career Awareness Project that emphasizes careers in the context of classroom instruction in rural and high-poverty districts (Kier et al., 2013). The similarities of the test schools for the STEM-CIS and the school for this study are that they are both rural school with a significant number of students on free/reduced lunch, therefore the STEM-CIS is a good tool to use for determining student STEM interest in this study. The STEM-CIS was found to be a valid instrument for analyzing career interests in STEM fields. (Kier et al., 2013). Data for the validation process was collected from 1,061 students in grades five through eight at seven middle schools in rural southeastern USA (Kier et al., 2013). In order to verify the validity of the STEM-CIS, content scales were used in science, mathematics, technology, and engineering and subjected to confirmatory factor analysis via AMOS (AMOS is the structural equation modeling software produced with IBM/SPSS; Kier et al., 2013). The STEM Career Interest Survey was shown to be valid for each of the content subscales. Kier, Blanchard, Osborne, and Albert (2013) conclude that the STEM-CIS instrument is defensible to use in middle grade populations. These researchers also conclude that it is possible to characterize the subscales in a variety of ways. Subscales can be used individually, more than one or all four calculating for each content area, or to combine all items into a single overall score reflecting career interests in the STEM field overall. (Kier et al., 2013).

Since the STEM-CIS was found to be a reliable assessment tool for assessing student interest in STEM careers, I chose to use it to collect reliable data on the interest of the participants in my study. In my study, the STEM-CIS was used as a pre and post survey in order to determine the impact of exposing rural students to STEM careers that they may not have otherwise known existed.

STEM Learning Experiences

Several studies have been conducted to determine the types of classroom experiences that contribute to increasing student interest in STEM fields. A meta-analysis conducted of 31 studies compared integrating math and science instruction (Honey, Pearson & Schweingruber, 2014). Research findings of this meta-analysis indicate that total integration produced the largest effect size. Total integration refers to combining all four STEM disciplines into a well-designed lesson within a single classroom. In-depth studies on the types of experiences that trigger and maintain an interest in STEM are important to understanding this relationship. Maltese and Tai (2011) included a two-part analysis assessing school-based factors related to the social cognitive career theory. The social cognitive career theory is defined by Lent, Brown, and Hackett (1994, 2000), as the belief that student aspirations are developed from a combination of intrinsic interest and extrinsic experiences. This study analyzed academic records and longitudinal surveys of a national sample of 4,700 students using a progression of logistic regression model. Study findings indicate that early interest in STEM as well as an increased enrollment in high school science are associated with completion of a STEM degree. Maltese and Tai (2011) believe the interest in STEM drives the course enrollment. Eighth grade students indicating the usefulness of science were also more likely to earn a STEM degree. The purpose of the study by Maltese and Tai (2011) was to gain an understanding of how student experiences, enrollment, and performance influenced a desire for a future career in STEM. An additional study by Maltese, Melki, and Wiebke (2014) consisted of a survey of 8000 individuals to address the experiences that may have triggered and maintained an interest or disinterest in STEM. Survey participants included both college STEM majors and non-STEM majors. A cross-sectional data analysis was conducted, and findings indicated that interests in STEM were either triggered or not prior to 6th grade. The experiences that generated the most interest included classes at school, building/tinkering, exposure to STEM through media, and playing outdoors. (Maltese et al., 2014). A large percentage of those interested in STEM had a well-developed personal interest in the field in middle school and high school contributing to their persistence in pursuing the interest. (Maltese et al., 2014). The studies by Maltese suggest that if students are given consistent opportunities to engage in STEM activities in the classroom during elementary school, they may develop a significant interest in a STEM subject. This interest could then progress through the four-phase model of interest development (Hidi & Renninger, 2006) and potentially result in the student choosing a STEM career path.

In the process of understanding the school experiences that contribute to an interest in STEM, analyzing multiple classroom strategies and school programs can provide insight into STEM interest development. Nugent, Barker, Welch, Grandgenett, and Wu (2015) conducted a structural equation modeling study to test factors contributing to STEM learning and career interests. A sample of 800 students aged 10-14 attending summer robotics camp completed pre- and post- surveys. Study findings suggest career interests are influenced by perceived benefits of the career and self-efficacy. Self-concept and educators also play a role in developing interest and career orientation. (Nugent et al, 2015). Nugent (2015) defines self-concept as a learner's perception of themselves and their competence in an academic discipline. Nugent's (2015) study, however, may have limitations due to the already perceived interest of those attending a summer robotics camp. To research the impact within a school setting, Sahin, Ayar, and Adiguezel (2014) conducted a study on the characteristics of after-school programs (such as Science Olympiad) at a K-12 charter school. This qualitative case study found that collaborative groups were important to accomplish goals and meaningful social communication skills. Participants were committed to their after-school program and the “hands-on, minds-on” activities created a feeling of motivation and joy. Participation in the programs showed an increase in students’ interest in STEM careers. Although these research studies have reported the increase in interest due to participation in STEM camps and after-school programs; students may already have a sustained interest in STEM, which influenced their choice to participate in these programs (Sahin et al., 2014). Since the previous studies were conducted within summer and after school activities, additional knowledge could be gained from research studies conducted within regular classroom settings to analyze how STEM methods within the classroom can impact student interest. Wyss, Heuskamo, and Siebert (2012) conducted a two-phase study to address the question, “Does showing video interviews with STEM professionals about their careers, increase middle school students’ interest in pursuing careers in the STEM fields?” (p. 4). Student interest in STEM careers was measured with a 3-interval (beginning, middle, end) survey. A series of 8 videos of interviews with STEM professionals were shown to a treatment group of 18 sixth grade students and 23 eighth grade students. A control group of 21 sixth grade students and 22 eighth grade students received the same classroom instruction without the addition of the videos. Major findings of this study indicate that the treatment group had significantly higher mid-test and post-test scores compared to the control group (Wyss et al., 2012). Although previous studies (Kier et al., 2014) suggest that the nature of interest development would indicate that without proper support, individuals can lose interest. Therefore continued methods of integrating STEM into the classroom, opportunities to engage in further activities when an interest in an area develops, as well as opportunities to learn about STEM careers from those in the field could be necessary to maintain this interest.

The integrated STEM experiences within these research studies provide researched suggestions for adapting my classroom practices to engage students in opportunities to explore STEM subjects. When choosing STEM activities to use within my study, I chose to incorporate several strategies listed within these research studies, such as exposure to STEM careers and people who work in those areas, robotics exploration, project-based learning opportunities, as well as videos to enhance learning.

Summary

Themes of previous research are interest development, assessing STEM interest, and STEM learning experiences. Overall research would suggest that STEM interest is triggered at the elementary level. Continued classroom STEM activities or learning experiences can sustain this interest and possibly contribute toward students' pursuing STEM careers. Furthermore, the types of classroom activities need to be addressed, as there are certain educational experiences that research suggests to have a greater impact on STEM interest, such as opportunities to individually pursue an area of interest as well as connect with STEM professionals in the field. The studies discussed in this literature review, while valuable, do not address STEM interest development at the elementary level within the regular classroom. The four-phase model of interest development has not been used in context with STEM education. During the development of the STEM-CIS, it was tested for validity, however, my study is putting it into use as an assessment tool to determine the impact integrated STEM experiences have within the classroom. The STEM experiences within some studies in this lit review, are used in after school programs, where it is assumed that participants already have an interest in STEM. My study addresses every student within a classroom, therefore there are fewer students with previously developed STEM interest, therefore viewing the impact on all students is valuable.

CHAPTER 3: METHODS

Overview

In this study, I am using action research to gather evidence of classroom STEM lessons and strategies that may contribute to developing and sustaining students' interest in STEM subjects and STEM careers. This study will address two questions. What happens to students' interest in STEM careers when I integrate STEM lessons into my classroom? What happens to students' interest in STEM subjects when I integrate STEM lessons into my classroom?

Context of the Study

This study was conducted in a rural PK-12 school setting. This school does not have a high level of diversity. Demographics include 85% White/Caucasian, 14% Hispanic, and 1% African American. There are 49% of students on free and reduced lunch. The school setting is divided into a PK-5 Elementary, 6-8 Middle School, and 9-12 High School all contained in one building. There is a strong community involvement in this school with parents, administrators, and school board members supporting STEM programs and implementation. Through a 1:1 initiative, students in grades PK-8 all have an assigned iPad and students in grades 9-12 are assigned a MacBook computer. An after-school Science Olympiad program is available to grades 6-12. A school goal is to emphasize college and career readiness as well as a focus on STEM relevant to the new Nebraska State Science Standards. The study school has chosen to add a semester-long STEM course for all students in grades 6-8 for the 2018-2019 school year. All PK-5 teachers were required to participate in a STEM professional development workshop during the summer 2018. As the 5th grade teacher in the study school, I will be both the researcher and a participating teacher. I have 14 years teaching experience, with 13 of those years in this school.

Participants

There are 15 students in grade 5. Study participants will be all 15 students in grade 5. All participants took a perceptions survey. The STEM-CIS (Kier et al., 2013), used in this study, was developed as a valid instrument for assessing middle school students' STEM interest. Student work samples and teacher observations were collected for all 15 students. Six students were selected to participate in individual interviews. These 6 students were selected based upon MAP Science scores. The Fall scores were divided into 3 groups: high, middle, and low. There were 2 students selected from each of these groups.

Data Collection

Data will be collected from student surveys, interviews, and observations. Student survey questions will come from the STEM-CIS (Kier, et al. 2013). The STEM-CIS survey questions have already been tested for sub-score validity. Interviews were conducted with 6 students once at the beginning of the research period and once at the end of the research period. Student work samples and reflections were collected at the end of each topic unit. Student surveys using STEM-CIS was collected from all 15 students at the beginning and end of the research period. Teacher observations and reflections were written each week.

Student interviews.

