

MOTIVATING ADOLESCENT FEMALES INTO SCIENCE, TECHNOLOGY,  
ENGINEERING AND MATHEMATICS (STEM)

by

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## ABSTRACT

During the treatment time period, the junior high life science class of seventh and eighth grade students were introduced to science, technology, engineering, and mathematics (STEM) with the goal to motivate the female students into related areas of study. During the treatment, students participated in presentations, labs, activities, and cooperative group assignments that dealt with STEM courses and careers. These included presenters with STEM careers coming into the classroom or meeting online to talk to the students about their STEM careers, engineering labs which the students participated in to heighten their awareness of everyday objects we use that are related to STEM, and the students working together in the classroom on STEM activities to reinforce the many aspects of STEM in our lives. All of this was done with the intense purpose to increase the female students' knowledge of STEM in order to motivate them to want to take more STEM related courses in school and to further their education into STEM related careers.

## INTRODUCTION AND BACKGROUND

Sandhills Public Schools is a consolidated school district located in central Nebraska. It spans 904 square miles, includes 4 towns, and touches 6 different counties. The school district was organized in 1973. The high school is located in Dunning and contains 60 students in grades 5-12; the elementary is located ten miles away in Halsey and has 34 students in grades K-4. The school district consists of 44% free and reduced meals, a graduation rate of 100%, and a drop-out rate of 0% ([reportcard.education.ne.gov](http://reportcard.education.ne.gov)).

Dunning has a population of 109 and there are only 4 businesses including Norm's Auto, Sheet's Haying, Sandhills Pottery, and Rush Construction. Sandhills High School does not have any ethnic diversity, as it is comprised of 100% Caucasian rural students and families. The culture of ranching serves the district well with excellent students and very supportive parents, families, and community members. The main challenge Sandhills Public Schools faces is a declining rural population, which is a wide spread rural economic development issue shared by many rural areas in Nebraska (D. Hafer, personal communication, April 19, 2015).

The school offers several extracurricular activities and clubs for the students to take part in. These include volleyball, basketball, football, track, wrestling, one acts, speech, quiz bowl, Future Farmers of America, Future Business Leaders of America, band, and choir. The majority of the junior and senior high students are involved in several extracurricular activities. Due to the low student body number, many students are involved in as many as three or four activities simultaneously which means practices held

before school and after school, one to two games per week, and performances throughout the school year. Between school, extracurricular activities, ranch chores, and family time, students do not have very much personal time for themselves. Therefore, I felt that any special activities associated with this capstone would have to be conducted during school hours from the first of October to the end of November 2016.

Due to the lack of job opportunities in Dunning and the surrounding area, it is imperative that female students are exposed to a variety of science, technology, engineering and mathematics (STEM) related opportunities, classes, and career choices. These students have stated that they will not be able to stay in this area to find employment nor will they even want to come back to this area following college graduation. They do not believe there is a future for them in this area in regards to a career related to the STEM field.

The goal of this capstone project was to find out how the female students view STEM and what motivating initiatives the school provides for these students, as well as what plans the school may be able to develop in the future to help motivate these students into the area of STEM classes and careers. The following purpose statement guided this study, how are the science, technology, engineering, and mathematics (STEM) initiatives available to adolescent girls at the Sandhills School District successfully motivating girls' interests in STEM topics and careers?

The sub-questions of the study included the following:

- What types of initiatives exist to motivate adolescent females into STEM?

- How well do the STEM classes currently being offered match with the types of careers that interest our female students?
- How have experiences within the school's classrooms impacted the thoughts and feelings of our female students regarding STEM?

### CONCEPTUAL FRAMEWORK

There is not one definition for science, technology, engineering, and mathematics (STEM); however, it is useful for a school, district, and/or state using a STEM approach to instruction to have a clear definition.

Sanders & Wells (2006) stated “integrated STEM education refers to technological/engineering design-based learning approaches that intentionally integrate the concepts and practices of science and/or mathematics education with the concepts and practices of technology and/or engineering education. Integrated STEM education may be enhanced through further integration with other school subjects, such as language arts, social studies, art, etc.” (p. 2).

As STEM becomes more important in our increasingly interconnected global society, it is imperative that educators find ways to encourage girls to participate in these fields (Kuchment, 2013). The absence of women from STEM education and careers affects more than the women; it is a missed opportunity for those fields. Women bring a different perspective that shapes and influences STEM disciplines (Milgram, 2011).

In previous decades, researchers have identified a gender gap in the careers and academic achievements of men and women in STEM. Recently, it has been suggested that some of these gender gaps no longer exist; however, the picture is subtle since women are represented well in some STEM fields such as biology and not in others such as computer science (Heilbronner, 2013). Expansive amounts of money and time have been provided in the hopes that STEM-based programs will boost student interest and

abilities related to STEM. Financiers include national government and industrial organizations (Mahoney, 2010). Federal funding supporting STEM has resulted in more secondary schools, recruitment and retention of students pursuing and earning degrees in STEM, K-12 teacher professional development in STEM, high school and undergrad research programs, and STEM workforce training (VanMeter-Adams, et al., 2014).

Students state that several factors have influenced their interests in STEM. These include their parents, extracurricular encounters, influence of a relative or family member, high school teachers, interest in the field, and experiences from their childhood (VanMeter-Adams et al., 2014). There are also limiting factors involved with girls not choosing STEM based courses. These include sociocultural and contextual factors, the expectancy value theory, the expected level of success, and the stereotypes of the chosen subjects and occupations. The expectancy value theory was designed to help explain the differences between genders in mathematics expectancies and values, and how these influenced the different choices being made between males and females.

Broadley (2015) stated that “the methods to increase the factors of motivating girls into STEM include start STEM specific career development early, collaborate with people of influence, flood the school with a diversity of STEM images, use role models and mentors to develop in-school programs, promote targeted work experience and out-of-school programs, engage with parents and families, target specific groups: girls experiencing disadvantages and high performing girls, and press for change in male dominated work places” (p. 33-36).

One of the students’ strongest factors that has influenced their interests in STEM is their parents. Parental involvement is the dedication of resources by the parent to the child within a given domain. Behavioral, cognitive-intellectual, and personal are the methods by which parents may be involved in their children’s lives (Grolnick, et al.,

1997). Parents are an untapped source for increasing the motivation for STEM related choices with adolescent children. Parents provide their children with different experiences and with different messages regarding their talents and their choices of both education and vocation. Parents also make different attributions for the successes and failures of their daughters versus those of their sons. These messages work to undermine the level of confidence of the girls in their abilities with math and math related courses. These beliefs also work to the differences exhibited in their career choices (Eccles, 2009).

Parents also hold beliefs and engage in the behaviors that may shape their children's values and academic motivation. Though parents may be instrumental in promoting their children's motivation to prepare for a career in STEM, the parents may not have the knowledge to support the children in this endeavor (Harackiewicz, 2012). The demographic factors that may predict the low quality of parental involvement in motivating their children into STEM include a lower income, less education, and a single parent household (Grolnick, et al., 1997).

High School teachers are another strong influencing factor of female students' attitudes towards STEM. Teachers hold a high influential value and are able to recruit a diverse group of girls who previously did not think they were smart enough to do science or work with technology. They are also instrumental in getting the girls interested in the field of STEM. For most of these girls, their science teachers are their only STEM role models, and their teachers may come from backgrounds very similar to their own so they feel comfortable and safe with their teachers (Mostache et al., 2013).

Students are being introduced to science through textbooks that are uninspiring and lectures from teachers who must stick to a curriculum dictated by standardized testing. Storytelling has been found to be an important learning strategy in science and has been growing over the last few years as scientists work to communicate with the general public and stimulate more critical thinking about important issues. With the use of storytelling in science, girls would most likely become more interested and their achievement levels would sky rocket (Kuchment, 2013).

In order to encourage girls to choose career paths in math and science related fields, teachers need to help students understand that academic abilities are expandable and improvable. They also need to provide prescriptive informative feedback and expose the girls to female role models who have succeeded in math and science. Teachers need to create a classroom environment that sparks initial curiosity and fosters long-term interest in math and science, and provide spatial skills training (Halpern, et al., 2007). The goal of most educators is not only to teach so that students learn the material, but also to motivate students so they care about what they are learning. If students are motivated during instruction, then they may enjoy the learning experience, value their educational endeavor, and perhaps even seek out similar educational experiences in the future (Durik & Harackiewicz, 2007). According to Mitchell (1993), educators can empower individuals by involving them in the learning process and the meaningful utilization of material. The material becomes relevant to the learner by acquiring new information actively rather than passively receiving it. Active versus passive aids in perceiving the material as meaningful in their lives. To promote interest in STEM,

teachers should manipulate features of the general context, examine features of the tasks themselves, and capitalize on tendencies that trigger interests in the girls (Durik & Harackiewicz, 2007). Teachers need to adapt the process to catch and hold the girls' attention and interests. Catch is the first of two processes involved in the development of situational interest and is related to stimulation and focused attention. Hold means to empower individuals by bringing meaning and importance to the material (Hidi & Baird, 1986).

