

THE EFFECTS OF INTRODUCING HIGH SCHOOL
STUDENTS TO STEM CAREERS

by

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ABSTRACT

In this investigation, five regular high school Earth science classes were introduced to science, technology, engineering and math (STEM) careers. The main goal of this study was to determine if learning about STEM careers would increase the number of students considering a career in a STEM field, and if that would change their engagement in the classroom and their choice of classes while still in high school. The treatment included four days of classroom instruction, web explorations, and discussions with STEM professionals. The results show that students were more interested in pursuing STEM careers, class participation improved, and students changed their courses for next year to include more STEM classes.

INTRODUCTION AND BACKGROUND

I currently teach Earth science and oceanography at Woodbridge Senior High School (WSHS), located in northern Virginia about 25 miles south of Washington, D.C. Approximately 2,800 students are enrolled at WSHS. According to the Prince William County Schools data profile for WSHS, 35.9% of students are Caucasian, 28.4% are Hispanic, 20.4% are African American, with the remaining students being Asian, Hawaiian, American Indian, or of mixed race (PWCS, 2012). The average household income for the area is \$93,277, and the top three employers are private industry, the federal government, and the state government. Private industry accounts for 54 % of workers and much of this supports the military facilities around Washington, D.C. The federal government accounts for 20% of the jobs in the area, and the state government employs 10% of the workforce (Informatics, 2013).

In 2008, WSHS implemented the Advanced Placement (AP) Scholars program. Our guidance counselors are encouraging more students to try AP classes, even though pre-requisites may be marginal. As Earth science and oceanography are not in the AP track, they tend to have the lower achieving students who are not as interested in studying science. During the past nine years of teaching oceanography, I have witnessed a decrease in student interest and engagement in the class. Oceanography is an upper level elective science course, and a majority of the 11th and 12th grade students who take it have not mastered the prerequisite skills needed to succeed in chemistry or physics and often do not express much interest in studying science. While the content of oceanography would seem to draw enthusiastic and motivated students, many of my

students do not come to school on a regular basis, rarely complete homework assignments and have trouble staying awake in class. When they are awake and mentally present, they ask very insightful questions. Unfortunately, lack of home support and sleep hinder students' abilities to remain attentive and engaged. I would apply a slightly different twist to the saying, "The lights are on but nobody's home." For my students, "The lights are out but I know they are in there somewhere!"

I have worked hard to provide meaningful, relevant experiences, knowing that the majority of my students have not been to the coast three hours away and have very little direct experience with the ocean. We have had many 'sit downs' to explain that learning science is not about becoming an oceanographer. It is about life skills and problem solving and they can practice these in an oceanography class as well as any other class. Throughout the course I highlight the various jobs people do in the field of oceanography, from the scientists who go down to the seafloor in a small three person submersible, to the ship's captain, to the animators that created *Finding Nemo*. I firmly believe that my low achieving students have great potential and perhaps one way to turn it on is to help them create a vision for themselves, to help them find their answer to the question "Why do I need to learn this?"

The recent emphasis on science, technology, engineering and math (STEM) careers highlights the need to expose students to potential career paths throughout their education. If kids can create a vision for themselves, then perhaps even low achieving, 'non-academic' students will take school more seriously and believe that it will prepare them for the future they envision.

I have always felt that a key piece missing from the science curriculum is career education. Very few students know what (or if) they want to study after high school because they know very little about what kinds of jobs are out there, especially with the blistering rate of change in the electronic age. As stated in the viral video “Did You Know?”, “We are preparing students for jobs that don’t yet exist using technologies that haven’t been invented in order to solve problems we don’t know are problems yet” (Fisch, McLeod, & Brenman, 2008).

For my research topic I chose to study the effects of introducing students to STEM careers. I was also interested to know if students consider this information valuable, would they change their course of study after learning about STEM careers, and would this new information change their engagement in the classroom.

CONCEPTUAL FRAMEWORK

Much has been written about the need for today’s students to pursue studies in STEM, and it is predicted there will be shortages in these careers in the near future. In 2012, President Obama’s Council of Advisors on Science and Technology published a report stating that one million additional STEM graduates will be needed in the next ten years (Charette, 2013). Education secretary Arnie Duncan stated that only 15% of the total 3.6 million student population declares a STEM major as a freshman in college, and only 6% graduate in that field after six years (Duncan, 2009). There are a number of programs that have been put in place to address this need. Race to the Top is a national initiative to highlight the importance of STEM education in the classroom. Educate to Innovate brings corporations and foundations together to fund after-school programs,

online math and science content, video games and student competitions. The National Science Teachers Association has an awareness campaign called Science Matters and is also participating in a national directory of STEM learning opportunities. President Obama also launched National Lab Day, a nationwide venture that will bring together educators, scientists, and engineers to improve and design laboratory and discovery-based experiences for students (Froschauer, 2010).

Taskinen (2003) suggests that schools play a critical role in maintaining students' interest in science which tends to decline after elementary school. Whether or not students pursue a career in science depends on their interest and their self-concept. Those who believe they are good at science are more likely to continue on a path toward a job in a science field. If students are interested in science and have a positive experience in school, they will be more motivated to learn about science. Motivated learners are more likely to enjoy learning. This will encourage students to seek out new information and opportunities to participate in science activities and get better at what they know. This in turn leads to more proficiency and higher performance in their area of interest. This interest/self-concept/motivation positive feedback loop can lead students to pursue a career in what they love. This research focused on two ways to foster interest and positive self-concept in science. First, students need to see that science is relevant to their everyday lives. Teachers can promote personal involvement in learning through instructional practices that develop different learning styles and student-centered classrooms. Second, students seem more interested in science when there are science-based extra-curricular activities available, whether or not they participate in them.

Additionally, it seems that science is more interesting to students when there is a supportive community surrounding them (Taskinen, 2013).

A more direct way that schools can promote careers in STEM is through career counseling and including career awareness in classroom instruction. Even though many students may like science in school, they may not see themselves as scientists. For most students the job description of scientist is vague and can mean many different things. Without accurate information about science careers students will rely on television and the internet, stereotypes and possibly their parents who may know little more about careers than their own (Taskinen, 2013). A common misconception is that scientists are mostly white males, work alone in a lab, are not creative and not people oriented (Masnick, Valenti, Cox, & Osman, 2010). Most students only know the details about the work their parents do, what they see on television, and the after school jobs they can get with little or no work experience. Students only strive for careers they are aware of (Herr, Cramer, & Niles, 2004). It is imperative that schools and science teachers take on the responsibility of changing the negative stereotypes and inform students about the nature and variety of careers in and related to the sciences and engineering (Yager, 2012).

Teachers serve as a very powerful force in delivering career information, yet related curriculum and professional development for teachers is non-existent. According to the National Science Education Standards (NSES) one of the goals of a science education is to “increase students’ economic productivity through the use of the knowledge, understanding, and skills of the scientifically literate person in their careers” (Yager, 2008, p.26). This would imply that one of the goals of teaching science is to

educate students about possible careers in or related to science yet the NSES does not address this need in the standards. Yager (2012) describes a large urban high school where counselors provided limited information, and students relied on peers and teachers for career advice. The students remarked that they really appreciated the “little life stories” the teachers told as they were so hungry for guidance about their life after high school.