Six students were individually interviewed. The first interview was conducted in February at the beginning of the research period. The second interview was conducted in

May at the end of research period. Interview questions are documented in Appendix A. I audio recorded each interview and transcribed it after.

Student surveys.

All 15 participants took the STEM-CIS survey at the beginning of the research period and also at the end of the research period. To make the survey accessibility easier for 5th graders, the survey questions were taken from the STEM-CIS and recreated in a google form. STEM-CIS is a Likert scale survey (See Appendix B). I felt that additional student perception data would be valuable as well, therefore an additional 5 question open-ended survey was given to all 15 participants at the end of the research period (See Appendix C).

Student work samples.

I collected work samples from all 15 participants. Each time we finished a topic unit, students had an opportunity to research STEM careers related to the topic. Each student chose a job that they wanted to learn more about. Students then wrote a reflection on whether the job held any interest to them with an explanation why it did or did not interest them. I kept these student reflections as a record on the types of jobs they chose to research and their interest in them.

Teacher observation journal.

I wrote journal entries at the end of each week. I described the activities that took place within the classroom as well as the engagement of the students. I was looking for evidence that students were interested in the topic of study for the week. I made note of any significant challenges for students as well as things that I felt I may need to adjust in my teaching in order to more effectively engage students are impact their learning.

Data Analysis

Student work samples.

Student work samples were analyzed for recurring mention of STEM jobs. A list was made of all the jobs that students chose to research throughout the course of this study. I was particularly interested in how many students chose the same job. These student samples were further coded to responses showing positive interest in a chosen career or negative interest in the career. Negative interest within the context of this study is defined as a student saying they are not interested in a selected STEM career.

Student survey data.

Student Survey Data using STEM-CIS was collected using a 1 through 5 Likert scale. I divided the questions into 2 groups based upon which research question they addressed. Then, data were analyzed to see the change in responses from the pre-survey given at the beginning of the study period to the post-survey given at the end of the study period. Deeper consideration was given to those questions in which there was a significant increase in higher scale responses.

Additional student post-survey.

Each of the questions 2, 3, and 4 from the additional post-survey were individually analyzed, because each question related to a different area of this study. Question 1 and 4 were of interest to the classroom teacher, but not particularly relevant to this study. Question 2 was coded to compare responses that indicate a positive increase in math interest after hands-on activities or a negative feeling toward math interest. Question 3 was analyzed for careers mentioned by students that they did not know existed before the activities in this study. Question 4 was coded for yes or no responses showing whether students intended to continue to research STEM careers on their own.

Student interviews.

Student interviews were recorded and transcribed. Student interview responses were analyzed for recurring themes. Themes included favorite subject mentioned in question 2, positive comments toward STEM activities in the classroom, feelings toward STEM compared to other subjects, positive changes in thinking about STEM subjects, and the impact it may have on a future career choice. Interview data was separated into pre and post interviews and recurring comments were recorded as well as the number of occurrences throughout the six student interviews.

Teacher observation journal.

Weekly observation journals were written throughout the study period. Teacher journals included current topics of study and STEM activities taking place in the classroom. Observations of student engagement and comments were also recorded. Notes were made to indicate if changes in classroom activities may be helpful to increase student engagement and interest.

Summary

Action research was used to study the effects of integrated STEM lessons on student interest in STEM subjects and STEM careers. A 5th grade classroom in a rural PK-12 school was the setting for this study. This research study took place from January to May. Participants were given a STEM-CIS survey at the beginning of the study period as well as at the end. Each of the 15 participants completed all in class STEM activities and each classroom unit of study concluded with a STEM career exploration activity. Six of the participants were selected for student interviews in order to gain deeper insight into their thoughts and feelings about STEM subjects and careers. At the end of the study, the researcher felt it would be beneficial for an additional short-answer perceptions survey in order to gain knowledge of whether students may choose to continue to pursue their interest in a particular STEM subject or career in the future.

CHAPTER 4: FINDINGS

Overview

The findings in this research study address two research questions. What happens to students' interest in STEM careers when I integrate STEM lessons into my classroom? What happens to students' interest in STEM subjects when I integrate lessons into my classroom? Major findings suggest that when students enjoy integrated STEM lessons and are introduced to STEM careers associated with the lesson topics, students will develop an interest in STEM career paths. Students may not be pursuing STEM careers, not because they do not have an interest in them, but rather because they are not aware of all the career opportunities in STEM fields. Students' enjoyment of STEM lessons may also lead to an increased interest in STEM subjects in the classroom as well as increased learning since students are more engaged during hands-on activities.

Before looking into the findings of this study, it may be helpful to look into the progression of a typical science unit in my classroom that incorporates STEM activities. Some science lessons begin with overview and background information on the topic. Starting with an engaging phenomenon that piques student interest, it a great way to introduce a new topic. Many of my STEM activities were culminating activities for students to use their knowledge of a topic to solve a challenge question. Within the introduction of a new topic, students are very engaged when I show short video clips. Before each video, I give students some questions to think about and then these are discussed at the end of the video. Since our space unit was the most involved unit during this research period, I use it in my example. We started with a video on the changes in gravity in the solar system. Students them participated in a group activity measuring their jump height and then calculating their jump height on with different gravity pulls on different planets. Our next video and activity involved the stars, the moon and the rotation of the earth. Using a skyviewer, students had to make a claim about why we see phases of the moon within a month or different constellations during each season.

Next, groups of students were assigned a specific planet to research and create poster of facts. Once the poster was finished, students began the STEM activity. Each group was given the challenge that NASA is wanting to explore space vehicles that could travel to and explore each planet in the solar system. Students had to take into consideration the facts they learned about their planet to create a prototype of a space vehicle. Groups went through the Engineering Design Process as they were brainstorming, planning, and beginning to create their space vehicles. As the teacher, I was a facilitator of the activity. I may assist a group to discuss ideas and come up with a way to compromise and incorporate several ideas. Groups also had to get my check of approval for each step of the design process before moving on to the next. Once students had built their vehicle, they had to write how they would present their prototype to NASA, specifically telling how their design will work and why NASA should choose to use it. The next step in the unit, was to research NASA and space jobs. Students chose 2 jobs that they wanted to look into more. Once their research was complete, students reflected on if the career interested them or not and why.

During STEM units, students could not wait for it to be time to work on their project. When students had free time, they wanted to work on their STEM projects. Students were always very engaged during STEM activities and their enjoyment showed when they would seek out opportunities to work whenever they could. My observations while facilitating STEM activities was consistent with the findings from the data that were collected.

What happens to students' interest in STEM careers when I integrate STEM lessons into my classroom?

Data suggest that when students enjoy integrated STEM activities in the classroom and are introduced to STEM careers associated with the lesson topics, students begin to develop an interest in STEM career paths. Throughout the course of this study, each time a topic of study was completed, students were given opportunities for STEM career exploration. Once students researched a STEM career of their choice, they would reflect on their interest in their chosen career as indicate why they may be interested in it or not. Table 1 lists all the careers researched throughout the units of study as well as the number of students mentioning these careers.

Table 1

STEM job interest count within units of study

STEM job mentioned	Number of students	Unit of study
Urban and Regional Planners	2	BrickLab Area/Perimeter Time/Personnel activity
Interior Decorator	1	
Electrician	1	
Architect	1	
Construction and Building Inspectors	1	
Construction Manager	1	
Photographer	1	Space Exploration
Engineer (Electronic, Aerospace)	7	
Atmospheric Scientist	2	
Astronaut	3	
Astronomer	4	
NASA		

Mediawriter/producer	1	
Rover camera operator	3	
Avionics Technology	2	
Biologist	2	
Physicist	1	
NASA project manager	1	
Graphic Designer	1	
Tornado Chaser	6	Extreme Weather
Volcanologist	2	
Snow Scientist	4	
Water Resources Engineer	2	
Civil Engineer	1	
NASCAR Fire Rescue	1	The science of NASCAR
NASCAR corner worker	3	
Project Analyst	1	
Event Coordinator	4	
Financial Analyst	1	
NASCAR Engineer	1	
Quality Assurance Engineer	1	
NASCAR driver	3	

During the first unit of study, BrickLab, the number of positive interest responses in the STEM careers was equal to the number of negative interest responses. The data indicate that as students had continued opportunities to explore STEM careers, their positive interest increased. Figure 3 shows the change in positive student interest in STEM careers during 3 units of study. Negative interest within the context of this study is defined as a student saying they are not interested in a selected STEM career.

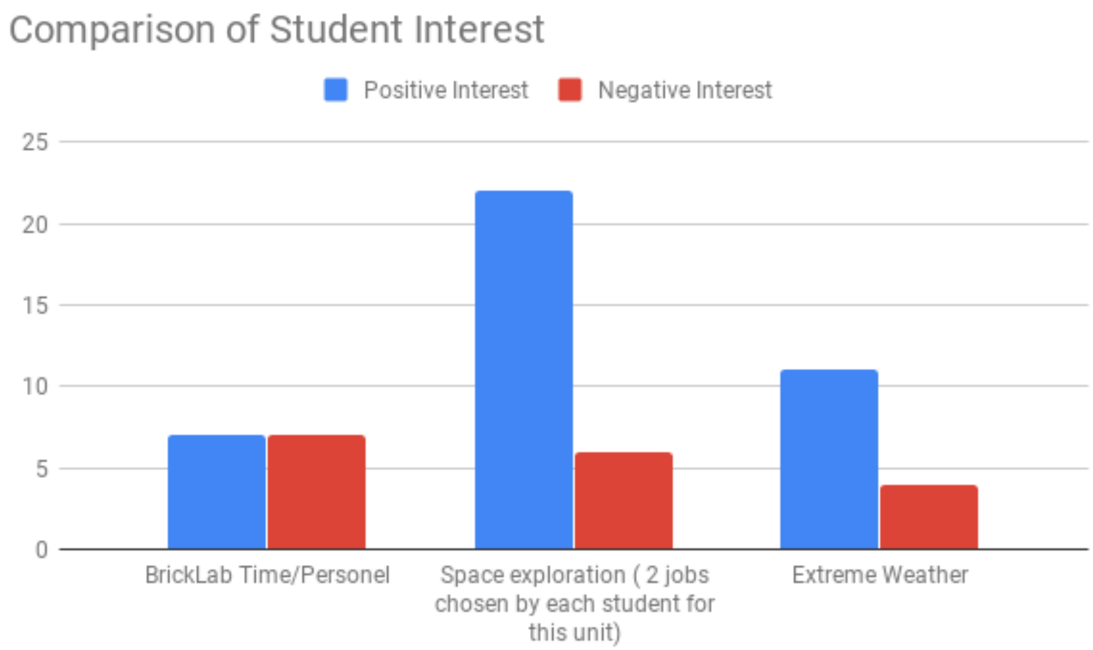

Figure 3. Comparison of student Positive and Negative Interest toward chosen research career in each unit of study.