While parents and teachers impact a female's decision to pursue a STEM career, another one of the main reasons that more females go into jobs not related to STEM is that women tend to want to acquire jobs in which they help people. Gender roles related to job acquisition usually require women to support their husbands and raise their children, whereas men support their families and confirm their existence with their careers (Ceci, 2009). Gender differences impact student career aspirations and subject selection. Students decide about a STEM career before the age of 14. Fewer girls than boys pursue STEM courses and careers. There are actually fewer brain differences between males and females than what may be thought (Broadley, 2015). Boys may outscore girls on standardized tests, but girls get better grades in math and science (Mostache et al., 2013).

To help encourage more girls to pursue STEM careers from an early age, there are innumerable choices of organizations and workshops available to help motivate girls into the area of STEM. The goals of these hands-on programs include identifying the factors that initially attract students to STEM fields, and retaining student interest in them.

Research has documented the role of afterschool programs in fostering improved attitudes and enthusiasm among girls and other underserved groups. These include greater confidence in their science ability, improved performance in scientific subjects, persistence in the field of science, increased knowledge of and interest in STEM careers, changes in the courses they decide to take, improved problem-solving skills, and changes in their perceptions of who can do science (Clewell & Darke, 2000).

Hands-on programs have provided a space for the girls to learn to think and work like scientists, to develop personal and professional skills relevant to a career in science, and to reinforce the desire of students to obtain a STEM degree. Participating students have enhanced their critical thinking and scientific analysis skills. They also have improved their levels of understanding the material learned in the classroom and their ability to read scientific literature. These students have improved proficiency at identifying and understanding scientific research, and advanced creativity for solving problems inside and outside the classroom (VanMeter-Adams et al., 2014).

Out-of-school time programs that focus on girls' involvement in STEM can play an essential role in improving female representation in traditionally male-dominant fields. These STEM programs include structured afterschool modules, recreational activities, intensive summer trips, and mentoring. The positive results from these OST programs include an increased confidence in the girls' math skills, improved attitudes toward and engagement in math, and an increase in plans to attend or enroll in college (Chun & Harris, 2011).

In conclusion, the factors for motivating adolescent girls into STEM include supporting parents, teachers, and family members, effective STEM programs, personal interest, and positive STEM role models. There are innumerable possibilities for girls to pursue STEM courses and obtain careers in STEM related fields. With the nation lacking in number of qualified STEM career graduates, female adolescents are an obvious choice that could grow the number of graduates in STEM fields. Establishing links between how girls view STEM, learning situations, and eliminating the barriers when confronted with STEM activities may provide the connection needed that will encourage young women in the STEM fields (Notter, 2010).

#### METHODOLOGY

This classroom research project based on the action research model of motivating females into science, technology, engineering, and mathematics (STEM) took place for eight weeks. The non-treatment group involved in this study included the 11 boys in grades 7 and 8 and the treatment group was the 9 females in those two grades ( $N=9$ ). The study focused mainly on the topics of STEM, courses and careers in STEM, and STEM futures. I invited speakers with STEM careers to come to the school, we also met online in a virtual presentation with engineering students from the University of Nebraska – Lincoln. College representatives also spoke to the students in regards to STEM classes and related careers, and I did several presentations and activities in the classroom which focused on STEM opportunities within our school such as STEM classes and STEM career choices. The research methodology for this project received an exemption by

Montana State University Institutional Review Board and compliance for working with human subjects was maintained (Appendix A).

During the time of the study, Pre-and Post-Treatment STEM Information Surveys were assigned to all students with questions that focused on STEM (Appendix B). For each statement, students chose either *strongly disagree*, *disagree*, *agree*, or *strongly agree*. A histogram was used to illustrate the compared results of the Pre-and Post-treatment STEM Information Surveys. This information was also used to ascertain the changes made in the students' thoughts about STEM within the school and as a potential career.

All students were required to maintain a STEM notebook in which they organized information, kept ongoing journal entries of the presentations, and summarized the STEM activities performed in the classroom (Appendix C). The journals were assessed for a completion grade using a rubric that included the summary worth 5 points, writing a sentence of what they learned from the presentation for 2 points, drawing a picture of the presentation worth 2 points, and coloring the picture worth 1 point for a cumulative possible score for each entry of 10 points. These journals were evaluated for students' perceptions of the presenters and the information they shared. All students also worked in groups of four, with mixed gender, to prepare a virtual poster of one of the presenters. Each group presented their virtual poster both orally and visually. These presentations were graded based on a rubric of 50 points possible. The groups were instructed to include information related to the presenters' jobs, explain how STEM was incorporated into those jobs, graphs and pictures used to illustrate what they learned from the

presenters about their jobs as they related to STEM, the information from the surveys they conducted, and the overall oral presentation as a group (Appendix D). Fifteen percent of all students later stated this was their favorite part of the treatment on STEM.

Three weeks after the treatment began, all students were assigned a minute paper to answer a question regarding the support they felt they would receive if they obtained a career in STEM (Appendix E). They also answered two misconception probes (Appendix F). Near the end of the treatment, all students took part in several engineering labs to increase their interests in the engineering portion of STEM. These labs allowed for the students to take common every-day items to use in the labs such as ballpoint pens, clips and clamps, household towels, and toothbrushes (Appendix G). Following the completion of the treatment, all students were asked a muddiest point question based on any unanswered questions they still had about STEM careers (Appendix H). The minute paper, misconception probes, and muddiest point were assigned through Schoology, an online learning management system, and the students' answers were returned for a completion grade and analysis of their thoughts and feelings towards STEM related courses and careers. All of this information was used to evaluate the students' thought processes on STEM related school initiatives, school activities, and STEM courses and career choices. Since this information was in written form, the students spent more time formalizing their ideas and feelings toward STEM.

Towards the end of the treatment, the female students were interviewed (Appendix I). Nine of the 20 students in this class were females, and all of them were chosen for the teacher interviews. The data from all of these assignments were evaluated

for common themes to ascertain the female students' views on the STEM presentations and activities with the possibility to motivate more females into the choices of STEM courses and careers.

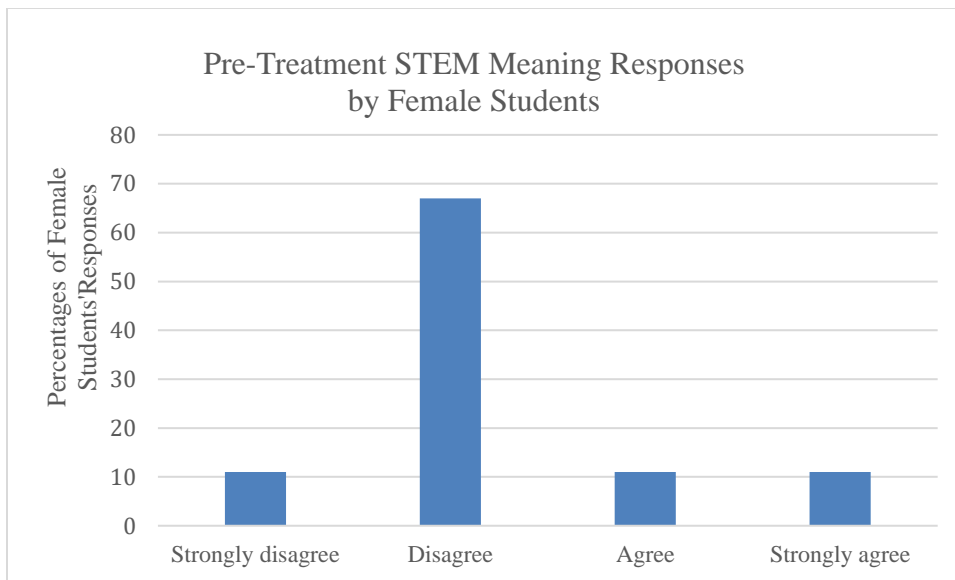
After the treatment was complete and the Post-Treatment Survey finished, the students were given a Recall, Summarize, Question, Connect and Comment (RSQC2) writing assignment (Appendix J). The students went online to Schoology to answer the sections of the RSQC2 and returned the assignment via Schoology for a completion grade. The information that the students provided from the RSQC2 was analyzed to determine if more information was needed regarding STEM. It was apparent that the students' ideas of possible STEM courses and careers were beginning to change as they answered the RSQC2. A summary of the data collection strategies is found in Table 1.