Providing opportunity for all socio-economic levels is critical and teachers are also best positioned for this role. Students whose parents received college degrees were more likely to encourage their children to take STEM classes and enter STEM-related careers. However, students from low-income families who do not have that same encouragement and stimulation at home will most likely miss out on STEM-related opportunities if they are not part of a required curriculum at the high school and even earlier grade levels (Paredes, 2011).

METHODOLOGY

The purpose of this study was to examine the effects of introducing high school students to STEM careers. The treatment took place over four consecutive block classes in February 2015, with five earth science classes composed mostly of 10th grade students ($N=135$). During the first three blocks students watched an introductory/motivational video, explored STEM careers, and discussed which STEM careers they might be interested in. Methods used were class discussion, internet videos and websites, and the STEMJOBS magazine that is available through the school guidance department. On the fourth block of treatment, the students met with a small panel of STEM professionals

who shared their day-to-day job experiences, answered questions and talked with students about working as a professional in a STEM career. Data collection consisted of mixed-methods as described by Mills (2011), and the triangulation chart shows which data collection instruments were used to answer the proposed research questions (Table 1). All students received the research treatment. The research methodology for this project received an exemption by Montana State University's Institutional Review Board and compliance for working with human subjects was maintained (Appendix A).

Throughout the four block treatment period the students wrote in journals titled, *#DO WHAT YOU LOVE*. They used the journals to respond to teacher-directed prompts and enter information from websites. The journal entries were designed to help the students focus their attention and then reflect on what they had learned that day. While the journal entries were not used as data for the purposes of this study, they were used for a participation grade.

Research Treatment

On the first day of the STEM careers unit, the students watched a portion of Randy Pausch's famous last lecture at the Carnegie Mellon Institute in 2007 titled "Really Achieving Your Childhood Dreams" (Pausch, September 18, 2007). Students were asked to reflect on what a life's work meant to them by writing in their journal. They answered questions such as, "What were your favorite things to do as a child?" and "What would you do if you knew you could not fail?" This helped them begin to focus on what the future may hold for them and how they could begin to shape it during high school.

On the second day the students were shown a short PowerPoint presentation defining the term STEM, why it might be important to them and how they could benefit from a career in a STEM field. They also began investigating the first website, STEMJOBS.com, by taking the STEM type quiz (STEMJOBS, 2013). After they determined their STEM type, students completed two pages in their journals describing jobs they liked that were related to their STEM type. With a new foundation for thinking about their futures, students were given a homework assignment to interview their parents about how they found their jobs.

On the third day of treatment, students explored the STEMJOBS magazine and a second website, TheFuturesChannel.com. With two magazines to choose from, students read articles about a variety of new and traditional careers which included online game testing and design, cyber security, broadcast engineering, filmmaking, and automotive design. They completed The STEM Jobs Magazine Assignment by describing three jobs that sounded interesting to them, including the education and skills needed, along with the pay for these jobs (Appendix B). Students then explored The Futures Channel website (Featured Movies, 2014). They watched up to ten short videos (two to six minutes long) and completed The Futures Channel Video Worksheet (Appendix C). This follow sheet helped students track basic information about the people, their careers, what they loved about their job, and what skills they used. Five of the videos were pre-selected and were related to the topic they were studying at the time, so that students could better make the connection between school and the real world.

On the final day of treatment, two STEM professionals came to the classroom to talk with the students. One is a geologist with the U.S. Geological Survey in Reston Virginia and the other an engineering consultant for the U.S. Navy. Each guest was invited to talk about the education needed for their occupation, some interesting experiences they have had on the job, and advice they would give to students now who are thinking about their future careers. Students were invited to ask questions afterwards.

Data Collection Instruments

At the beginning of the treatment period students were asked to complete three pre-treatment activities. Each of these activities also had a corresponding post-treatment version. The first was the Draw a Scientist Test (DAST) (Appendix D). Students drew and colored a scientist at work and were asked to include what they wear, equipment they may use, what they are doing in the drawing and where they may be working. Students were also asked to list three words that come to mind when they think of a scientist and list three things a scientist does in a typical day. This provided a snapshot of their perceptions of people as scientists for later comparison. This activity was evaluated with the Draw a Scientist Rubric (Appendix E). At the end of the treatment period students were asked to complete this activity again. The results listed on the rubric were tallied to provide a quantitative comparison of how students' ideas about scientists changed as a result of this research treatment.

The second pre-treatment instrument was the STEM Career Interest Survey (SCIS), a Likert-style questionnaire (Appendix F). The SCIS was used to measure student opinion of five STEM attributes. Students were asked to respond to statements which

measured their personal interest in STEM, potential goals in STEM fields, expected outcome of their participation in STEM classes, their abilities in STEM subjects, and their potential support system with respect to STEM careers. The survey utilized a Likert scale where a score of 4 meant they *strongly agree*, a 3 meant *they agree*, a 2 meant they *disagree*, and a 1 meant they *strongly disagree* with the statement given. These surveys were administered through Google Forms. Students completed the same survey at the end of the treatment period. In order to analyze the data from the STEM Career Interest Survey, the *strongly agree* and *agree* responses were combined (Agree) and the *strongly disagree* and *disagree* responses were combined (Disagree). For each STEM question posed, the percentage of students that responded with Agree pre treatment was compared with the percentage of students that responded with Agree post treatment. The data was analyzed to look for changes in students' opinions with respect to STEM careers.

The third pre treatment instrument was the Future Me Map, a handout that had the students map out which math and science courses they would take for the next two to three years of high school based on the course offerings at this high school (Appendix G). This study was timed to coincide with students scheduling their classes for the next school year. Within two weeks of learning about STEM careers, students completed their official course selections for the following school year. Using the Post Treatment Future Me Map Questionnaire, students filled out the science, math, engineering and 'tech' classes they signed up for next year (Appendix H). Student predictions about their courses for next year were compared to the actual courses selected to determine if there was an increase in the number of students selecting STEM courses.

Additional post treatment instruments included the STEM Careers Questionnaire (Appendix I) and the STEM Careers Teacher Interview (Appendix J). The STEM Careers Questionnaire was a set of five questions designed to provide supporting information for all of the research questions posed. Using the Teacher STEM Interview, I personally conducted interviews with 15 randomly selected students (approximately 20% of the treatment group) in order to assess student's perceptions of STEM careers and whether or not they felt this lesson was helpful as they think about their futures. I quantified changes in student engagement by analyzing the completion rates for five consecutive homework assignments before and after the treatment period. Higher completion rates post treatment would indicate that students were more engaged in their classwork as a result of learning about STEM careers. I also compared the average of three consecutive quiz grades before and after treatment in order to discern any change in student performance. An increase in average quiz scores would indicate that learning about STEM improved performance in the classroom.