On Question 3 of the additional post survey, which asks students to indicate if they learned about any careers that they didn't know previously existed, one student wrote, "Yes, practically every job we talked about". Other students listed careers and some of them were mentioned more than once. Table 2 shows the STEM careers mentioned in Question 3.

Table 2

Additional post survey Question 3 Responses

STEM job student responses	**Number of Students**
Tornado Chaser	**3**
NASCAR corner worker	**1**
Space Jobs	**1**
Astronaut	**1**
Camera Rover Operator	**1**
News Writer for NASA	**1**

Quality Assurance Engineer	**2**
Snow Scientist	**2**
Marketing Coordinator	**1**
Astronomer	**3**
Event Coordinator	**1**
Forensic Anthropologist	**1**
Financial Analyst	**1**
Space Engineer	**1**
Digital Editorial	**2**

These data suggest there may be a shortage of rural kids choosing to major in STEM careers not because they do not have an interest in those careers, but rather because they are not aware of all the STEM careers that are even available. During student interviews, one student said " I didn't even know aerospace engineering was a thing until we talked about it". When the study participants were given multiple opportunities to explore STEM careers and associate those careers with topics, such as space, that already interest them, their interest in these careers increased.

Although STEM careers include some integration of all the STEM subjects, the STEM-CIS data breaks down how students view careers associated with each separate STEM area. Figure 4 shows the results from question 1 indicating that there was a significant increase between pre and post surveys in students who planned to enter a science related career. Figures 5 and 6 are additional indicators that student interest in Science-related careers increased over the course of this study.

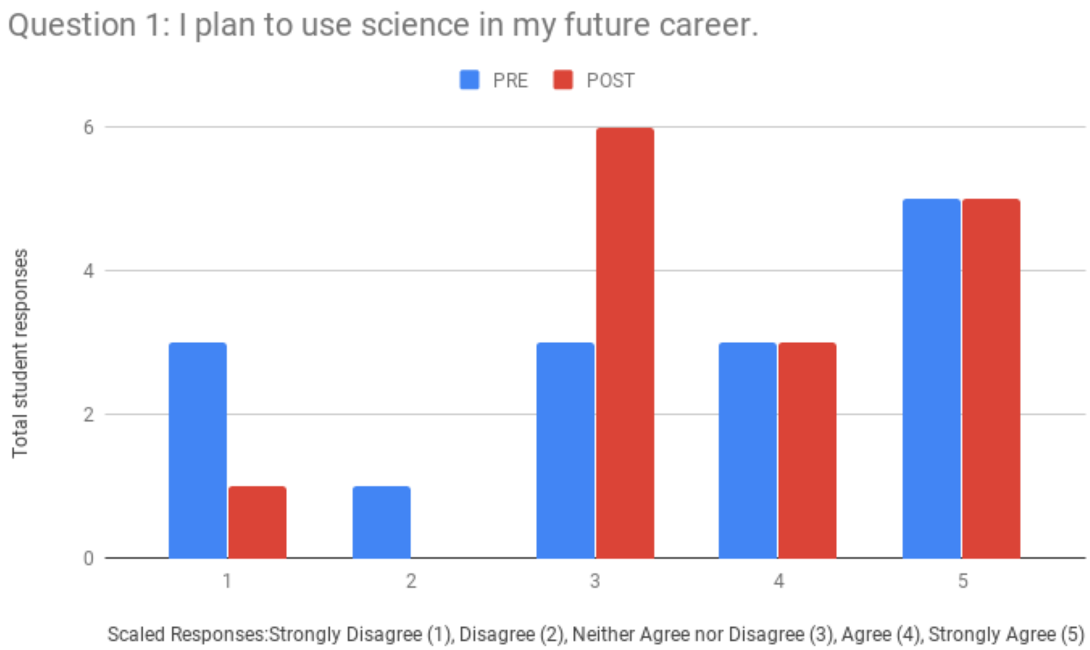

Figure 4. STEM-CIS responses to the question, "I plan to use science in my future career".

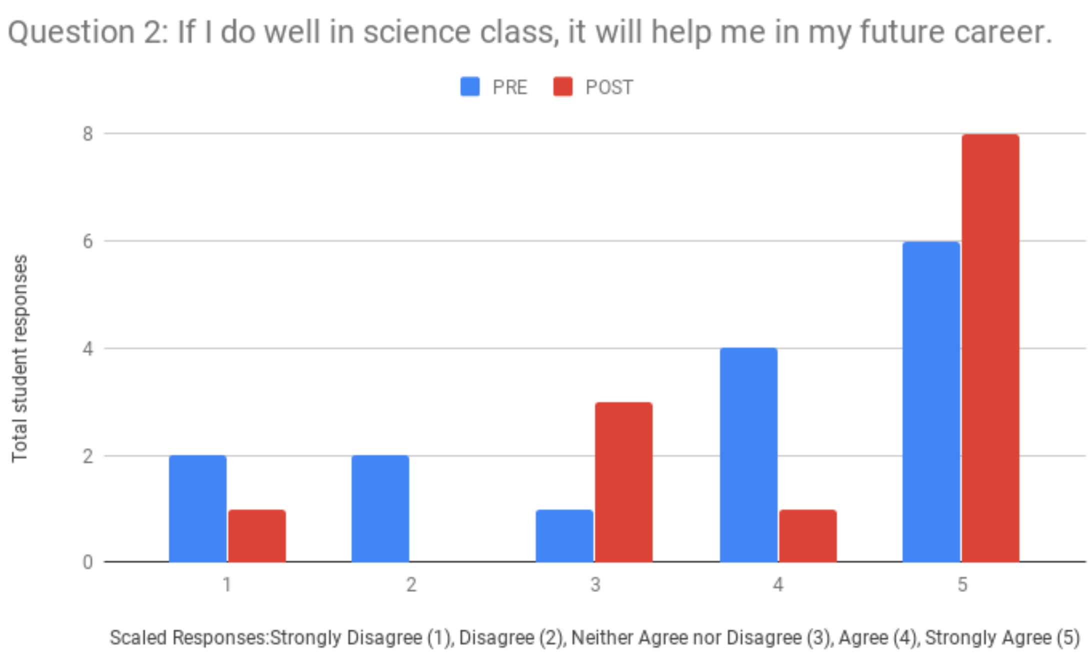

Figure 5. STEM-CIS responses to the question, "If I do well in science class, it will help me in my future career".

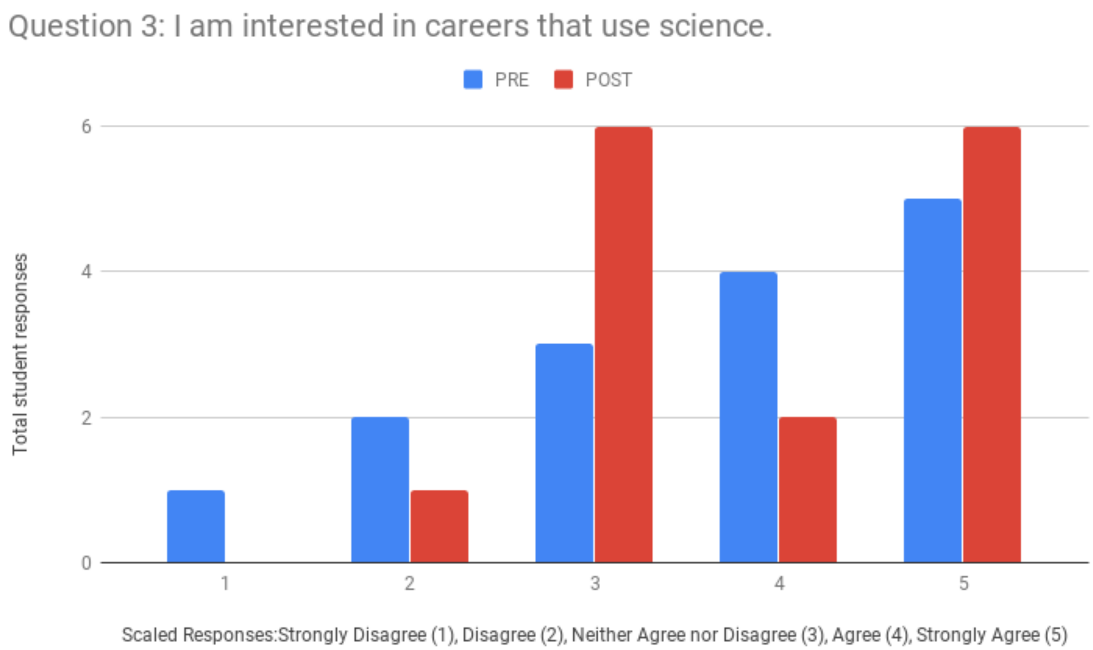

Figure 6. STEM-CIS responses to the question, "I am interested in careers that use science".

The question on the STEM-CIS related to mathematics had less of a shift in Figures 7 and 8 suggesting that participants previously understood the importance of math in future careers. However, there was a significant increase in participant interest in careers involving mathematics, as shown in Figure 9.

