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The Effect of Role Models and Real-World STEM Content on 6th Grade Student Learning and Interest in a STEM Career

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Abstract

This study investigated the effects of using role models to teach lessons about real-world STEM (science, technology, engineering, and mathematics) content through experiential learning to increase interest in STEM careers. The research conducted in a large upper Midwest middle school. Five data collection tools were used: Likert scale rating, pre and post intervention student interest in STEM surveys, student role model evaluation survey, STEM role model research project scores, and Rube Goldberg project scores. Pre and post data was categorized into three content areas: science, math, and technology and engineering. While quantitative evidence identified a minor decrease in interest of technology and engineering, increases in math and science were identified in student interest surveys. Quantitative evidence identified both project scores showed average class scores of “C’s.” Evidence from the role model evaluations resulted in varied results of neutral and increased interest in STEM. The findings suggest that role models teaching lessons about real-world STEM, and providing learning experiences related to their content area for students, does increase interest in STEM career as indicated by the pre and post intervention student interest surveys.

Keywords: STEM education, student interest, role models, and real-world content

EFFECTS OF USING ROLE MODELS AND REAL-WORLD STEM CONTENT TO INCREASE LEARNING AND INTEREST IN A STEM CAREER

Introduction

Science is often viewed as a method of thinking and solving problems to help make life better. The sciences have driven major changes in thinking; from the Earth being made of the elements earth, wind, fire, and water, to the Earth consisting of 92 natural elements and 26 others created by humans. Major advancements in science have given humans the ability to live longer, grow more food, heal and prevent sickness, and explore the cosmos. These advancements in scientific thinking have been contributed to by countless thinkers in the collective entity: Science, Technology, Engineering, and Mathematics (STEM).

As learners gain interest in STEM fields, they often find themselves using combinations of math, science, technology, and engineering in their work. According to Wyss, Heulskamp, and Siebert (2012), there are two major issues that currently exist in the STEM field: "The Bureau of Labor Statistics in 2005 projects that in 2010 the U.S. will have a difficult time filling STEM careers that will become vacant due to retirements and a decrease in students interested in STEM" (p. 501).

Several attempts have been made by schools to increase students' interest in STEM fields. Some are offering hands-on after-school programs/clubs such as robotics, coding, and 3D printing. Additionally, many communities run summer STEM programs where STEM experts visit camps for a day or a week. Unfortunately, these attempts at increasing student interest have mostly occurred with small populations that are in after-school clubs and summer programs that are often only offered in high socioeconomic areas. Seeing success from these programs, many districts now offer STEM-based classes, but these are only offered to students expressing an interest in STEM. Schools beginning to require STEM to all students at the middle school level haven't had the opportunity to evaluate the rates of students entering a pathway to a STEM career.

Statement of the Problem

The study of STEM education is a relatively new field that has been poorly defined and until recently. Honey, Pearson, and Schweingruber, (2014) are increasing calls for emphasizing connections between and among the subjects. Little is known about the initiatives for increasing students' interest in STEM education and STEM careers. As a result, educators know little about how to respond and implement a new curriculum, with no set standards, to address the growing need for interested, young learners in STEM careers. To this end, the purpose of this action research study is to explore the effects of role models, and real-world STEM content has on 6th-grade students' learning and interest in a STEM career.

Theoretical Framework

Wegner and Lave argue that the domain of learning takes place in Communities of Practice (CoP) by increasing student participation as cited in (Smith, Hayes & Shea, 2017). Research by Kimura (2018) and Smith, Hayes, & Shea (2017) support that CoP are broken into three key characteristics: domain, community and practice.

Kimura (2018) argues that in the Communities of Practice theory, domain refers to members engaging in a joint activity (content) to help each other out by sharing information and a shared competence that distinguishes the members of the community from outsiders. Lave and Wenger had an original study occur in 1991 that defined domain as stated in (Smith, Hayes, & Shea,

2017) as “a set of relations among persons and activity in overlapping communities of practice” (p. 211). The “domain” of this study is STEM with an emphasis on science.

Practice is the next area that Lave and Wegner focused on in the Communities of Practice theory. Their theory originally looked at the cognitive and social participation with the community, however, their final definition of practice was a group of individuals that engage in a joint activity by helping each other out and sharing information (Kimura, 2018). In this study, “practice” of STEM will occur with the activities that each of the guest speakers bring with them and the use of simple machines in the Rube Goldberg Project.