Table 1
Data Triangulation Matrix

Research Questions	Data Source 1	Data Source 2	Data Source 3
1. What are the effects of introducing students to STEM Careers?	Pre and Post Draw a Scientist Activity	STEM Careers Unit Questionnaire	Pre and Post STEM Career Interest Survey
2. Do students feel the STEM activities made them more interested in pursuing a STEM career?	Pre and Post STEM Career Interest Survey	Post treatment Teacher STEM Interview	STEM Careers Unit Questionnaire

3. Will introducing students to STEM careers impact their choice of Science/Tech courses in the next year of high school?	Pretreatment: Future Me Map Post treatment Future Me Map Questionnaire	Pre and Post STEM Career Interest Survey	STEM Careers Unit Questionnaire
4. Will introducing students to STEM Careers impact achievement in science class?	Pre and Post STEM Career Interest Survey	STEM Careers Unit Questionnaire	Four weeks pre and post treatment data; homework completion, daily quiz grades

DATA AND ANALYSIS

During this action research based classroom project, five regular Earth science classes participated in a four day lesson on STEM Careers. In order to determine students' attitudes and perceptions about science in particular and STEM in general, the research began with the pretreatment Draw a Scientist Test (Appendix D). The results showed that 75% of students depicted a scientist as a male, 87% showed no identifiable race other than white, 61% showed the scientist wearing a lab coat, and 58% drew the scientist working indoors in an office or lab setting ($N=134$). In addition, students were asked include other descriptors of appearance and equipment for their scientists. These items were compiled using the Draw a Scientist Rubric (Appendix E) and are presented in Figure 1.

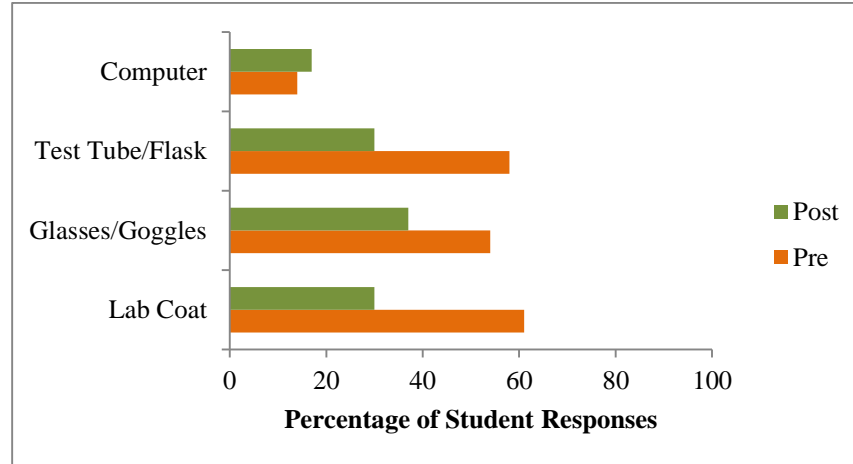


Figure 1. Student perceptions on Draw a Scientist test, ($N=134$).

When asked to list three words that came to mind about their scientist, the most frequently listed words were *smart*, *chemicals*, and *lab*. When students were asked to list three things a scientist does in a typical day, the most frequently listed responses were *experiments*, *studies*, and *research*. The students' drawings most often depicted a white male in a lab coat holding test tubes, and flasks showing vapors rising. They wore goggles or glasses and worked indoors with counters showing sinks and often microscopes. Aside from the stereotypical depiction, some pop culture references were visible. One scientist was depicted as a *Pokemon* who worked in a *Poke lab* and was holding a *Poke ball*. Another scientist had a suit for super powers. There was even an *evil scientist* dressed as a mummy, working on *evil germs* holding an *evil book*, with his *evil sidekick the evil scientist dog*. We completed the astronomy unit earlier in the year and had recently discussed the upcoming launch of astronaut Scott Kelly, who would spend a year living on the International Space Station. There was one sketch of an astronaut out of 134 drawings completed. It was also interesting to note that 14% of students included the use of computers as tool for scientists.

After the students had learned about STEM careers, they completed the post treatment DAST (Appendix B). In the post treatment drawings the percentage of male scientists decreased by 5%, while the female scientists increased by 2%, and non-gender specific scientists increased by 3%. It was difficult to identify the drawings with respect to race, so unless a student included an identifiable aspect or trait of another ethnic group, I assumed the scientist to be white, mostly based skin color and hair style. If the scientist was bald I did count them as male, but listed the ethnicity as “can’t tell”. While the number of African American scientists increased by 7%, the number of bald scientists increased by 27%. Perhaps students just didn’t know how to draw someone other than ‘white’, and drawing them bald was a way to draw a more generic person. In the category of *overall appearance*, the percentage of scientists depicted as eccentric, sinister, neutral or positive changed very little. The most common stereotypes of lab coat, goggles, test tubes and flasks decreased, and there was a slight increase in the percentage of scientists using computers (Figure 1).

Post treatment, the three words most frequently used to describe the scientists, were *smart*, *chemicals*, and *math*. The only change from the pre treatment list was the addition of the word *math* in place of the word *lab*. The three words or phrases most frequently used to describe what scientists do were *experiment*, *eat*, and *test things*. In the words describing what scientists do, *experiment* was still the most common word used, but now students said that scientists *eat* and *test things*. In addition, the variety of words used to describe their scientist increased in the post treatment DAST.

The post treatment drawings showed scientists doing a much greater variety of

jobs, including scuba diving, working with plants, taking pictures, and observing nature. Drawings showed an increase in the number of scientists working outdoors. The scientists depicted showed connections to the things we had been studying in class, including one scientist who was collecting lava. Ten scientists were depicted doing astronomy related jobs. As might be expected, students also drew their scientists doing the things we had learned about in the STEM lessons. There were many more drawings of people in the medical professions, a few architects, and even a wind turbine engineer.

After being exposed to many different kinds of STEM professionals in the research treatment, including two speakers who came to visit the classroom, there was a slight increase in female and African American scientists in the drawings. The majority of students still depicted their scientists as somewhat average white males. Other characteristics did seem to change more in response to the treatment. The scientist pictures had fewer test tubes and showed an increase in the variety of jobs performed. The words used to describe scientists increased in variety as well, and they seemed to see scientists as more human since one of the three most common words used to describe what they do in a day was *eat* (Figure 2a and Figure 2b).