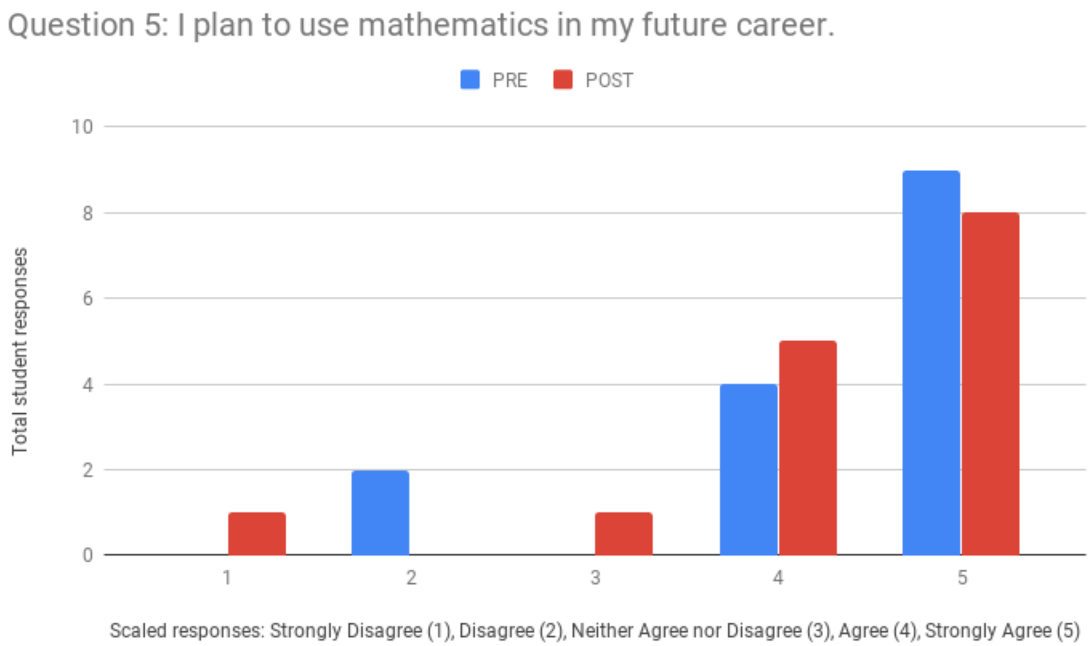

Figure 7. STEM-CIS responses to the question, "I plan to use mathematics in my future career".

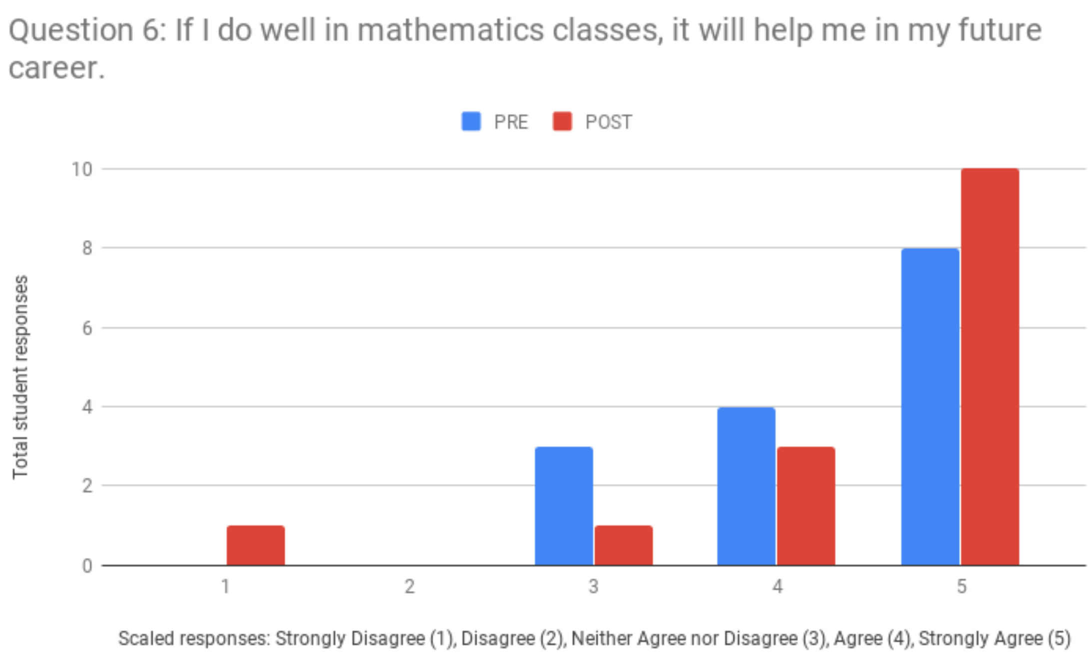

Figure 8. STEM-CIS responses to the question, "If I do well in mathematics class, it will help me in my future career".

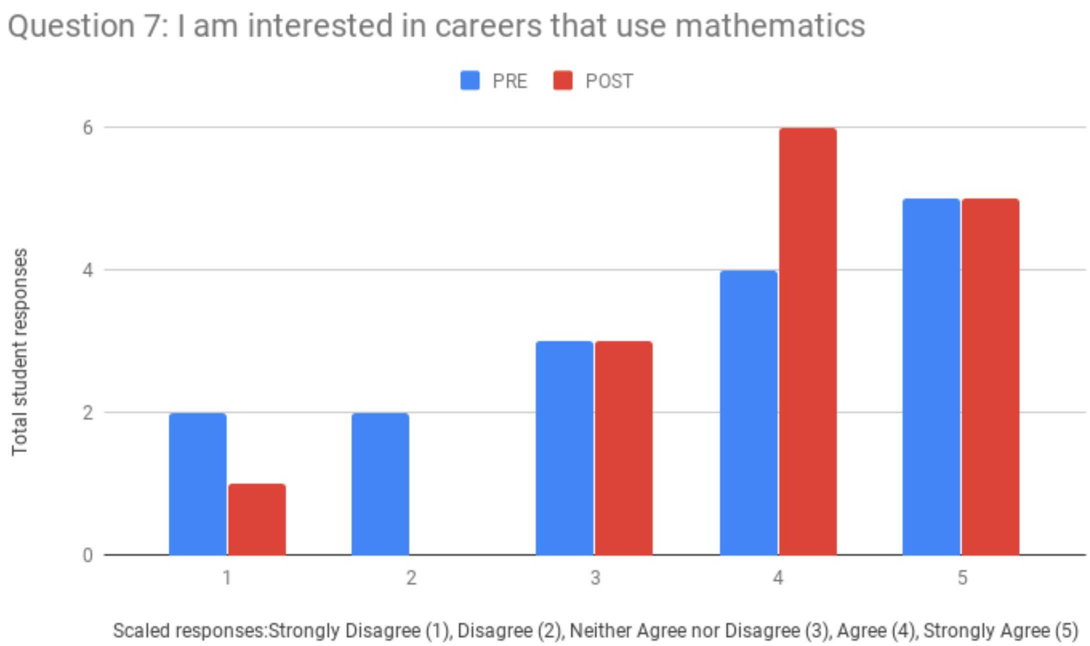

Figure 9. STEM-CIS responses to the question, "I am interested in careers that use mathematics".

Some interesting results in the STEM-CIS survey were in the questions related to technology. Figure 10 shows a slight decrease in the participants planning to use technology in a future career. Perhaps this could be better understood, if more information could be obtained to show their perception of technology. Figure 11 also shows a slight decrease in participants who felt they needed to know lots of technology to do many jobs. This data, however, did not seem to significantly affect the number of students interested in technology related careers, as only three participants indicated little interest in a technology-related career.

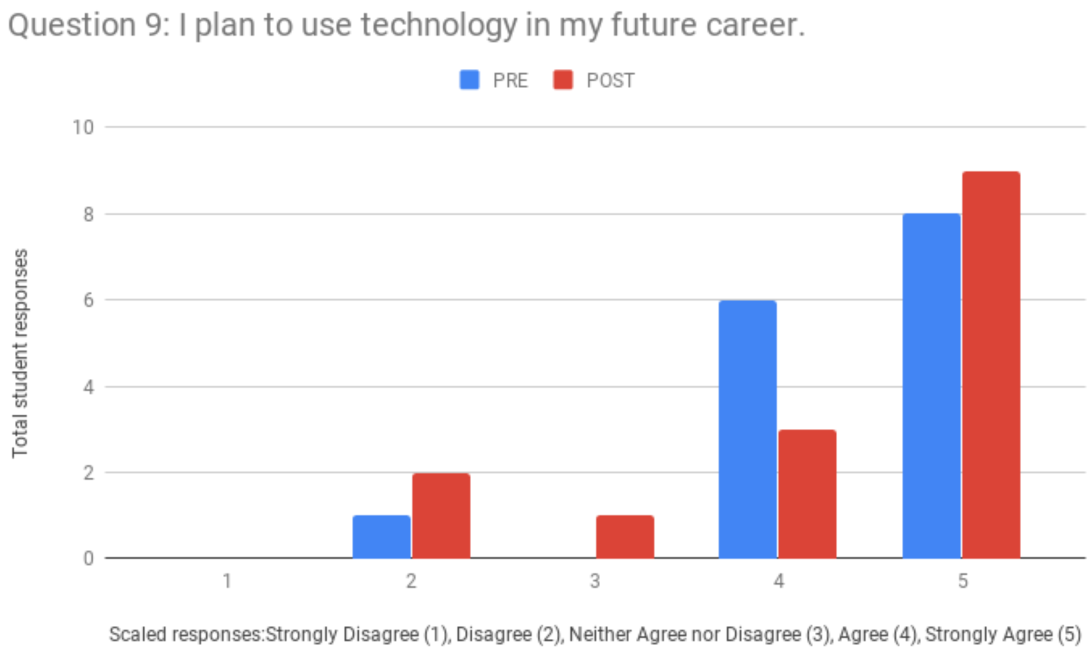

Figure 10. STEM-CIS responses to the question, "I plan to use technology in my future career".