Table 1  
*Data Triangulation Matrix*

Focus Question	Data Source 1	Data Source 2	Data Source 3
<i>Primary Question:</i> How are the science, technology, engineering, and mathematics (STEM) initiatives available to adolescent girls at Sandhills School District motivating girls' interests in STEM topics and careers?	Pre-Treatment Survey	Minute Paper Presentations Engineering Labs	Post-Treatment Survey Teacher Interviews RSQC2
<i>Sub-Questions</i> 2. What types of initiatives exist to motivate adolescent females into STEM?	Pre-Treatment Survey	Presentations Minute Paper Students' Notebooks Engineering Labs	Post-Treatment Survey Teacher Interviews RSQC2
3. How well do the STEM classes currently being offered match with the types of careers that interest our female students?	Pre-Treatment Survey	Presentations Students' Notebooks Misconception Probe Engineering Labs	Post-Treatment Survey Teacher Interviews Muddiest Point
4. How have experiences within the school's classrooms impacted the thoughts and feelings of our female students regarding STEM?	Pre-Treatment Survey	Students' Notebooks Engineering Labs	Post-Treatment Survey Teacher Interviews Muddiest Point RSQC2

## DATA AND ANALYSIS

On the first day of presenting the students with the treatment information for the capstone, the students rated their knowledge and attitudes of science, technology, engineering, and mathematics (STEM) by answering a Pre-Treatment STEM Information Survey, ( $N=20$ ). When the female students answered the survey question regarding knowing what STEM stood for, 11% said they *strongly disagreed*, 67% *disagreed*, 11% *agreed*, and 11% *strongly agreed* (Figure 1). Based on this information, it was decided that the first course of action would be to introduce the students to STEM and explain the subjects that were represented by the letters.



*Figure 1.* Pre-treatment percentages of female students' responses to knowing the meaning of STEM, ( $N=9$ ).

Based on their answers to the survey questions, the female students revealed they did not want jobs in STEM and were not interested in being scientists. This information from these students confirmed the ideas that would be needed to broaden what they thought about STEM and related courses and careers. The students did not need to focus

just on the science part of STEM, but to include all of the different parts of STEM and how each had a significant impact on almost every career. The pre-treatment survey questions that dealt with STEM interests revealed 33% of the female students liked understanding how things work, almost 90% liked doing hands-on science projects, only 22% liked understanding how things are built, 90% liked building or putting things together, over half (55%) liked understanding how the natural world works and felt they were more driven than other kids their age, but only 33% liked doing math problems. This information also helped to plan the presenters that would come into the classroom or meet with the students online in order to enlighten the female students on different careers associated with STEM (Figure 2, Figure 3).

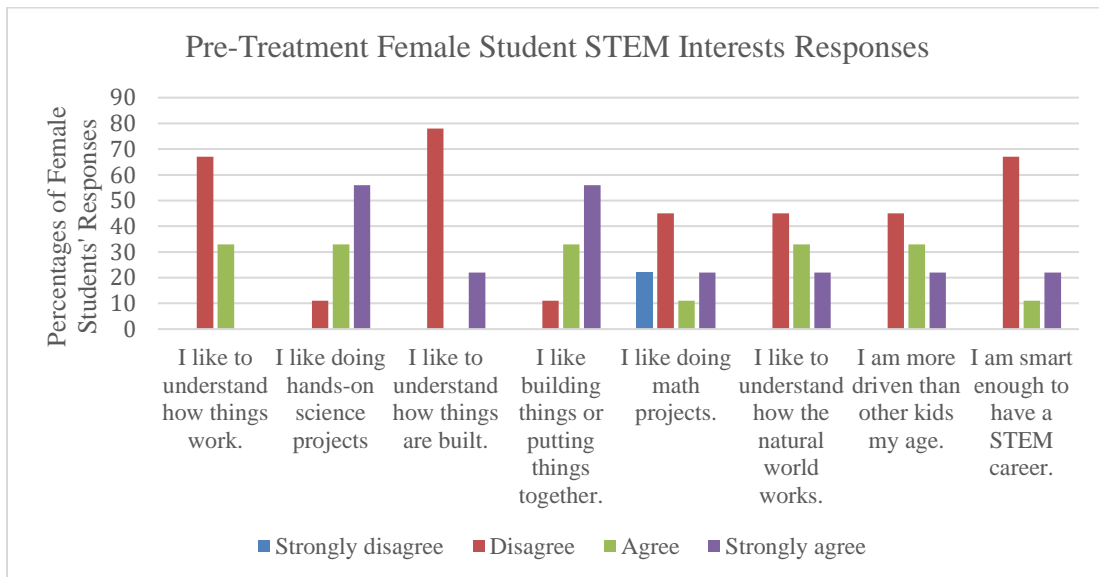
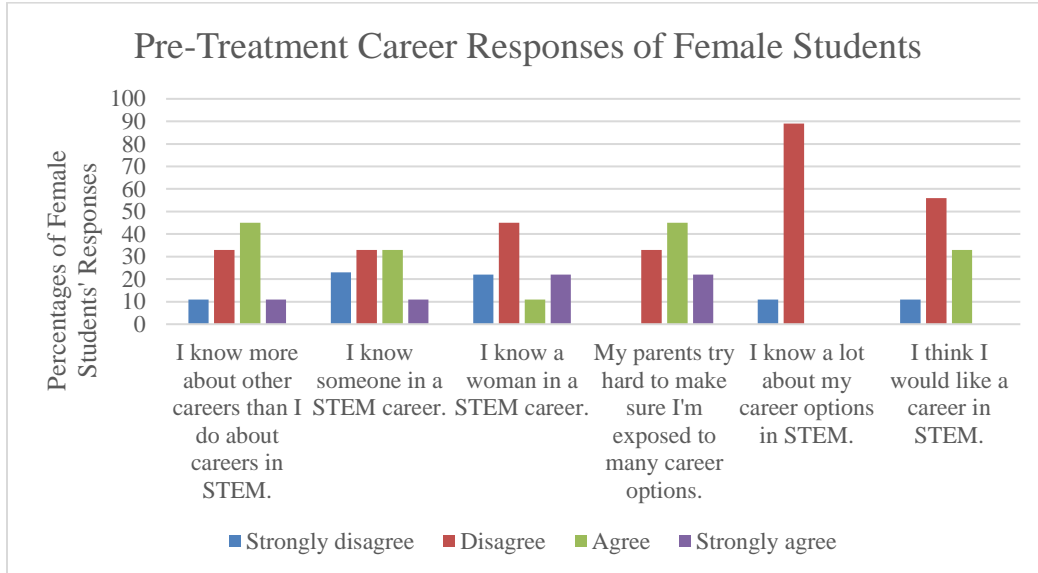


Figure 2. Female students’ responses to selected pre-treatment STEM survey questions, (N=9).



*Figure 3.* Female students' responses to selected pre-treatment survey questions, ( $N=9$ ).

The presenters who came to the classroom represented the areas of STEM which included oil and mining, veterinary medicine, wildlife biology, animal husbandry, meteorology, engineering, piloting, and genetics. The presenter from the field of oil and mining was born in the next county over and stressed to the students that he never thought he would be able to travel outside of his birth county much less have the privilege of traveling to other countries. He recently retired from his job as a safety manager who taught safety measures around the world. The students stated they related well to him due to the fact that he was a local person who had a STEM job that allowed him to travel all over the world.

The students also related well to the animal husbandry presenter, and the veterinary medicine presenter as she was the mother of one of their classmates. Several female students stated they wanted to study the field of veterinary medicine and animal husbandry which was the reason to invite these two presenters to the classroom. They

explained how each portion of STEM played a role in their jobs every day. Both of these presenters were also local born which helped the students understand how they could also take STEM courses and obtain STEM related careers and live locally. These presentations helped the students to better understand STEM and it also helped the students plan future STEM careers. Each student was responsible for a notebook in which they entered information about the presenter and the presentation, drew and colored a picture that related to the presentation, and stated one thing they learned from the presentation (Figure 4). The notebooks were graded using a rubric. Following the completion of the presentations, the students were divided into teams and worked together on a virtual poster of their favorite presenter (Figure 5, Figure 6). These posters were graded with the use of a rubric on several items which had to be included on the posters such as information about the presenter, incorporating STEM into their jobs, what the students learned from the presentation, a display of the collected survey information, and the oral presentation.