(b)

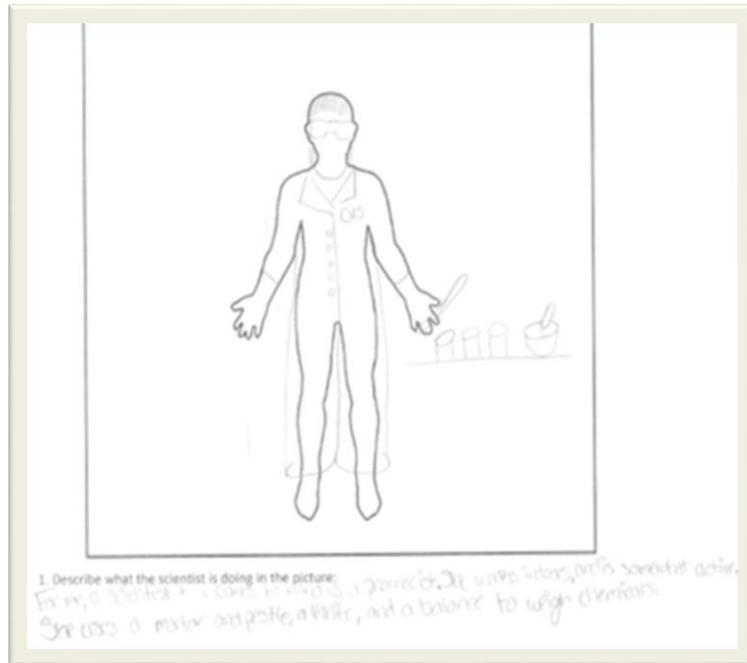


Figure 2. Example of one student's Draw a Scientist Test (DAST).
Figure 2a: pre treatment, Figure 2b: post treatment

The pre treatment STEM Career Interest Survey (SCIS) was used to measure student opinion of five STEM attributes (Appendix C). Results from the pre treatment SCIS showed that students' interest in science and technology was generally 20 percentage points higher than their interest in math and engineering. The *Agree* category showed 72% of students were interested in science, 52% were interested in math, 79% were interested in technology, and 58% were interested in engineering (Figure 2). The highest interest was in the category of technology.

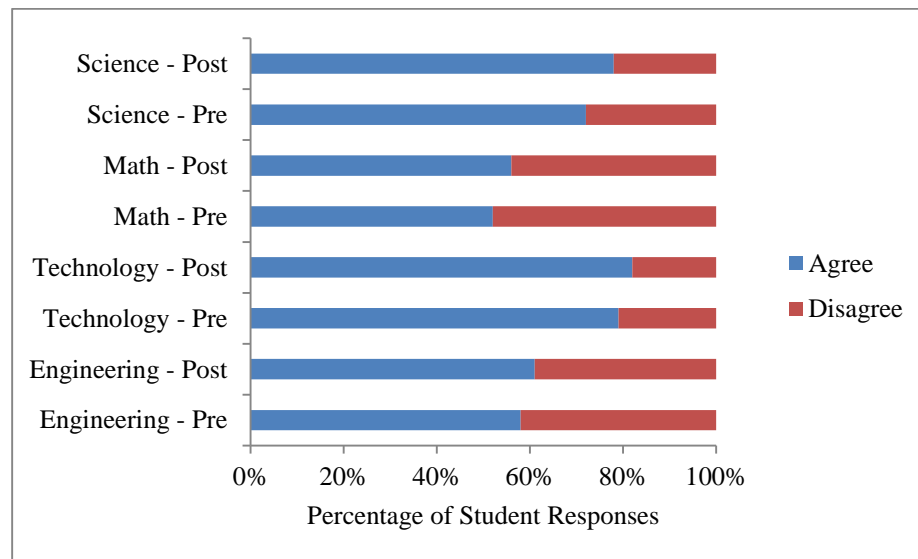


Figure 3. Student interest in STEM, ($N=120$).

The post treatment SCIS showed an increase in interest in all STEM fields (Appendix C). The *Agree* responses increased 6% for science, 4% for math, 3% for technology, and 3% for engineering (Figure 2). By allowing students to see professionals enjoying their work and having meaningful careers in these fields, they are more likely to see STEM as an opportunity for themselves.

In a pre treatment comparison of interest in a STEM field to interest in a career in that field, interest in a career was from 5% to 43% less than their interest in the field itself. This shows that although students were interested in STEM disciplines, they were not as interested in pursuing STEM careers. Science showed the greatest difference, where 72% of students *Agreed* with the statement “I am interested in science,” while only 39% *Agreed* with the statement, “I am interested in careers that use science.”

Post treatment, students’ interest in STEM related careers increased in science, technology, and engineering, while interest in a math career decreased by 2% (Figure 3). These data show that when students learned about careers available to them, they became more interested in those careers. In interviews with students, one student said, “It gives us insight into what jobs are actually out there, maybe encouraging someone to go to college.”

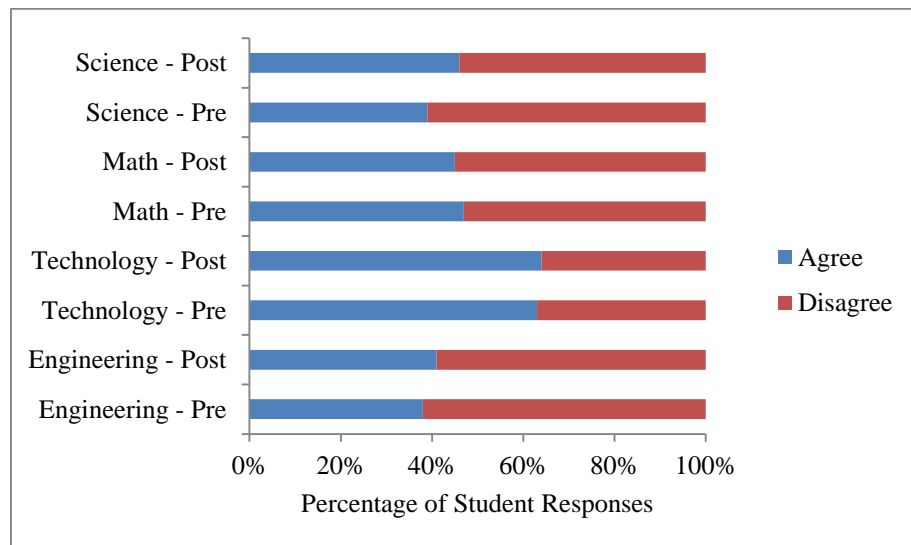


Figure 4. Student interest in STEM careers, (N=120).

Students’ perceptions of their abilities (self-efficacy) were highest in technology. In response to the statement “I think I am good at technology,” 75% said they agree or

strongly agree. For the subjects of math and science, students responded with 72% and 62% respectively, and only 40% thought they were good at engineering. After learning about the STEM fields and career opportunities, students' self-perception increased in three of the four fields, with math confidence decreasing by just 1% (Figure 4).

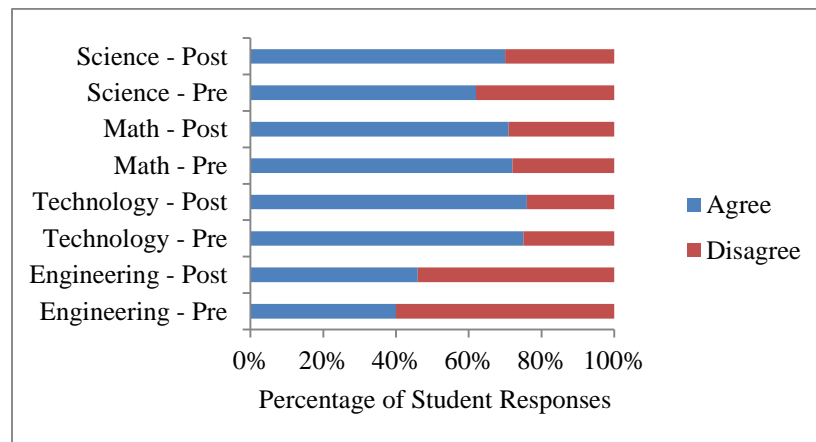


Figure 5. Student perception of ability in STEM, (N=120).