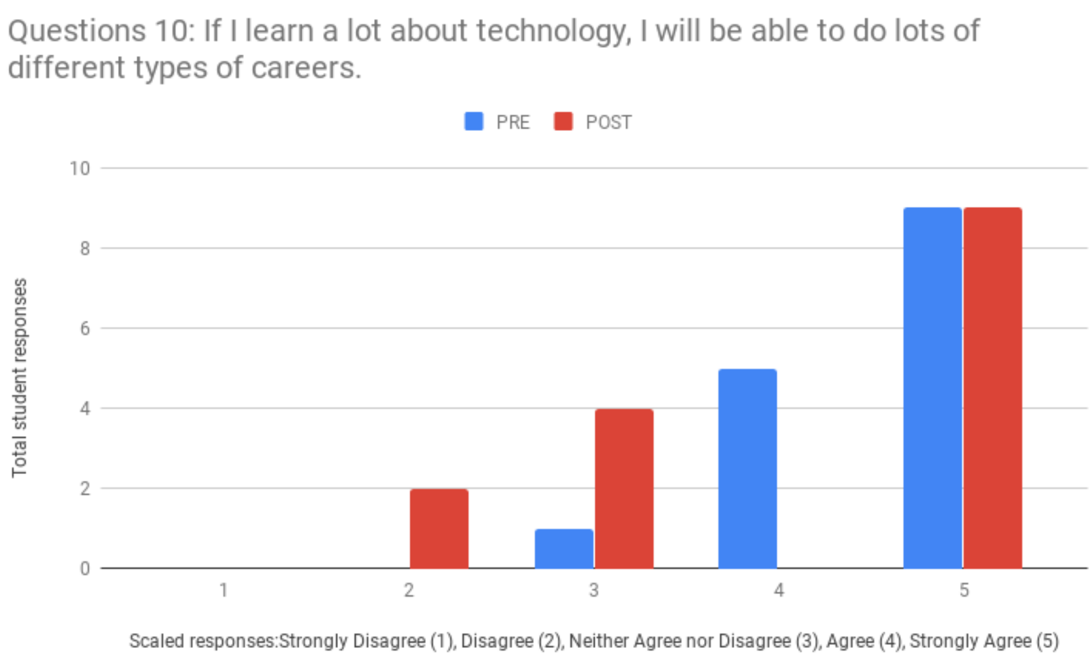

Figure 11. STEM-CIS responses to the question, "If I learn a lot about technology, I will be able to do lots of different types of careers".

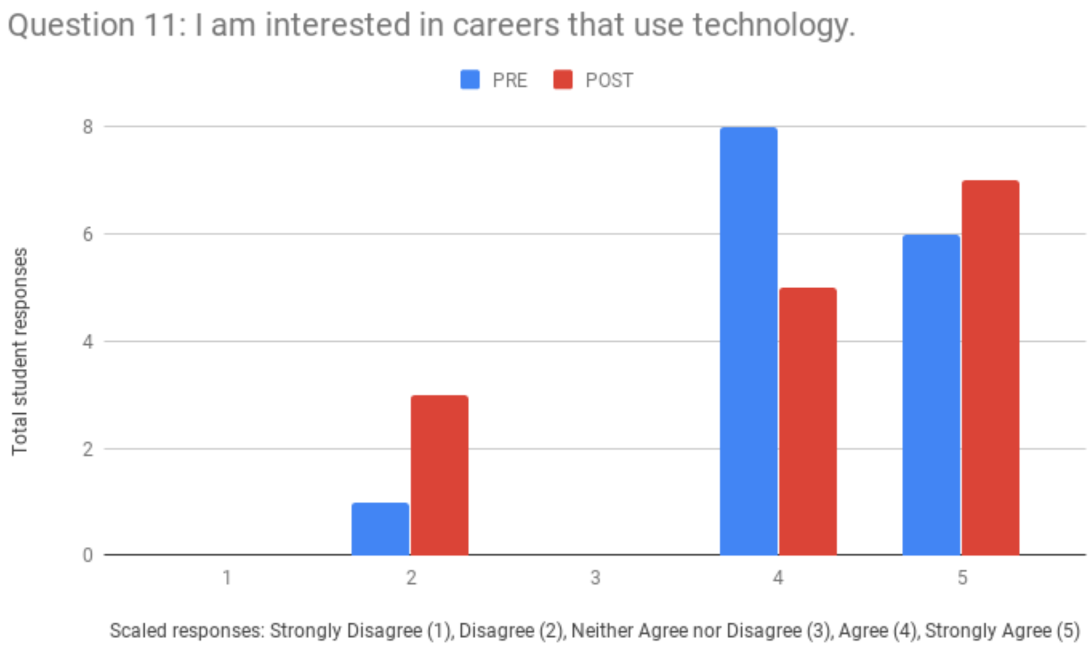

Figure 12. STEM-CIS responses to the question, “I am interested in careers that use technology”.

Figure 13 shows a significant increase in students’ interest in careers involving engineering. Several students researched different types of engineers during their career explorations, therefore, this suggests that by gaining an understanding of engineering careers, a higher interest may develop.

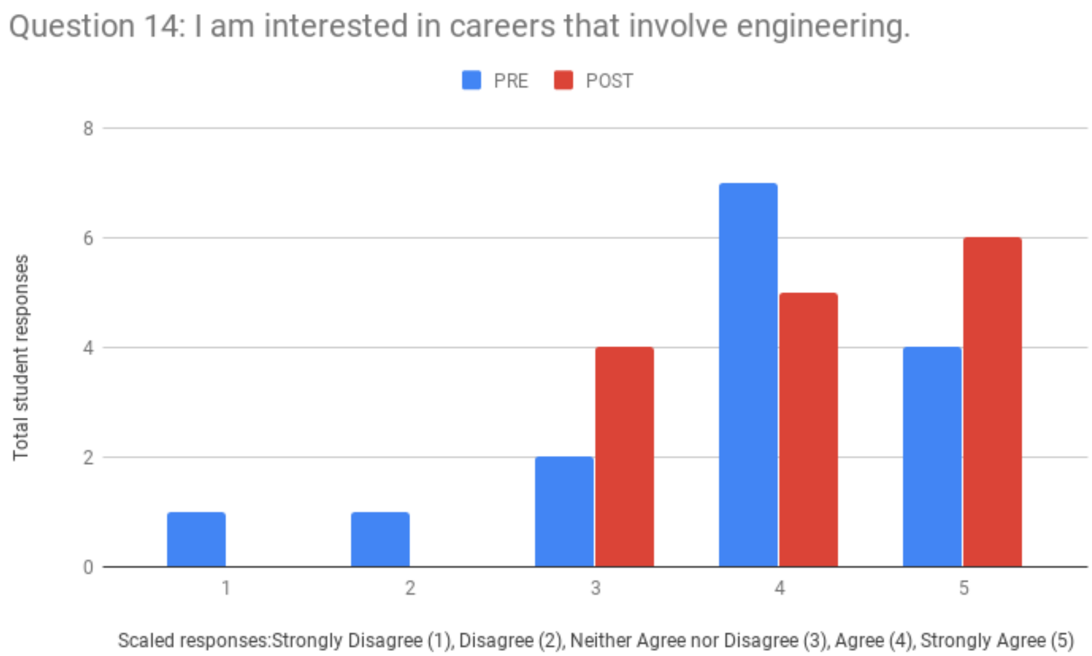

Figure 13. STEM-CIS responses to the question, “I am interested in careers that involve engineering”.

The next piece of data related to STEM careers comes from six student interviews. In the first interviews, two students did not know what they might be interested in for a future career and one student mentioned a career from our current unit of study. By the second interview, all six interviewed participants indicated either a STEM job or interest in something with science or math involved (see Figure 14). This suggests that when students are given opportunities to learn about new careers or to learn that perhaps a career that they already know about does involves STEM, there could be an increase in students choosing to pursue STEM careers in the future.

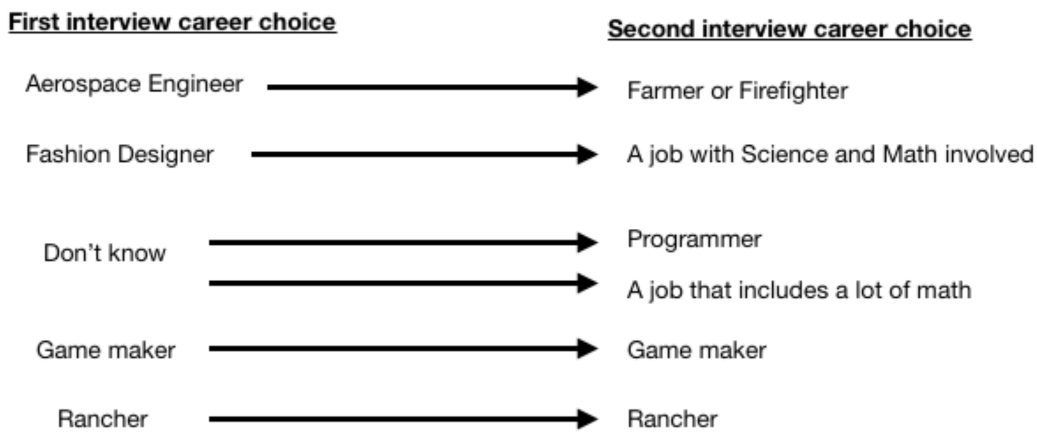

Figure 14. Student Interview Career Choices

During the addition perceptions survey at the end of the study, one question asked students if they will continue to explore STEM career options on their own. Figure 15 shows the results of this question. The 60% of students responding that they will continue to explore STEM careers suggests that once they develop and interest in STEM and begin to realize that there are so many jobs out there to explore, kids may continue to pursue areas of interest perhaps leading to a future STEM career choice. Figure 16 shows student comments on why they plan to continue to pursue STEM career choices that are available. These comments suggest that through STEM activities and career explorations in the classroom, they have developed an interest in science, engineering and math related fields.