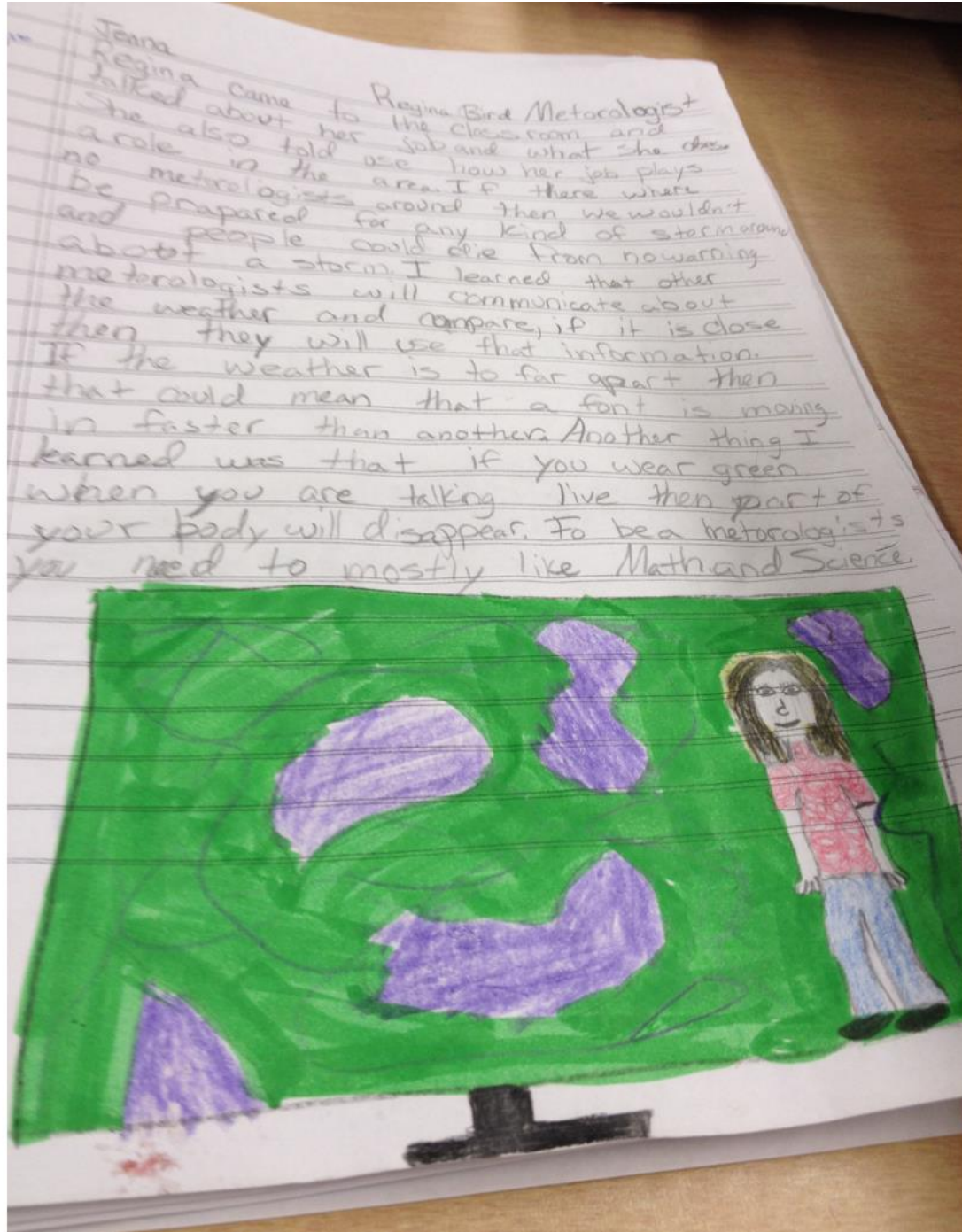


Figure 4. Female student notebook sample, ( $N=20$ ).

## JAY JONES SAFETY MANAGER

**Did you like Jay's Presentation?**

Yes	No
15	2

We learned that we can do whatever we want to do, as long as you set your mind to it and believe it will happen.

- He told us that you can do anything you set your mind too.
- He was a safety manager for oil business to make sure everything and everyone stayed safe.
- He went to tons of different countries, about 25.

**Places class would want to go**

Dubai	Niger	Caribbean Islands	Australia
1	0	8	9

We believe that his job is incorporated with Stem. The science part because he dealt with oil. The technology part because he had to type information down. Engineering part because he had to think about everyone's safety when he made plans. The Mathematics part because he had to use equations to execute all the plans safely

Madison  
Reed  
Reece  
Michael

Figure 5. Virtual poster of STEM safety manager presenter.

## REGINA BIRD

IS A METEOROLOGIST THAT WORKS FOR NTV

**WHY HER JOB IS IMPORTANT**  
She informs us what the weather will be like so that we can plan accordingly. Nobody wants to work calves when its snowing.

How Many People in Our Class want to be meteorologists

**WHAT WE LEARNED**  
That there are many different types of radars and forecasts.  
That it takes a lot of math to predict the weather  
It's hard to predict weather when it is more than 7-10 days away  
Meteorologists can't wear green otherwise they blend in with the map behind them

Regina Presentation

**Science**-They have to predict the weather using scientific methods

**Technology**-The weather radar and computer equipment

**Engineering**-They have to work the green screen and computers.

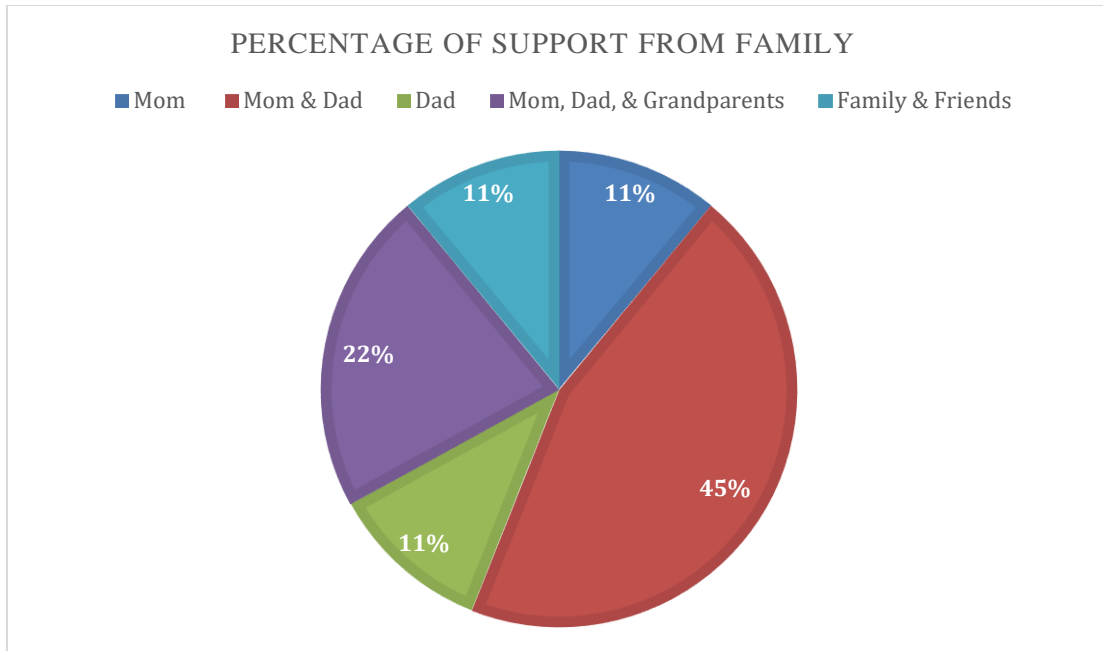
**Math**-They have to solve a long complicated math equation to determine what the weather will do.

Matthew, Brian,  
Zack, Jakob

Figure 6. Virtual poster of STEM meteorologist presenter.

The students were assigned a minute paper in which they answered the questions, “Who would support you in a STEM career and by what %?” Twenty percent of the female students stated their moms would support them, and 30% stated Mom and Dad,

while only 5% stated just Dad, 30% chose Mom/Dad/Grandparents, and 15% said their family and friends would support them. Most of the students responded that they would receive the support from their family members no matter what type of career they decided to go into (Figure 7).



*Figure 7.* Female students' responses regarding the minute paper asking who would support them in a STEM career and by what percent, ( $N=9$ ).