One question in the SCIS addressed students' goals with respect to STEM fields. When asked if students planned to use a STEM field in their future career, 30% planned to use science in their career, 54% planned to use math, 70% planned to use technology, and 37% planned to use engineering. Post treatment, the same question showed a 19% increase in the number of students planning a career in science, a 10% increase for a career in math, a 3% increase for a career using technology, and a 5% increase for those planning a career using engineering (Figure 5). This survey question shows that students' goal of using math in their careers increased after the treatment, while their interest in using math in their career decreased.

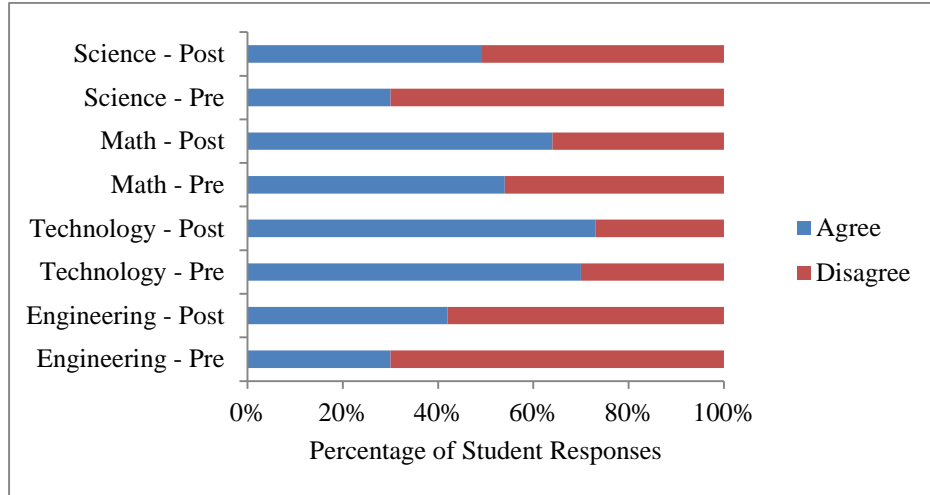


Figure 6. Students who plan to use STEM in their career, ($N=120$).

A related survey question asked students whether doing well in a STEM class would help them in their future career. The pre and post SCIS data showed that after completing the lessons on STEM careers, there was an overall increase from 61% to 66% of students who thought that that doing well in school would help them in their careers. These data show that when students understand how what they learn in school will help them in their future careers, they may try harder in their classes.

In order to measure if students would actually revise their choice of classes after learning about STEM careers, they completed the Future Me Map before learning about STEM careers (Appendix D). This provided a snapshot of the classes they wanted to take next year in high school. Using the Post Treatment Future Me Map Course Questionnaire (Appendix E), students filled out the science, math, engineering, and technology courses they signed up for in the next school year. The questionnaire also asked if they changed their mind about taking a certain course based on what they had learned about STEM

careers. While a number of students had already forgotten what they signed up for, 12%, or 16 students, did say they changed their choice of science course from oceanography to chemistry ($N=134$). At our high school, chemistry is considered a more rigorous course and students must have at least a C average in math in order to register for it.

I also wanted to measure any change in academic performance after learning about STEM career possibilities. The completion rates for five homework assignments given immediately before and after the STEM treatment show that four out of five classes increased their homework completion rate. This increase ranged from 1% to 14%, with one class showing a 3% decrease in homework completion (Figure 6). While the increases in completion rates were not dramatic, it is plausible that when students are more aware of how their performance in school can benefit them in the future, they will try harder to complete assignments.

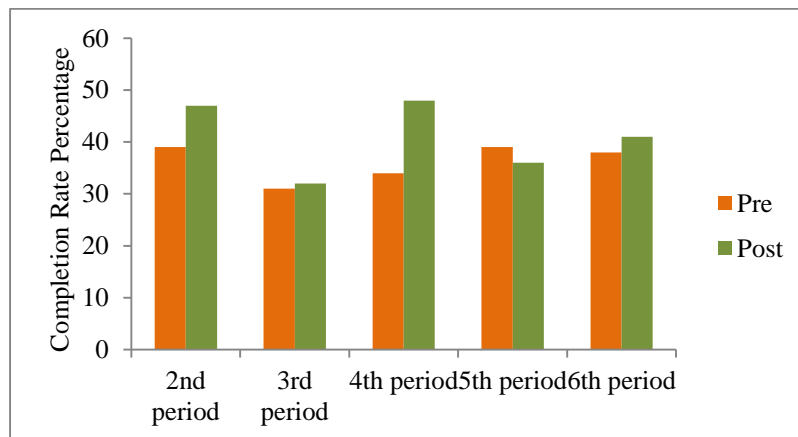


Figure 7. Pre and post treatment average homework completion rate, ($N=134$).

Average quiz grades before and after the STEM treatment were also compared. One class out of five showed a slight increase in average quiz scores while the other four classes showed a decrease in average quiz scores (Figure 7). The timing of the post

treatment quizzes was unfortunate. Our school system experienced five snow days in the two weeks after the treatment period. It is possible that the loss of time in school contributed to the lower quiz scores.

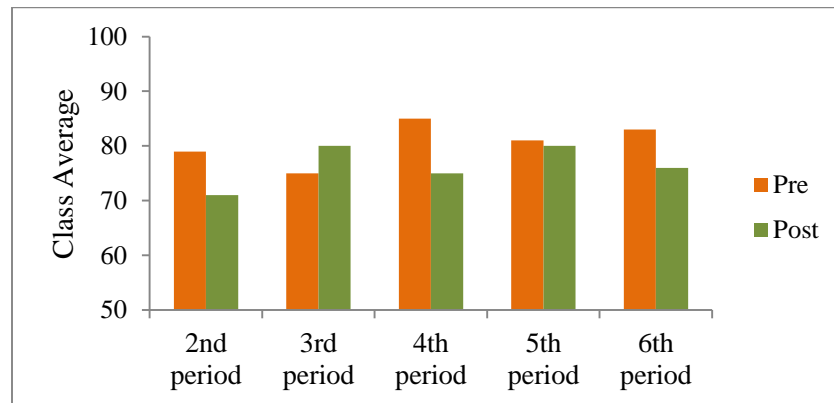


Figure 8. Pre and post treatment average of three quizzes, ($N=134$).

The results from the STEM Careers Unit Questionnaire (Appendix F) and the STEM Career Teacher Interview (Appendix G) showed an overwhelming appreciation for having learned about STEM careers. Upon completing the STEM Careers Unit Questionnaire, 86% of students reported that using class time to learn about STEM was worthwhile. One student said, “I honestly liked every bit of it, I thought it was interesting taking that quiz and finding out careers that we might be interested in.” Another said, “I liked finding new job opportunities that I like and didn’t think of.” One student who did not think the STEM unit was worthwhile responded, “no, because it didn’t have any careers I fit into and plus I fall into the arts categories which they don’t have.” When asked if they were more interested in pursuing a STEM career, 55% responded yes, 6% said no, and 36% reported no change in interest. One student said, “I saw that there are cool jobs out there that pay pretty well.” Another student said, “I liked this unit because it

showed me careers I didn't know.”