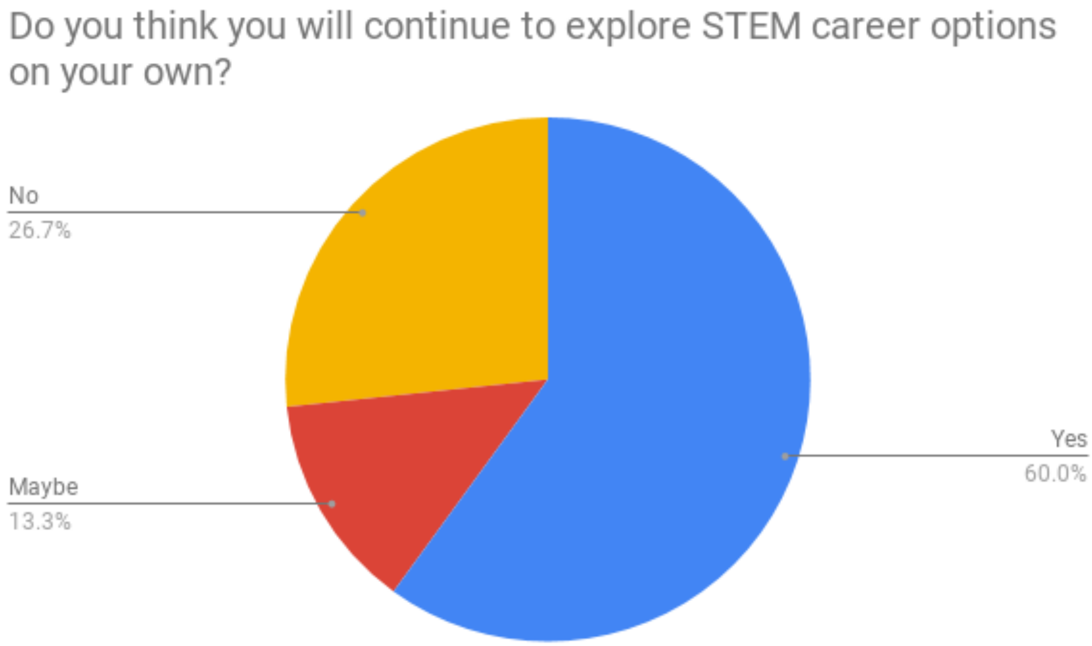

Figure 15. Student Perception Survey

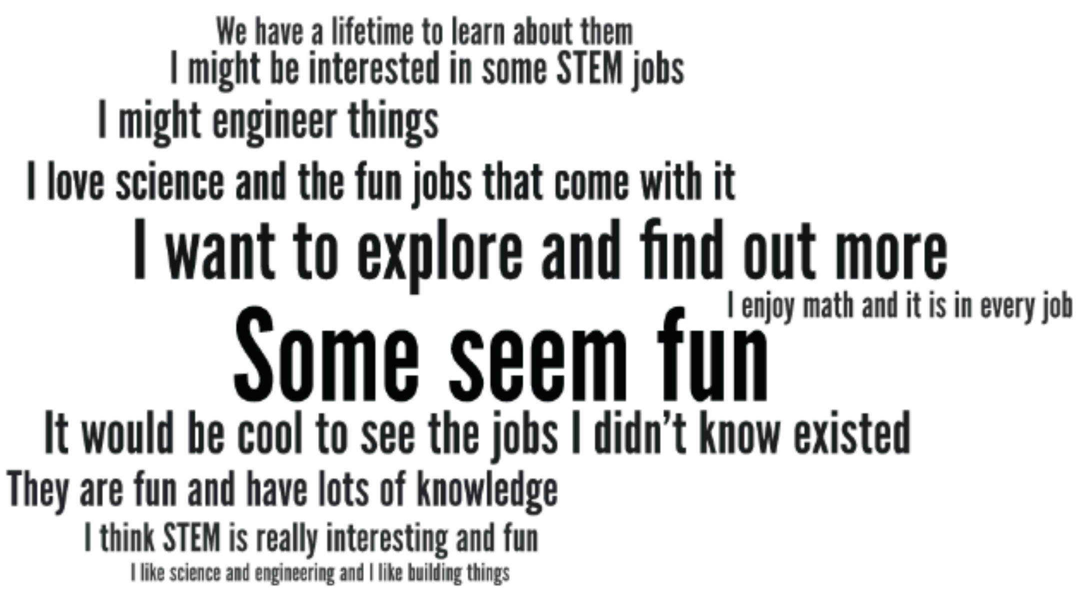

Figure 16. Student Perception Survey Comments

In summary, data shows that participants had an increase in interest for STEM careers after participating in engaging classroom STEM activities and STEM career explorations. Participants were not aware of many of the STEM careers that were explored during this study, therefore it may be important to offer many opportunities for students to be exposed to STEM careers available in order to possibly develop a deeper interest in STEM careers. Once students became intrigued by the possibility that there were so many jobs out there that they didn't even know about, participants are willing to continue to investigate jobs within areas that interest them in the future.

What happens to students' interest in STEM subjects when I integrate STEM lessons into my classroom?

Although all participating students may not end up choosing a STEM career, the other question this research investigated was the impact on student interest in science, technology, engineering, and math subjects. Figures 17 and 18 indicate an increase in student interest in science and math class by the end of the study period.

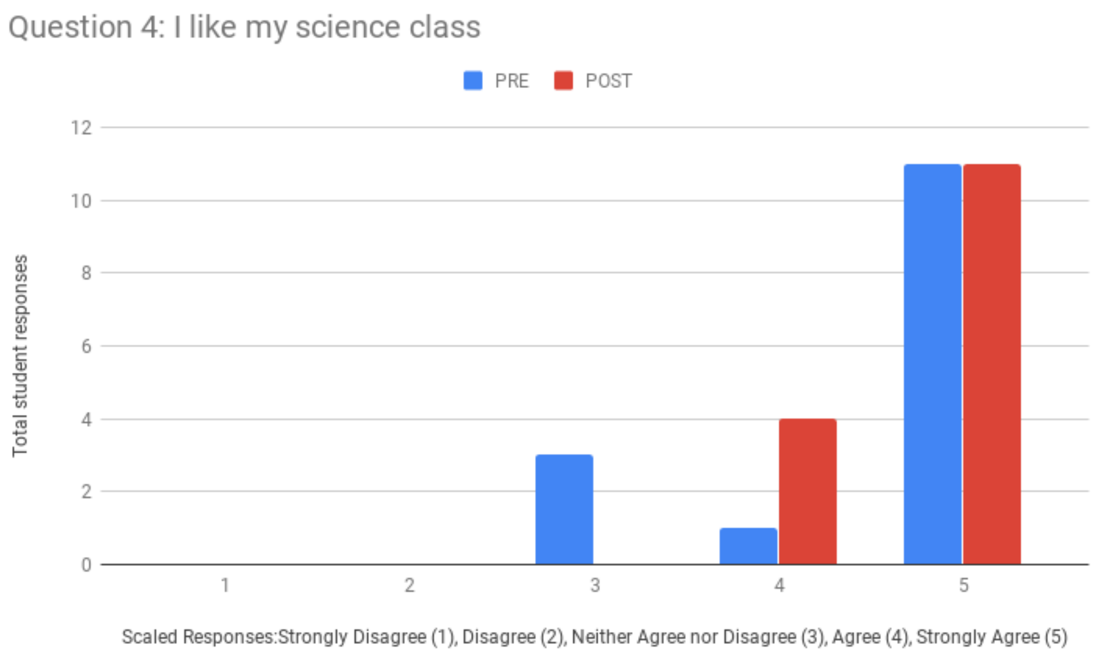

Figure 17. STEM-CIS responses to the question, "I like my science class".

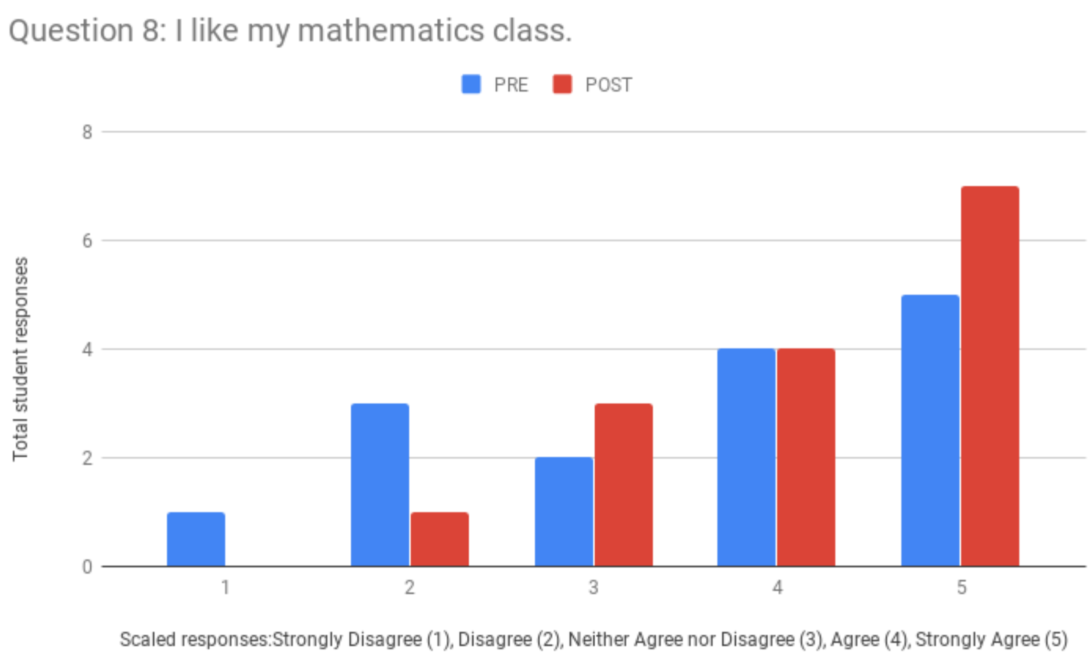

Figure 18. STEM-CIS responses to the question, "I like my mathematics class".