The students answered two misconception probes regarding STEM. The first probe stated, "A female in a STEM career cannot have a family and a normal life." Not any of the female students answered they agreed with the misconception probe, but 33% strongly disagreed and 67% disagreed. One of the girls stated, "I don't think this is true because they mostly work for their family and for their kids. I would still have kids if I were in a STEM career." Another female student said, "Lots of people who are in a STEM career still have normal lives and families." Since 100% of the female students either strongly disagreed or disagreed with the misconception probe, this was a positive

step involving the fact that these students believed females can indeed have STEM careers and normal lives. The other misconception probe stated, “There is not a place for me in STEM courses or careers.” Forty-four percent of the female students stated they agreed with this statement and did not feel as though there was a place for them in either STEM courses or careers. These students also stated they were not interested in STEM jobs, they did not know enough about STEM, and they wanted something other than a career related to STEM. Fifty-six percent of the female students disagreed with the misconception probe and stated they were interested in STEM courses and careers, as well as their careers plans were already related to STEM. One student answered, “I think that when I get older, I will be in a STEM career because my dream is to be a veterinarian.” Another student answered, “I will have a place in STEM careers because almost every job is some kind of STEM career” (Figure 8).

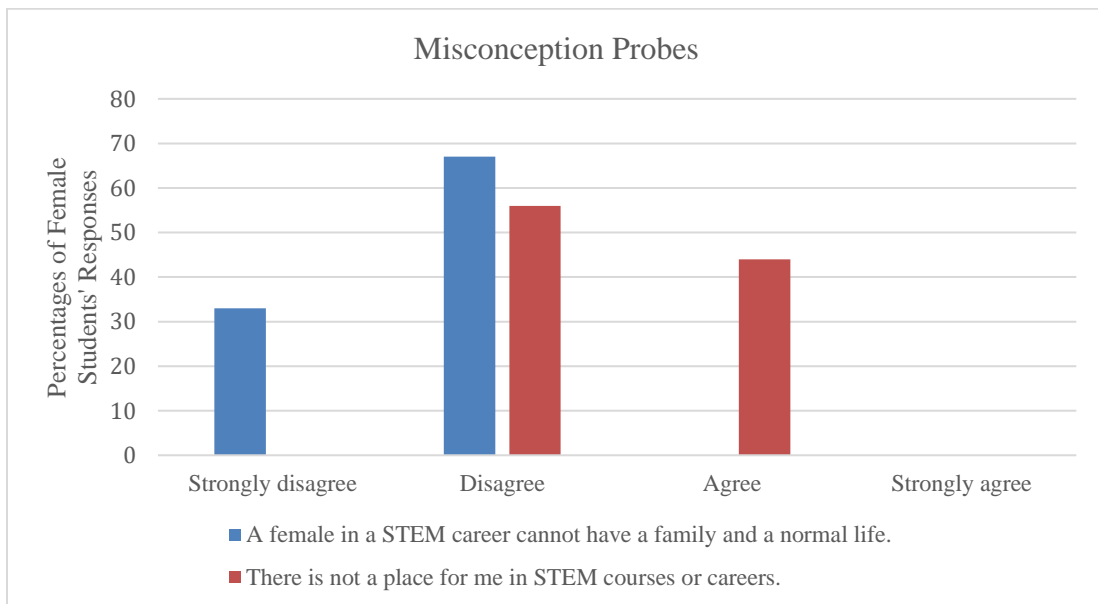


Figure 8. Female students' responses to the misconception probes, (N=9).

The students participated in four engineering labs to help increase their knowledge of STEM. These included Investigating Ballpoint Pens, Investigating Clips and Clamps, Investigating Towel Absorbency, and Investigating Toothbrush Designs. The students acknowledged that these labs all involved basic items from home, so these labs could easily be performed by the students and their families. The labs were also used to encourage the students to study engineering designs of household items. Following the labs, the students voted on their favorite lab with 50% of the students choosing the toothbrush design, 30% towel absorbency, 15% clips and clamps, and 5% ballpoint pens. All of the students stated that performing the labs did help them better understand engineering and how common household items are designed (Figure 9).

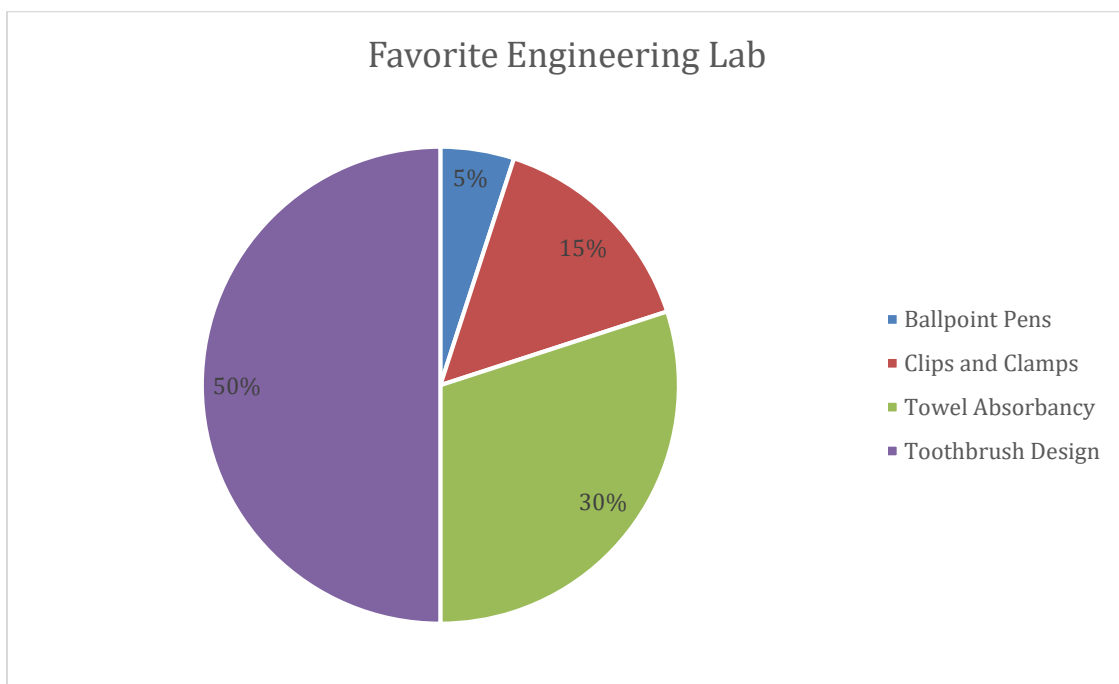
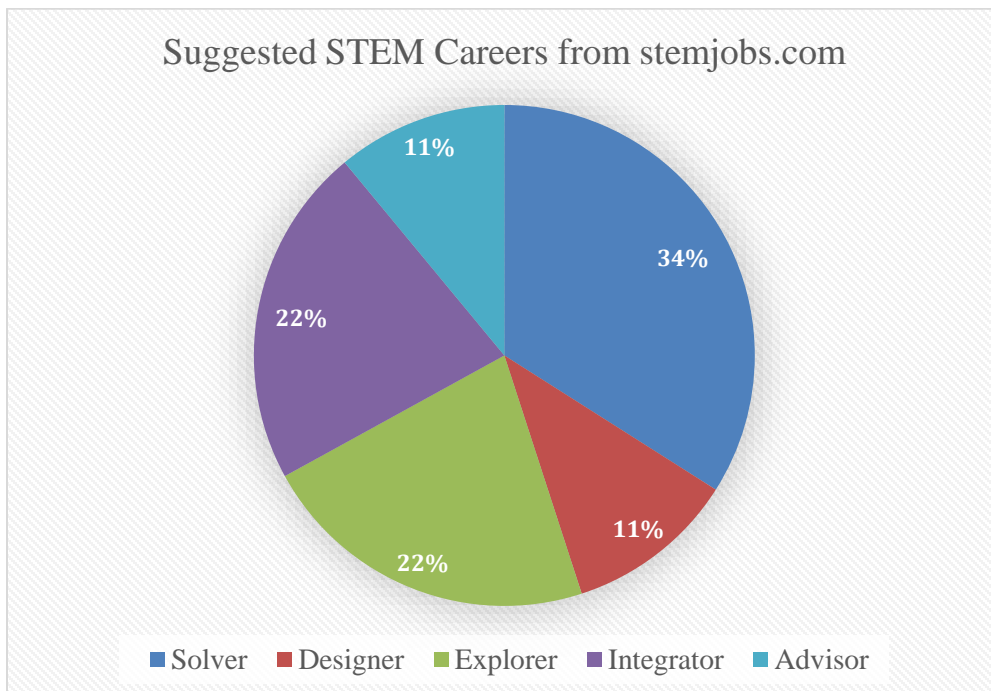


Figure 9. Students' responses to favorite engineering lab, (N=20).