When asked if they would change the courses they are taking, 52% said yes, they would take more science, technology, engineering or math courses if available. In the post treatment interview one student said, “. . .we learned about jobs that will most likely be created in the future due to dramatic increase in the use of technology.”

When asked whether they would work harder now in their STEM related classes, 66% of students said yes, they would work harder in these classes. When asked about whether teachers should take on a larger role in teaching students about STEM careers, one student summed up her feelings this way, “I think so, yes. So far it's been about college, not careers. I think there should be more. It helps to think about what you might like to do in college.”

INTERPRETATION AND CONCLUSION

The results of this study show that introducing high school students to STEM careers changed their perception of the usefulness of STEM fields, increased their interest in STEM fields, and helped them see the connection between what they are studying now in school and how this may help them in their future career. While students were more interested in the STEM disciplines, they were not as interested in pursuing STEM careers. The results of the Draw A Scientist Test (Appendix B) showed the most common perception of a scientist was a chemist with test tubes, a lab coat and goggles. Students might like science, but don't see themselves as a scientist because of their lack of awareness about what scientists look like or what they do in a typical day. After learning about STEM, their pictures of scientists became much more varied and included people

doing the kinds of things we had been learning about in our Earth science class and things they saw professionals doing in the STEM lessons. Students became more interested in the STEM fields because they could better relate to the people in STEM careers after they learned about them.

Students also reported an increase in their abilities in the STEM fields (Appendix C). It is possible that after learning about the value of STEM in the workplace they came to value their own abilities a little bit more. These data are supported by prior research that showed students who are interested in a subject and feel good about their abilities are much more likely to continue their studies and eventually pursue a career in that field (Taskinen, 2013).

The highest interest for any STEM field was technology. This is surprising in that our school system offers very few classes directly related to the use of technology. It is not surprising in that students are using technology for many of their other daily activities. Cell phones and computers are used for social contact, enjoying music, gaming, shopping, etc. Technology is readily available in their lives, but not nearly as available in their choice of classes. If their classes don't include technology, students don't see the classes as relevant to their lives and their futures.

Perhaps the greatest success in teaching students about STEM careers was that students learned about the great variety of careers available, many of which they could see themselves doing. For example, using the STEM JOBS magazine (STEMJOBS, 2014), students found all types of careers that use math, but learned that they don't have to become a mathematician or an accountant. This provided the realization for students

that maybe the math class they are in now is important and relevant. The post treatment SCIS showed that students were willing to work harder and that they believed doing well in their STEM classes would help them in their future careers.

VALUE

The experience of planning and conducting this research project has changed my approach to teaching and my relationship with my students. I have been teaching lower level 11th and 12th grade students for the past eight years. I see them go through the motions of school without actually investing in their futures. They come to class just enough, they care about their grade just enough to pass, they don't ask questions in class, and don't complete any work outside of class. I felt I had done a good job of showing them that learning and doing science could be fun. I wanted to show them that having this scientific knowledge was important to decisions they might make in their future, and that taking care of the environment was critical for future generations. While I realize that these are my values and hoped that my students would adopt them, I realized that I could impact my students' lives in a more tangible way.

Teaching students about the many types of STEM jobs available to them increases their awareness of possible careers and as a result, they will be more likely to pursue one of these careers if they know it exists. By discovering that STEM disciplines are used in thousands of careers previously unknown to them, they have realized that what they do in high school is an investment in their future, even though they don't know what that future may hold. Teaching STEM creates awareness, interest, and the added potential for students to pursue a productive and rewarding career.

I also realized that as my students were going through the motions of learning, over time, I began going through the motions of teaching. Due to the pressure of having to cover large amounts of standards based content, I began covering material just to cover it, and my teaching became less student-oriented and less inquiry-based. My students didn't really care, so why should I? When I watched them get excited about taking the online STEM TYPE quiz, or I heard them say, "I want to be a drummer and that uses math," I started to remember how much opportunity I have to influence them and truly shape their lives by what and how I teach. Implementing this research has re-ignited my passion for teaching, and reminded me that what and how I teach has the power to shape someone's future.

Finally, I would like to approach the administration at my school about developing a school wide STEM event. I don't know what this would be yet, but we are implementing a 'flex' class next year that can be used for class meetings, pep rallies and other large or small group events. This would be a perfect opportunity to establish a school sponsored program that teaches students about STEM opportunities and careers.

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APPENDICES

APPENDIX A
IRB EXEMPTION

INSTITUTIONAL REVIEW BOARD

For the Protection of Human Subjects

FWA 00000165



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MEMORANDUM

TO: Martha Lindemann and John Graves

FROM: Mark Quinn ;1?/

OJ

DATE: January 27, 2015

RE: "What are the Effects of Introducing Students to STEM Careers in Earth Science Class at the 9-12 Grade Levels?" [NL012715-EX]

The above research, described in your submission of January 27, 2015, is exempt from the requirement of review by the Institutional Review Board in accordance with the Code of Federal regulations, Part 46, section 101. The specific paragraph which applies to your research is:

- (b) (1) Research conducted in established or commonly accepted educational settings, involving normal educational practices such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.
- (b) (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability, or be damaging to the subjects' financial standing, employability, or reputation.
- (b) (3) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (b)(2) of this section, if: (i) the human subjects are elected or appointed public officials or candidates for public office; or (ii) federal statute(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.
- (b) (4) Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available, or if the information is recorded by the investigator in such a manner that the subjects cannot be identified, directly or through identifiers linked to the subjects.
- (b) (5) Research and demonstration projects, which are conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine: (i) public benefit or service programs; (ii) procedures for obtaining benefits or services under those programs; (iii) possible changes in or alternatives to those programs or procedures; or (iv) possible changes in methods or levels of payment for benefits or services under those programs.
- (b) (6) Taste and food quality evaluation and consumer acceptance studies, (i) if wholesome foods without additives are consumed, or (ii) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the FDA, or approved by the EPA, or the Food Safety and Inspection Service of the USDA

Although review by the Institutional Review Board is not required for the above research, the Committee will be glad to review it. If you wish a review and committee approval, please submit 3 copies of the usual application form and it will be processed by expedited review.

APPENDIX B

STEM JOBS MAGAZINE ASSIGNMENT

STEM Jobs Magazine Assignment _____ **Name** _____ **pd** _____

- Choose topics from the TEM JOBS magazines available in the classroom. The "index" is shown below.
- Read the articles and find information about the type of person will like it?, positions, salaries, schools, and companies that hire for these jobs.
- Late Fall 2014 [Blue Space Cover](#)
- [Hackers](#)
- [Cybersecurity/Hackathons](#)
- [Interstellar](#)
- [Filmmaking/Cinematic science](#)
- [Gaming-Paid to Play](#)
- [Gamer Profile](#)
- Early Fall 2014 [Red SPN Cover](#)
- [Virtual Technology and Car Design](#)
- [Automotive Keep in \(virtually\) Real](#)
- [Broadcasting](#)
- [Cool places to work / SPN](#)
- [Robotics](#)
- [Cool Industries // Robotics, Drones](#)

	Choice	Choice	Choice
Will like it?	?	?	?
STEM JOBS	?	?	?
Type	?	?	?
What will do?			
Median salary	?	?	?
Schools (list two)	?	?	?
Who's hiring? (list two)	?	?	?