During student interviews, students were asked how they feel about STEM activities and what they like about STEM. Figure 19 shows student responses. The most frequent comments were that STEM activities are fun, they enjoy the hands-on activities, especially the engineering/building aspect of the activities. There was also a comment that STEM activities are challenging. The positive responses that STEM is fun would suggest that students do not mind thinking critically and taking on a challenge, it would seem that they enjoy it more than regular classroom work. Students were also asked in interviews if they like STEM activities more or less than other subjects. Every student indicated that they enjoy STEM more. Figure 20 shows specific student comments. Not only did they all like STEM more, but they specifically said it is better and worksheets and just sitting at their desks. Once again the comments that STEM is fun because it is hands-on indicates that students are more engaged. If students are more engaged and enjoying the activities, this may increase student learning.

Figure 19. Student Interview comments- What do you like about STEM activities?

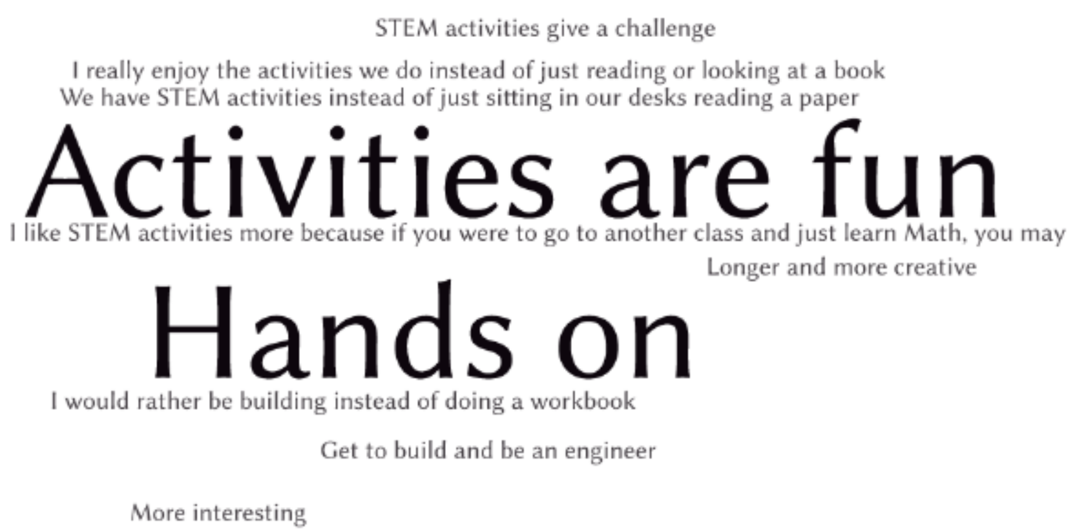

Figure 20. Student Interview comments – Do you like STEM more or less than other activities?

During student interviews, participants were asked if STEM activities have changed their thinking about STEM subjects. Figure 21 shows student responses to this question.

Several comments specifically indicated that they did not enjoy Math and now they do. It was interesting that out of the STEM subjects, math seemed to be the least favorite. This is also suggested by the STEM-CIS pre-survey in Figure 18.

When I noticed this theme in the pre-survey as well as the first round of interviews, I decided to make some changes in Math class. Since students were indicating how much they enjoyed hands-on activities, I decided to incorporate many hands-on activities into Math class. Some of these activities included finding area and perimeter of a Lego house floor plan and making origami 3-D shapes and finding the surface area of them.

In order to find out student perceptions of Math after the implementation of these activities, I asked students on the additional perceptions survey, if the hands-on Math activities increased interest in Math. Figure 22 shows that 73% said “Yes”, their interest in Math increased. Figure 23 shows specific student comments. Some comments include that Math was more fun. They enjoyed not doing a worksheet. There were even comments about the activities helping them learn better and feeling more confident in their Math skills. These comments would suggest that if students are more engaged with creative hands-on activities, it can increase not only their interest in the subject itself, but also improve how much they learn.

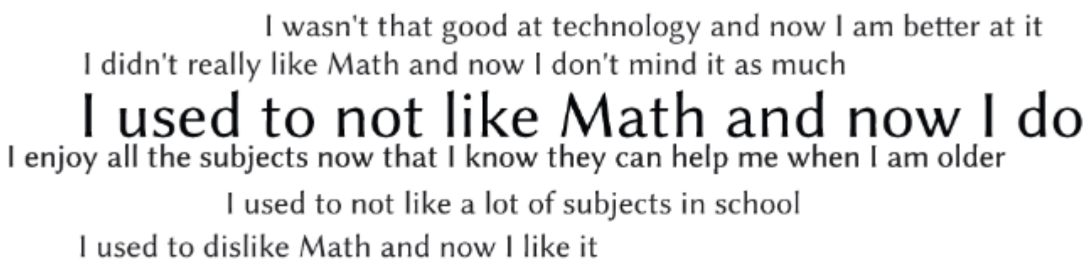

Figure 21. Student Interview comments- Have these STEM activities changed your thinking about STEM subjects?

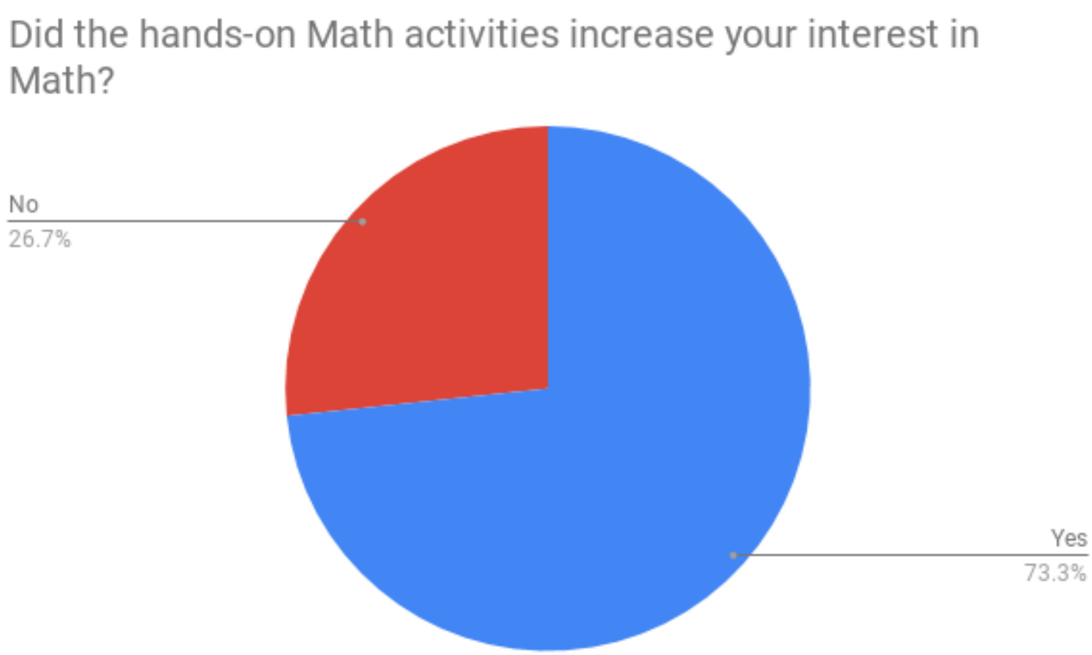

Figure 22. Student Perception Post-Survey

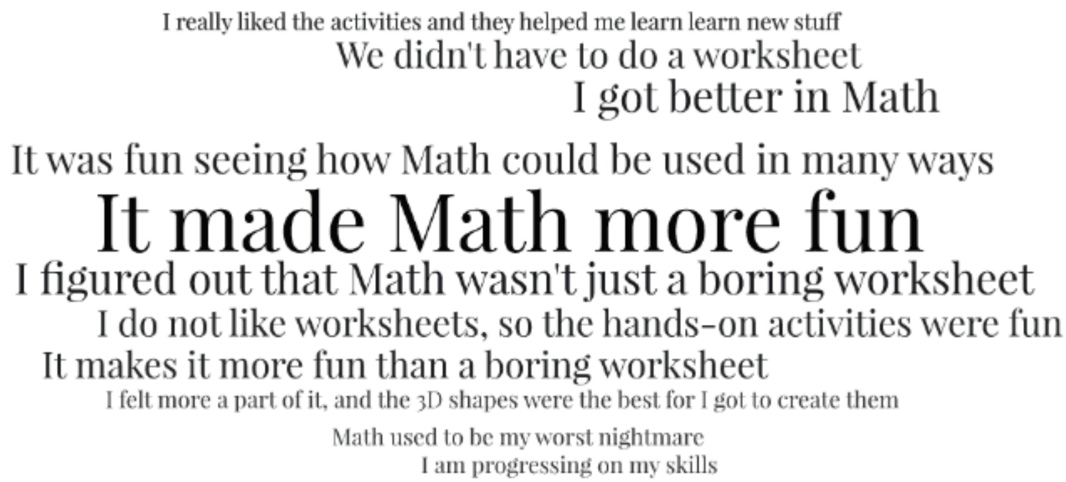

Figure 23. Student Perception Post-Survey comments

Summary

Data collected through student interviews, a pre and post STEM-CIS survey, student work samples, as well as a post student perception survey suggests that students need to have opportunities to learn about and explore STEM career options, because they do not even realize all the career options available to them. A lack of student choosing STEM careers may be due to a lack of exposure to careers rather than a lack of interest in them. When STEM activities are integrated into the classroom, students are more engaged and enjoy the hands-on activities. This enjoyment may lead to an increase in interest in pursuing a STEM career in the future as well as an increase in interest in STEM subjects in the classroom. There is potential to engage students and increase their interest within any subject that STEM activities can be incorporated into.