All students used an online site (stemjobs.com) to answer questions regarding STEM career choices. At the end of the questions, the students were given the suggested STEM career based on their answers. The survey suggested careers as a solver for 34% of the female students, designer 11%, explorer 22%, investigator 0%, integrator 22%, and advisor 11%. Out of nine female students, 78% agreed with the online STEM career suggestions for careers. One female student who was given the career suggestion of solver stated, “Yes, I agree with being a solver. I like being the brains in a team. I think solver would really work for me.” Another female student who was given the career suggestion of explorer said, “Yes, because I love to learn about many topics that others may not know about. I also would like to run many experiments.” The students stated that the online site got them thinking about areas of careers they might be interested in and consider for their futures (Figure 10).



*Figure 10.* Percentages of STEM career suggestions for female students from stemjobs.com, (N=9).

One of the last writing assignments for the students involved answering the Muddiest Point, “After all the past weeks of studying STEM careers, what unanswered questions do you have”? Most of the female students asked questions that related to careers in STEM such as “Do you have to go in a field of STEM?”, “How many careers is STEM involved in?”, “Is STEM something people think about when choosing their career?” and “What is the importance of STEM in these careers?” But one female student answered, “I do not have any more questions, I fully understand STEM.” The class took the time to use these questions for discussion and as an acknowledgement that the students did understand the importance of STEM careers since almost every career was involved in STEM.

Teacher interviews were held with the nine female students. I asked the same five STEM related questions of each student. These questions dealt with the presentations, the presenters lifestyles and how the student connected with the presenters, STEM courses and careers, and an obstacle that could prevent the student from pursuing a STEM career. There was not one designated presenter that they all connected with. Each of the girls chose a different presenter to connect with due to a variety of reasons. One of the girls answered that she just was not interested in a career in STEM. Five girls stated that the time in college might make a difference, while gender preference played a significant role too. One of the students stated, “Not very many women get to handle engineering and technology, that’s mostly men.” Another student stated, “Some people think that women are not as smart as men and shouldn’t be in STEM careers.”. The one common thread that each of the girls responded to was the presenters’ lifestyles and the

fact that they were local made the thought of having a career in STEM a definite possibility.

All students responded to the Recall, Summarize, Question, Connect, and Comment (RSQC2) portions of the capstone activities by answering the questions. These answers were analyzed based on the students' responses. The students recalled the information related to STEM and answered the question, "What Has Been Most Important/Useful?" One female student answered, "I liked having people come in with STEM jobs to teach us what it's like to have a STEM career." Another female student said, "I liked understanding what STEM is and how it is used in multiple careers." In their responses to summarize, "What was the goal of STEM?" One female student answered, "The goal was to develop our knowledge of STEM and realize that many careers are involved in STEM." Another student stated, "The goal was to develop our knowledge of STEM and the careers that are available to use." The unanswered questions of the female students revolved around "How many careers is STEM involved in?" and "What is one job that doesn't have STEM in it?" When the female students stated the main point of the presentations and activities, they felt it was to teach them about STEM, develop and expand their knowledge of STEM, and to introduce them to other career opportunities in the STEM field. In regards to the comment portion of RSQC2, the female students completed the following statement, "What I enjoyed most about the presentations..." and "During most of the presentations, I felt..." One student answered, "I enjoyed the people that came in and how we wrote about what they do and what we learned about it." Another student stated, "What I enjoyed most was the stories of how all of the presenters

got involved in STEM. I felt like all the presentations and activities helped me gain a better understanding of STEM, and that these careers are not completely out of reach.”

### INTERPRETATION AND CONCLUSION

The goal of this capstone project was to find out how the seventh and eighth grade female students viewed science, technology, engineering, and mathematics (STEM) and what motivating initiatives the school was providing for these students, as well as what plans the school has developed to help motivate these students into the areas of STEM courses and careers. In regards to the purpose statement based on how the STEM initiatives available to adolescent girls at the Sandhills School District were successfully motivating the girls’ interests in STEM topics and careers, I discovered there were not many STEM initiatives available at the school. In planning the treatment for this capstone, I had to search for my own materials, presenters, and activities for the students. This enlightened me to the fact that the school district needs to improve the STEM initiatives and opportunities available to the students.

In reference to the sub-question of types of initiatives existing to motivate adolescent females into STEM, I discovered a lack of initiatives within the school district, and I spent time with the superintendent informing him of my plans to provide the necessary initiatives to help motivate the students into STEM within my classroom in order to catch and hold their interests with STEM. Though I did feel limited due to the location and size of our school, I was able to devise several methods of activities, labs, and presenters that I felt helped motivate the students into areas of STEM.

Another sub-question was based on experiences the female students have had within the school's classrooms which have impacted their thoughts and feelings towards STEM. During their interviews, the students answered that the presenters, labs, and activities they participated in had a tremendous impact on their views of STEM and increased their knowledge in regards to choosing courses and careers. They also stated the local presenters made them feel more secure about choosing STEM careers and realizing those choices could be realities.

All of the answers to the presenters' questions, and the female students' own questions, the surveys, activities, and labs revealed that many of the students began the treatment not knowing what STEM stood for, much less if they wanted to consider courses or careers in STEM. The presenters had more of an impact on the students' knowledge of STEM than any of the other labs and activities which the students took part. Most of this came when the presenters explained how each part of STEM was involved in their own careers. The female students related well to the presenters as evidenced by their questions to the presenters, their notebooks and virtual poster presentations.

The female students' Post-Treatment Survey answers revealed a significant increase in their STEM knowledge and positive attitudes towards obtaining STEM courses and careers. Many of these students stated they would definitely be taking more STEM courses and would work towards obtaining a career in STEM, while those who had been so adamantly against STEM courses and careers were thinking strongly about pursuing these two areas. The female students stated again that it was the presenters'

information that made the most impact on changing their thoughts towards STEM. The female students' attitudes were also changing towards women having STEM careers with families and normal lives. All of these positive changes resulted in many of the female students stating they wanted STEM careers which was a marked improvement over their Pre-Treatment thoughts of a male dominated STEM world (Figure 11).

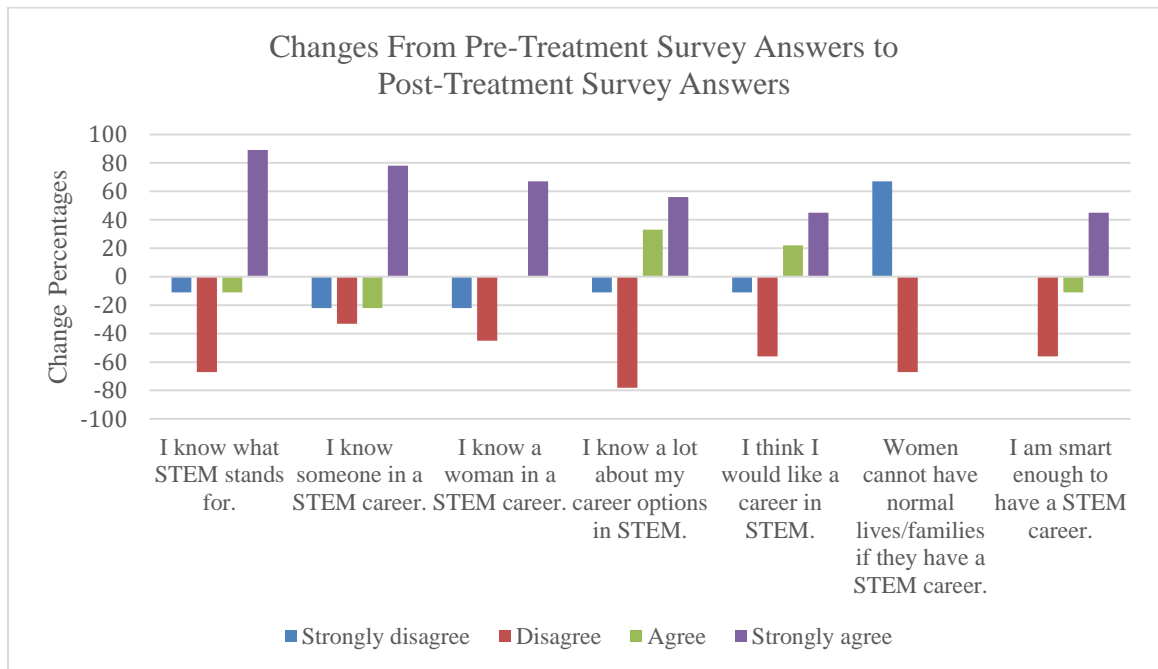


Figure 11. Significant changes in female students' answers from the pre-treatment survey to the post-treatment survey, (N=9).