#Trivia Challenge: What are the top video games for 2015?

APPENDIX C

FUTURES CHANNEL VIDEO WORKSHEET



Name _____

Period _____

Your FUTURES' assignment is to watch 5-10 short videos and report back on what these professionals do and what skills they need to do what they love!

Click on the link: <http://thefutureschannel.com/> Login: Earthscience Password: 2015

Watch the five listed below and then choose five of your own based on your personal interests:

Art & Music: The Rhythm Track

Who:

What:

Why:

Skills needed:

Design: Creating Cars

Who:

What:

Why:

Skills needed:

Environmental: The Wind Business

Who:

What:

Why:

Skills needed:

Earth Science: Predicting the Weather

Who:

What:

Why:

Skills needed:

Sports: Designing Stronger Skateboards

Who:

What:

Why:

Skills needed:

YOUR CHOICE!! Choose one video from each of the following categories:

Space Science:
Who:
What:
Why:
Skills needed:

Business and Commerce:
Who:
What:
Why:
Skills needed:

Architecture:
Who:
What:
Why:
Skills needed:

Your Choice:
Who:
What:
Why:
Skills needed:

Your Choice:
Who:
What:
Why:
Skills needed:

Now go back and rate your TOP FIVE jobs or job categories. Use #1 for your favorite job!
(Write your ranking in the left hand margin)

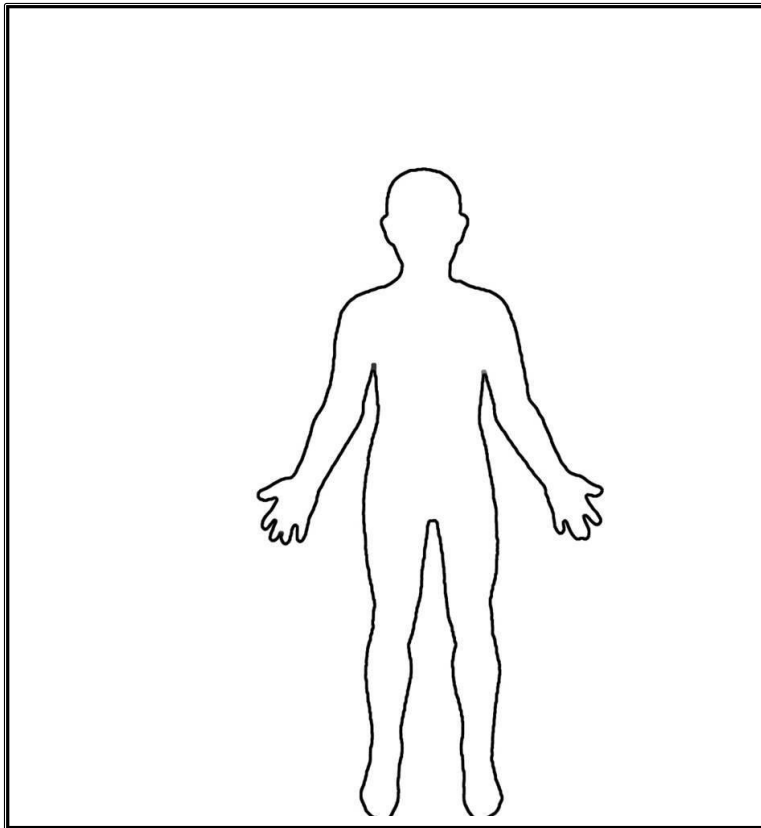
APPENDIX D
DRAW A SCIENTIST TEST
PRE/POST

Draw a Scientist

Participation in this research is voluntary and participation or non-participation will not affect a student's grades or class standing in any way.

Scientists are people who try to solve problems and understand the world we live in. Imagine the person that comes to mind when you think of a scientist. Draw a picture of that person below. Include the following:

- Where do they do their work? (Indoor, outdoor, active, desk job, etc.)
- What kind of equipment do they use? (Include at least 2 things)
- What are they wearing?



1. Describe what the scientist is doing in the picture:

2. List three words that come to mind when you think of this scientist?

--	--	--

3. What kinds of things do you think this scientist does on a typical day, List at least three things.

--	--	--

APPENDIX E

DRAW A SCIENTIST TEST RUBRIC

PRE/POST

Draw-a-Scientist Test (DAST) Modified Rating Rubric
--

Total number of drawings received: _____

How many drawings included the following...	Tally Marks	Total # of Tall	% of Drawings with this
Personal Characteristics			
Laboratory coat			
Eyeglasses			
Facial hair			
Pencils/pens in pocket			
Unkempt appearance			
Symbols/Tools of Research			
Test tubes/Flasks			
Microscope			
Bunsen burner			
Experimental animals			
Other:			
List "other" symbols of research.			
Symbols of Knowledge			
Books			
Filing cabinets			
Other			
List of other symbols			
Signs of Technology (as product of science, tool, or symbol of knowledge)			
Solutions in glassware			
Machines			
Other			
Please list "other" symbols of technology			

HOW MANY DRAWINGS DEPICTED WOMEN AND MEN?			
Drawings of men			
Drawings of women			
Drawings in which you can't tell if scientist is a man or woman			
DESCRIBE THE RACIAL/ETHNIC GROUP OF THE SCIENTISTS.			
Drawings of scientists who appear to be Caucasian/White			
Drawings of scientists who appear to be African- American, Hispanic or Native American			
Drawings of scientists who appear to be Asian or Asian- American			
Drawings in which racial/ethnic group of scientists is not evident			

WOULD YOU CHARACTERIZE THE OVERALL APPEARANCE OF THE SCIENTIST AS...

Eccentric – Wild hair; clashing, unfashionable clothing; unkempt appearance; bloodshot eyes; bad complexion; antisocial (nerdy) characters

Sinister - Violent explosions; evil facial expressions; animals crying or yelping for help; Frankenstein's monster type characters; captions with violent language

Neutral – Not necessarily positive or negative.

Positive – Depicts the scientist in a non-traditional setting or using unusual or outdoor lab equipment.

Overall appearance	Tally Marks	Total # of Tally	% of Drawings with this appearanc e*
Eccentric			
Sinister			
Neutral			
Positive			

Note: A drawing may have more than one of these characteristics.

ⁱ Adapted from Mason, C.L., Kahle, J.B., & Gardner, A.L. (1991). "Draw-A-Scientist Test: Future Implications." *School Science and Mathematics*, 91(5), 193-198.

<http://www.ecu.edu/ncspacegrant/docs/restepdocs/dastratingrubric.pdf>

APPENDIX F
STEM CAREER INTEREST SURVEY
PRE/POST

Pre and Post STEM Career Interest Survey

Participation in this research is voluntary and participation or non-participation will not affect student's grades or class standing in any way.

S1) I think science is interesting.