CHAPTER 5: DISCUSSION AND CONCLUSIONS

Overview

Hidi and Renninger (2006) developed a four-phase model of interest development. This model along with Kier, Blanchard, Osborne, and Albert (2013) STEM-CIS survey may provide a framework to contribute to developing student interest in STEM careers and subjects. Many studies (e.g., Honey, Pearson & Schweingruber, 2014; Maltese, Melki, & Wiebke, 2014;Wyss et al., 2012) suggest classroom methods for creating an engaging integrated STEM experience in order to pique students' interest and develop an interest in STEM activities. Through these engaging activities, students may increase their learning as well as progress through the four stage model of interest development perhaps leading to choosing a STEM career path in the future.

Discussion

The nature of the research questions is based upon students' interest and perceptions of STEM subjects and careers. Previous research articles indicated that there is a lack of research available to conclude that a specific STEM strategy or experience can influence students to pursue a career in STEM. Hidi and Renninger (2006) created a four-phase model of interest development. This model suggests that interest develops from being triggered in phase one to becoming a sustained interest in phase four. Findings of my study show students are entering phase one of the interest development model. Many of the careers that students explored, they did not previously know had existed. Student comments that indicate their possible interest in STEM careers shows that their interest was triggered. In order to progress through the second phase of this model, maintained situational interest, students would need to continue to explore STEM careers as they continue on into middle school. Findings in the additional perception survey indicate that 60% of students plan to continue to explore STEM careers. The study school also has the availability of a Science Olympiad program, if students choose to participate in this program, this would indicate moving into emerging individual interest. Tseng, Chang, Lou, and Chen (2013), suggest that PBL allows students to be creative which may contribute to an increased developed interest in a particular topic. The STEM activities incorporated into the classroom in my study all involved critical thinking and collaboration in order to creatively solve the engineering task. Hidi and Renninger (2006) also find that a person needs to be exposed to content before they can develop an interest in it. Part of the task of my study was to expose students to STEM career opportunities that are available and tie them to classroom content that students have already demonstrated an interest in. Student comments suggest that student participants did develop an interest in STEM careers and subjects. Student interview comments indicate that students enjoyed STEM activities because they were fun, hands-on, and challenging. Students indicated that they enjoy STEM activities more than other activities in the classroom and STEM incorporated into Math class increased their enjoyment of Math. All positive student comments toward STEM activities within the classroom suggest that students have developed an interest in STEM subjects and careers during this research period. By exposing students to these STEM activities and careers, I am giving students a pathway toward developing and sustaining an interest in STEM.

A valid tool for assessing student interest in STEM careers and content areas is the STEM-CIS developed by Kier, Blanchard, Osborne, and Albert (2013). This survey was used as a pre and post survey of all 15 participants in my study. Findings of my study show that there was a significant increase in interest for careers involving science, math, and engineering. Through exposure and development of interest in various STEM topics, students showed excitement for these activities in the classroom, often times asking multiple times when it would be time to work on their project and choosing to use free time to explore their project more. When analyzing the results comparison between the pre and post STEM-CIS, an increasing trend in interest is shown in my students. Since the STEM-CIS has been found to be a valid tool for assessing student interest in STEM careers and subjects, This increase shown in the data of the participants in my study, suggests that through the activities incorporated into the classroom in my study, students increased their interest in STEM careers and subjects.

A meta-analysis of 31 studies compared effective integration of math and science instruction. (Honey, Pearson & Schweingruber, 2014). The largest increase in learning came from total integration of the math and science (Honey, Pearson & Schweingruber, 2014). Participants in my study were given multiple opportunities to participate in STEM activities within both Math and Science courses. When the pre STEM-CIS survey indicated a low interest in Math, adjustments were made to the classroom activities to incorporate more hands-on math activities. Student responses were positive about how this increased their interest in Math and they also felt that it helped them become better at some Math skills. These findings suggest that when students are more engaged and interested in the activities that are taking place, their learning increases. Nugent (2015) found that self-concept and educators play a role in developing interest in career orientation. Therefore, if participants in my study gain confidence in their Math skills through engaging hands-on activities, they may be more likely to develop a sustained interest in activities or careers that involve mathematics.

My study along with other research studies suggest that methods of integrating STEM in the classroom, opportunities to engage in further activities when an interest in an area develops, as well as opportunities to learn about STEM careers from those fields may combine to move students from triggered situational interest to sustained individual interest in STEM careers and subjects.

Conclusions

The findings from my action research suggest that it is important to incorporate engaging STEM activities into all subject areas in order to increase student interest as well as learning skills. If students are given many opportunities to learn STEM content including exposure to STEM careers that are available within these topics of interest, students may progress through the four stage model of interest development and perhaps choose a STEM career in the future.

My research model may be able to be replicated in similar classroom setting, however transferability to non-similar settings is unknown. As the classroom teacher as well as the researcher in my study, I intend to continue to provide future students with opportunities to engage in STEM within all content areas in my classroom. I plan to adjust the career exploration activities to also include interactions with people in their chosen STEM careers, possibly facilitating these interactions through videoconferencing.

In rural areas, we do not have the resources or large numbers of people within the community with degrees in various STEM jobs, therefore using technology to bring awareness to my students will be a benefit and perhaps add an extra level of interest for them. I plan to share my findings with our school improvement committee as well as with the middle and high school science teachers. If it is possible for them to continue providing similar opportunities for the students in my study, perhaps they will progress through the fourth stage of the interest development model, thus possibly leading to them pursuing a STEM career they didn't even know existed before this study. I would also like to share my findings and demonstrate my integration of STEM activities to the other elementary teachers. If engagement in STEM activities begins in early elementary, perhaps in the future, I will be able to progress students beyond the first stage of interest development prior to them beginning middle school.

In conclusion, exposure to STEM from elementary throughout high school will provide students with more opportunities to explore possible career options in the future. With a shortage of high school students pursuing STEM majors after graduation, any additional opportunities and guidance we can provide as they choose career interests could only be a benefit to their future.

Limitations

Limitations of this study include, the time frame of this study, therefore, the long-term effects will be unknown unless further research is conducted. Since STEM activities were being incorporated into this classroom starting in August and the study period was from January to May, the impact within the study period may not have been as significant as it may have been if started in August. Due to time and supervision constraints, final student interviews were conducted with all 6 students in the classroom, this may have affected responses to be more similar.

Future Research

A longitudinal study would be beneficial that follows this same group of students through graduation to see if they continue to pursue STEM interest and if they choose to major or enter into a STEM career after high school. If this same study was repeated, more impactful data may be obtained if the study were started in August and then continued through May in order to get a larger range of data, as well as more time to incorporate more career explorations. It would be valuable to conduct this study within a different school setting to see if results are consistent. Since there is a strong emphasis in STEM education to increase the number of girls and minorities in STEM majors, conducting this study with more diverse participant groups would be valuable as well.

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APPENDIX A: Student Interview Questions

1.) What kind of job do you want to have when you grow up?

2.) What is your favorite part about school? Why?

3.) "STEM stands for Science Technology Engineering and Math" (Give them a visual poster)
How do feel about these STEM subjects?

4.) How do you feel about the activities we are doing in STEM classes?

5.) Do you like the STEM activities more or less than other activities we do? Why?

6.) Have these activities changed your thinking about STEM subjects?

7.) Do our class activities make you think about doing something similar for a future career?

APPENDIX B: STEM-CIS

Student Survey Questions (Based on the STEM-CIS)

Students will complete survey using iPad and a google form. Each question is a Likert scale with the following choices:
Strongly Disagree (1), Disagree (2), Neither Agree nor Disagree (3), Agree (4), Strongly Agree (5)

Science
S1 I am able to get a good grade in my science class.
S2 I am able to complete my science homework.
S3 I plan to use science in my future career.
S4 I work hard in my science classes.
S5 If I do well in science classes, it will help me in my future career.
S6 I am interested in careers that use science.
S7 I like my science class.
S8 I would like to talk to people who work in science careers.

Mathematics
M1 I am able to get a good grade in my math class.
M2 I am able to complete my math homework.
M3 I plan to use mathematics in my future career.
M4 I work hard in my mathematics classes.
M5 If I do well in mathematics classes, it will help me in my future career.
M6 I am interested in careers that use mathematics.
M7 I like my mathematics class.
M8 I would like to talk to people who work in mathematics careers.

Technology
T1 I am able to do well in activities that involve technology.
T2 I am able to learn new technologies.
T3 I plan to use technology in my future career.
T4 I like to learn about new technologies that will help me with school.
T5 If I learn a lot about technology, I will be able to do lots of different types of careers.
T6 I like to use technology for class work.
T7 I am interested in careers that use technology.
T8 I would like to talk to people who work in technology careers.

Engineering
E1 I am able to do well in activities that involve engineering.
E2 I am able to complete activities that involve engineering.
E3 I plan to use engineering in my future career.
E4 I work hard on activities at school that involve engineering.
E5 If I learn a lot about engineering, I will be able to do lots of different types of careers.
E6 I am interested in careers that involve engineering.
E7 I like activities that involve engineering.
E8 I would like to talk to people who work in engineering careers.

APPENDIX C: OPEN-ENDED STUDENT SURVEY

Student End of the Year survey questions

What is your favorite STEM activity and why was it your favorite?

Did the hands-on math activities increase your interest in math? Why or why not?

Did you learn about any careers this year that you didn't know existed before? Please List.

Do you think you will continue to explore STEM career options on your own? Why or why not?

Are there any activities that you wish we would have done this year? Why?