The remaining survey questions revealed improvement in the female students' knowledge regarding STEM in the areas of females in STEM careers, understanding how things are built and how they work, and having participated in STEM activities. These changes in the students' Post-Treatment survey responses indicated that the students have participated in the treatment based on STEM and have changed their thoughts towards STEM courses and careers. This information will be useful in regards to continuing the

school's initiatives that I have used to motivate the female students into STEM. We will also plan future STEM classes based on the students' areas of interests.

The female students' responses to the pre-treatment survey matched the data research in which the students felt as though they were not smart enough to have a STEM career, did not know a lot about STEM career options, and they did not know what STEM stood for. The post-treatment survey revealed a dramatic change in the female students' thoughts that they were not smart enough to have a STEM career. One student stated, "There is room for me if I want a career in STEM." Their interview responses also revealed changes in their attitudes towards working in STEM careers. They also felt as though the gender gap was not as apparent. This was mostly due to the female presenters and their positive attitudes towards their careers in STEM.

#### VALUE

Before beginning the science, technology, engineering and mathematics (STEM) treatment, almost 80% of the female students stated they did not know what STEM stood for. This was an eye opener for me since that was what I taught. I had decided to use STEM as my capstone topic as I wanted to increase the students' knowledge of STEM in hopes of them obtaining a desire to pursue more STEM courses and maybe STEM careers. I was also hoping their careers would bring the students back to the community of Dunning as well as their families.

Since the beginning of the treatment as the students have studied STEM, I have witnessed marked interest in STEM by the students. Where they once did not even know what STEM stood for, they now know about careers in STEM, people with careers in

STEM, and the many options of STEM courses and careers. Maybe not every student in the treatment will pursue a career in STEM, but they have the knowledge that almost every job has some type of STEM connection. Teaching the concepts of STEM will be a continued endeavor of mine each year as I try to incorporate more STEM labs and activities into my science curriculum.

I no longer take the things for granted with my students that I once did, such the knowledge of the meaning of STEM. I have spent several weeks incorporating this knowledge into my seventh and eighth grade students. The reason I chose this class was they were the youngest students I taught which will give me the opportunity over the next few years to continue teaching them about STEM and the many course options and career choices they will have in their futures. I have seen an increase in these students' interests in STEM based on their responses to the writing assignments and lab activities during the treatment. My interest has also increased which will help me plan more activities, presenters, and labs in my classroom in the coming years for these students and others so as to continue increasing their knowledge and interests in STEM. I am looking forward to these students learning more and wanting to take more related classes, and maybe choosing STEM careers and moving back to this area with potential STEM jobs.

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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:** Sandra Lea Essman and John Graves  
**FROM:** Mark Quinn *Mark Quinn CJ*  
**DATE:** November 9, 2016  
**SUBJECT:** "Motivating Adolescent Females in Science, Technology, Engineering, and Mathematics at Sandhills Public School in Seventh and Eighth Grade STEM Classes" [SE110916-EX]

The above research, described in your submission of November 8, 2016, 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

PRE- AND POST-TREATMENT STEM INFORMATION SURVEY

\*\*Please note: This survey is completely voluntary and will in no way affect your grade or class standing\*\*

- 1 strongly disagree
- 2 disagree
- 3 agree
- 4 strongly agree

	1	2	3	4
1 I like to understand how things work.				
2 I like doing hands-on science projects.				
3 I know more about other careers than I do about careers in STEM.				
4 I like to understand how things are built.				
5 I like building things or putting things together.				
6 I know what STEM stands for.				
7 I like doing math problems.				
8 Females are treated like an outsider if they pursue a career in STEM.				
9 I know someone in a STEM career.				
10 I know a woman in a STEM career.				
11 My parents try hard to make sure I'm exposed to many career options.				
12 I know a lot about my career options in STEM.				
13 I think I would like a career in STEM.				
14 I have participated in STEM activities outside of school such as camps, after-school programs, etc.				
15 I like to understand how the natural world works.				
16 Women cannot have a normal life/family if they have a STEM career.				
17 Employers in the fields of STEM do not usually want to hire women.				
18 I am more driven than other kids my age.				
19 I am smart enough to have a STEM career.				

APPENDIX C  
STUDENTS' NOTEBOOKS RUBRIC

40

presentation summary	5 points
What I learned from the presentation	2 points
Drawn and colored picture	<u>3 points</u>
total possible	10 points

APPENDIX D  
VIRTUAL POSTER RUBRIC

	Obtained Points	Possible Points
Presenter's Name and Job Title		6
How STEM Are Incorporated Into The Job		15
Names Of The Group Members Located In The Bottom Right Corner		4
School Logo Located In The Bottom Left Corner		5
Graphs, pictures, and written information:		(20)
a. What did you learn from the presentation?		7
b. Survey Information and display		7
c. Your presentation information		6
Total Points		50

APPENDIX E  
MINUTE PAPER

Who would support you in a STEM career and by what percentage would they support you?

APPENDIX F  
MISCONCEPTION PROBES

- a. A female in a STEM career cannot have a family and a normal life.
- b. There is not a place for me in STEM courses or careers.

APPENDIX G  
ENGINEERING LABS

## CHAPTER

## 2

## ACTIVITY WORKSHEET 2.1

## Investigating Ballpoint Pens

**Engage**

Look at the assortment of ballpoint pens and think about the characteristics of each pen. In this activity, you will investigate the following: How do the parts of the two types of pens (stick and retractable) compare?

**Explore**

Safety note: Wear chemical-splash safety goggles.

1. Take apart the capped pen without breaking the pieces. Do not try to take the ink tube apart. Make a drawing of how the parts fit together. What is the purpose of each part?
2. Now, take apart the retractable pen. Make a drawing of how the parts fit together. What is the purpose of each part?

**Explain**

1. Put your findings into a table to compare the parts of the two types of pens to answer the question from Engage: How do the parts of the two types of pens (stick and retractable) compare?

2. Look at your drawing of the retractable pen. Does the spring keep the tip inside the pen or does it push it out when you want to write?

**Extend**

1. Look at another retractable pen to examine the parts.
2. How does this retractable pen compare to the first one? Explain how this retractable pen works without a "clicker."

**Evaluate**

Now that you have examined many different pens, consider a way that you could improve or invent a new pen. Draw your design and explain how each part of the pen works.

**ACTIVITY WORKSHEET 3.1**

## Investigating Clips and Clamps

**Engage**

Safety note: You must wear safety goggles at all times during this investigation.

1. Brainstorm a list of different types of clips and clamps with which you are familiar and discuss with the class.
2. Carefully examine the binder clip your teacher has provided to determine how it works. How does it open? What keeps it closed? Record your ideas.
3. Now examine the clip without handles. Compare how easily it opens to the one with handles. Record your findings.
4. In the Explore stage that follows, you will test clips with handles of various sizes. How does the size of the handle affect the opening and closing of the clip?

**Explore**

1. Your teacher will provide your group with binder clips for your investigation.
2. Measure the length of each handle and then carefully try to open each binder clip using only your fingers. Construct a data table to record your results.
3. Qualitatively describe how much force was required to open each binder clip and record.
4. Using the materials provided by your teacher, construct a binder clip that requires much less force to open. Make a drawing of your idea. Share your plan with the teacher before you build your binder clip.
5. Test your idea and record your results.
6. Use your results to answer the following questions: How does the size of the handle affect the opening of the clip? How does the size of the handle affect the closing of the clip?

**Explain**

1. Share your results with your classmates.
2. Why do you think the length of the handle is important? How is the handle like a lever?
3. Your teacher is going to do a demonstration with two clips that have handles of different lengths to quantitatively determine how much force is needed to open each clip. Compare the length of each handle to the amount of force needed to open each clip. Determine the length of the handle that protrudes out beyond the clip. Record your results in the table on page 24.

*(Activity Worksheet 3.1 continues)*

## CHAPTER 8

### ACTIVITY WORKSHEET 8.1

#### Investigating Towel Absorbency

In this activity, you will examine a number of towels and determine if their properties affect the amount of water that they can absorb.

#### Engage

1. Examine the towels provided by your teacher. Which would you rather use to dry off after swimming or a shower?
2. Based on what characteristics of the towel did you make your choice? Record your ideas and share with your classmates.
3. Obtain the towel samples from your teacher and note the characteristics of each. Use a hand lens to study the weaves of the towels. Draw and label what you see.
4. Based on your observations, which sample will be able to absorb the most water? Give reasons for making this prediction.

the procedure could have caused errors or flaws in the data?