Science (geosciences, biology, chemistry, physics, atmospheric science, astronomy, medicine, environmental studies, agriculture, etc.)

- Strongly Agree
- Agree
- Disagree
- Strongly Disagree

S2) I think I am good at science.

- Strongly Agree
- Agree
- Disagree
- Strongly Disagree

S3) I work hard in my science classes.

- Strongly Agree
- Agree
- Disagree
- Strongly Disagree

S4) I like my science class(es).

- Strongly Agree
- Agree
- Disagree
- Strongly Disagree

S5) If I do well in science classes, it will help me in my future career.

- Strongly Agree
- Agree
- Disagree
- Strongly Disagree

S6) I plan to use science in my future career.

- Strongly Agree
- Agree
- Disagree
- Strongly Disagree

S7) I am interested in careers that use science.

- Strongly Agree
- Agree
- Disagree
- Strongly Disagree

S8) I have a role model/someone in my family who uses science their career.

- Strongly Agree
- Agree
- Disagree
- Strongly Disagree

M1) I think math is interesting

Mathematics (financial jobs, data analysis, statistics, accounting, assessing risk, mathematical modeling, computational math, etc.)

- Strongly Agree
- Agree
- Disagree
- Strongly Disagree

M2) I think I am good at math.

- Strongly Agree
- Agree
- Disagree
- Strongly Disagree

M3) I work hard in my math classes.

- Strongly Agree
- Agree
- Disagree

Strongly Disagree

M4) I like my math class(es).

- Strongly Agree
 Agree
 Disagree
 Strongly Disagree

M5) If I do well in math classes, it will help me in my future career.

- Strongly Agree
 Agree
 Disagree
 Strongly Disagree

M6) I plan to use math in my future career.

- Strongly Agree
 Agree
 Disagree
 Strongly Disagree

M7) I am interested in careers that use math.

- Strongly Agree
 Agree
 Disagree
 Strongly Disagree

M8) I have a role model/someone in my family who uses math their career.

- Strongly Agree
 Agree
 Disagree
 Strongly Disagree

T1) I think technology is interesting.

Technology (computer programming, software design, systems analysis, managing databases, etc.)

- Strongly Agree

- Agree
- Disagree
- Strongly Disagree

T2) I think I am good at using technology.

- Strongly Agree
- Agree
- Disagree
- Strongly Disagree

T3) I work hard in my technology classes.

- Strongly Agree
- Agree
- Disagree
- Strongly Disagree
- Currently not in a technology class

T4) I like my technology class(es).

- Strongly Agree
- Agree
- Disagree
- Strongly Disagree
- Currently not in a technology class

T5) If I do well in technology classes, it will help me in my future career.

- Strongly Agree
- Agree
- Disagree
- Strongly Disagree

T6) I plan to use technology in my future career.

- Strongly Agree
- Agree
- Disagree
- Strongly Disagree

T7) I am interested in careers that use technology.

- Strongly Agree
- Agree
- Disagree
- Strongly Disagree

T8) I have a role model/someone in my family who uses technology their career.

- Strongly Agree
- Agree
- Disagree
- Strongly Disagree

E1) I think engineering is interesting.

Engineering (Aerospace, Agricultural , Biomedical, Chemical, Civil, Electrical, Electronics, Environmental, Health and Safety, Industrial, Marine, Materials, Mechanical, Mining and Geological, Nuclear, Petroleum, and just about everything else, etc.)

- Strongly Agree
- Agree
- Disagree
- Strongly Disagree

E2) I think I am good at engineering.

- Strongly Agree
- Agree
- Disagree
- Strongly Disagree

E3) I work hard in my engineering classes.

- Strongly Agree
- Agree
- Disagree
- Strongly Disagree
- Currently not enrolled in an engineering class

E4) I like my engineering classes

- Strongly Agree
- Agree
- Disagree
- Strongly Disagree
- Currently not enrolled in an engineering class

E5) If I do well in engineering classes, it will help me in my future career.

- Strongly Agree
- Agree
- Disagree
- Strongly Disagree

E6) I plan to use engineering in my future career.

- Strongly Agree
- Agree
- Disagree
- Strongly Disagree

E7) I am interested in careers that use engineering.

- Strongly Agree
- Agree
- Disagree
- Strongly Disagree

E8) I have a role model/someone in my family who uses engineering their career.

- Strongly Agree
- Agree
- Disagree
- Strongly Disagree

APPENDIX G
FUTURE ME MAP
PRE TREATMENT

Future Me Map:

Participation in this research is voluntary and participation or non-participation will not affect a student's grades or class standing in any way.

What do you think you will be doing in the next four years concerning classes, college, and work?

Year	Science Classes	Technology/Engineering Classes	Math Classes
Sophomore Junior Senior	Biology, AP Bio Chemistry, AP Chem Physics AP Environmental Science Oceanography	(To be filled in when I know what they are, meeting with guidance 11/10-11/14)	Algebra 1 Geometry Statistics, probability (The rest to be filled in when I know what they are, meeting with guidance 11/10-11/14))
Sophomore Year (if you are a sophomore this year, your science class is Earth Science)			
Junior Year			
Senior Year			

Work and College Plans:

(Grade)	Work None/Part time/Full time Do you have a part time job this year? Do you expect to get one this summer? Do you expect to work full time after high school? Write a statement on what you may do each year wrt paid employment.	College Plans Community/4 year	Undecided/don't know
(Sophomore year) 2014-15		Full time High school	
(Junior year) 2015-16		Full time High school	
(Senior Year) 2016-17		Full time High school	
() 2017-18			
() 2018-19			

APPENDIX H
FUTURE ME MAP QUESTIONNAIRE
POST TREATMENT

Name _____ pd _____

Future Me Map Follow up

Participation in this research is voluntary and participation or non-participation will not affect a student's grades or class standing in any way.

Future Me Map Follow up-Courses I signed up for next Year:

Science _____

Technology: _____

Math _____

Engineering: _____

Based on the STEM information, did you change your mind about what to take next year? If so, what did you change?

APPENDIX I

POST STEM CAREERS UNIT QUESTIONNAIRE

Post STEM Careers Unit Questionnaire

Participation in this research is voluntary and participation or non-participation will not affect a student's grades or class standing in any way.

* Required

1. Do you think the STEM careers unit was worth using class time to complete? *

- Yes
- No

If you said yes, what did you like? _____

If you said no, what did you not like? _____

2. Has the STEM unit made you more or less interested in pursuing a STEM career? *

- More interested
- Less interested
- No change in STEM career interest

3. Will you consider changing (or adding) a science, math, engineering or technology course in your next (two) years of high school as a result of learning about STEM career possibilities? * You may choose more than one response

- No, I already planned to take as much math and science as I can
- Yes, I would like to take more STEM related courses in high school
- Yes, I would take engineering and technology courses if they were available
- No, I would not like to take more STEM related classes

4. Does learning about STEM career possibilities make you want to work harder in your STEM related classes? * (this would be math and science for most students)

- Yes
- No

5. Is there anything else you would like to share with me or a question you would like to ask about STEM careers?

APPENDIX J

STEM CAREERS TEACHER INTERVIEW