2. Rank the towels from least to most absorbent. Describe how the characteristics of the towels change over this range. How do the weaves differ?
3. Determine the grams per square per meter (GSM) of a dry cotton towel sample by dividing its mass in grams by its area in square meters. How does the GSM compare to the amount of water absorbed?
4. How do you think your rankings compare to the cost of the towels? When might people choose to use towels of different absorbency levels?

#### Explore

Safety note: Wear safety glasses to protect your eyes.

1. Attach one of the sample towels over the top of a beaker with a rubber band. Make sure there is a small indentation in the top of the towel so that water can drip into the beaker.
2. Use a pipette to add water to the depression in the towel sample on top of the beaker. Count the number of whole pipettes of water you add before the towel can no longer hold any more and some of the water drips into the beaker. Make a data table and record your data.
3. Repeat steps 1 and 2 for each of your towel samples.

#### Extend

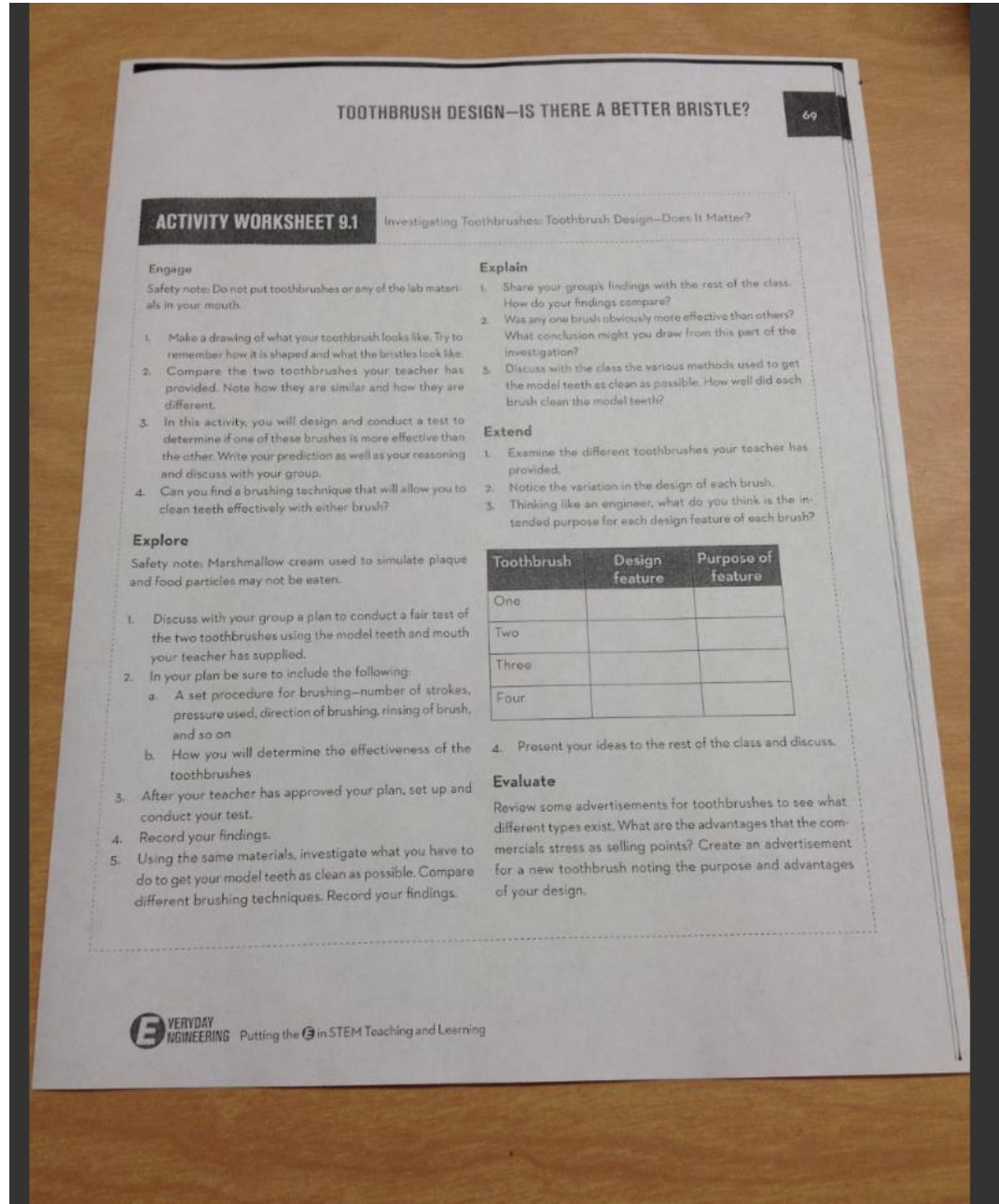
1. How does the mass of water a towel can absorb compare to the dry mass of the towel?
2. Obtain one more dry towel sample. Mass and record. Mass an empty baggie and record.
3. Immerse the towel in a beaker of water until it is saturated. Remove the towel and let it drip for a minute and then place it in the baggie and mass once again.
4. How can you find the mass of the water that the towel has absorbed?
5. Can a towel absorb a mass of water that is more than the towel? How do your results compare with your classmates'?

#### Explain

1. Share your results with your classmates. Which towel absorbed the most water? What steps in

#### Evaluate

You have a wet pet. Your parent has given you an old, thin, worn-out towel. You want to use a newer, plusher towel. How can you convince your parent that the newer towel will dry your pet better? Explain your thinking in writing and include a drawing.



TOOTHBRUSH DESIGN—IS THERE A BETTER BRISTLE?

**ACTIVITY WORKSHEET 9.1**

Investigating Toothbrushes: Toothbrush Design—Does It Matter?

**Engage**

Safety note: Do not put toothbrushes or any of the lab materials in your mouth.

1. Make a drawing of what your toothbrush looks like. Try to remember how it is shaped and what the bristles look like.
2. Compare the two toothbrushes your teacher has provided. Note how they are similar and how they are different.
3. In this activity, you will design and conduct a test to determine if one of these brushes is more effective than the other. Write your prediction as well as your reasoning and discuss with your group.
4. Can you find a brushing technique that will allow you to clean teeth effectively with either brush?

**Explain**

1. Share your group's findings with the rest of the class. How do your findings compare?
2. Was any one brush obviously more effective than others? What conclusion might you draw from this part of the investigation?
3. Discuss with the class the various methods used to get the model teeth as clean as possible. How well did each brush clean the model teeth?

**Extend**

1. Examine the different toothbrushes your teacher has provided.
2. Notice the variation in the design of each brush.
3. Thinking like an engineer, what do you think is the intended purpose for each design feature of each brush?

**Explore**

Safety note: Marshmallow cream used to simulate plaque and food particles may not be eaten.

1. Discuss with your group a plan to conduct a fair test of the two toothbrushes using the model teeth and mouth your teacher has supplied.
2. In your plan be sure to include the following:
  - a. A set procedure for brushing—number of strokes, pressure used, direction of brushing, rinsing of brush, and so on
  - b. How you will determine the effectiveness of the toothbrushes
3. After your teacher has approved your plan, set up and conduct your test.
4. Record your findings.
5. Using the same materials, investigate what you have to do to get your model teeth as clean as possible. Compare different brushing techniques. Record your findings.

Toothbrush	Design feature	Purpose of feature
One		
Two		
Three		
Four		

4. Present your ideas to the rest of the class and discuss.

**Evaluate**

Review some advertisements for toothbrushes to see what different types exist. What are the advantages that the commercials stress as selling points? Create an advertisement for a new toothbrush noting the purpose and advantages of your design.

(Moyer, 2012)

APPENDIX H  
MUDDIEST POINT

After all the past weeks of studying STEM careers, what unanswered questions do you still have?

APPENDIX I  
INTERVIEW QUESTIONS

**\*\*Please note: This interview is completely voluntary and will in no way affect your grade or class standing\*\***

- a. What presentation/activity best helped you understand about STEM?
- b. What have you learned about STEM courses and careers?
- c. Which presenter did you connect with the most?
- d. What about the presenter's lifestyle made you think of yourself?
- e. What do you see as an obstacle to pursuing activities and careers in STEM?

APPENDIX J

RECALL, SUMMARIZE, QUESTION, CONNECT AND COMMENT

- a. Recall – what has been most important/useful
- b. Summarize – one sentence that captures the essence of the goal
- c. Question – any unanswered questions
- d. Connect – main point of presentations/activities
- e. Comment – “What I enjoyed the most was ...”, “During most of the presentations/activities, I felt ...”