The last part of Lave and Wegner’s Community of Practice theory is “Community”. Community is any person (instructors, professionals, students, apprentices) that has a shared interest or shared practice (Smith, Hayes, & Shea, 2017). According to Booker and Campbell-Whatley (2018) belongingness is a multifaceted and complex state of being that is heavily influenced by both internal and external factors. Community has a large role in this STEM study where students access professional STEM role models, whether they physically visit the classroom or work with students in other ways. The role models work with the students to share information about choosing careers in STEM by sharing their experiences on the job. Students in the community also learn more about a specific STEM career that peaks their interest and share their interest with others in the class.

Review of Literature

Establishing Domain in STEM

Asunda & Mativo, 2017, Barakos, Lujan, & Strang, 2012, Hayden et. al., 2011, Honey, Pearson & Schweingruber, 2014, and Weber, 2011 all have discussed the need for STEM education in our schools. However, a clear explanation of what is STEM and how it should look in the classroom is still unclear. Any kind of educational intervention associated with science, technology, engineering or math can be referred to as a STEM innovation (Hershbach 2011). He also mentions that, in many schools, the STEM initiative tends to be perceived mainly as a way to strengthen stand-alone math and science courses for college-bound students, with less attention given to non-college bound programming levels. STEM is a part of everyone's life whether they realize it or not and that is why future learners need to be familiar with STEM content. Kubat (2018) argues that real-world problems are seldom solved using knowledge from a single subject area (as cited in Green 2014). The school experiences of students should embody this reality.

Studies exploring students' perceptions of scientists have demonstrated that students do not have a clear understanding of what science has to offer them or what scientists do (Wyss et al., 2012). Many students perceive scientists as being old, white males working in a laboratory with dangerous experiments. According to Wyss, Heulskamp, and Siebert, a way to break this stereotypical perspective, is to relate science and STEM to reality, thereby increasing student interest, especially through the use of videos (as cited in Jackson 2018). The videos focus on real-world STEM professionals answering a set of questions about their career choice, the path that led them to their field of work and the work involved in their jobs. Nwankwo and Okoye (2015) argue that science clubs have also been found to increase students' interest in STEM and also attribute increased STEM interest to student collaboration to find a solution, practice the process skills needed in science, develop and practice critical thinking skills, and experience a wide range of topics. Additionally, students are introduced to techniques and practices of engineering and acquire practical skills which will be of value to their future employers.

Hayden and others found that summer camps where technology-enhanced activities and applications for target student populations were implemented, increased students' STEM interest (2011). Some programs stress STEM interest and engagement among all students; others focus on specific populations, such as those historically underrepresented in STEM fields such as girls and certain minorities (Honey et al., 2014). Hayden and others argue that students' interest develops over time, beginning with the triggering of attention and extending to voluntary reengagement, often characterized in terms of curiosity, persistence, and resourcefulness (Hidi & Renninger, 2006; Renninger & Hidi, 2011)

There exists a national movement in support of the idea of STEM education; however, the failure to agree on what STEM is, why STEM is important, and how to implement STEM means that too few students are graduating from STEM programs in order to meet the demands of U.S. employers (Mitts, 2016). As schools add STEM into their curriculum, Mitts also suggests the addition of art, forming the acronym STEAM. Mitts (2016) continues on to suggest adding an "R" for reading to form STREAM (as cited in Sousa & Pilecki (2013). Due to design engineers taking culture into account when designing any public structure, adding an “S” for social studies, results in STREAMS (Weyman, 2015).

Having so many acronyms for STEM creates much confusion. Coming to consensus on the purpose of teaching STEM might give more direction as to what's taught in STEM classrooms. Barakos, Lujan, and Strang (2012) state that for the U.S. to be successful in an increasingly global marketplace, all its citizens should possess a working understanding of STEM content. Thomasian (2011) explains that STEM workers with some college experience or an Associate's degree earn $7.61/hour more than their non-STEM counterparts. STEM jobs are also fast-growing, pay significantly above the national average, and individuals with a wage advantage have higher employment security throughout their careers (Thomasian, 2011). In 2005 the Bureau of Labor Statistics projected that by 2010 the U.S. will have a difficult time filling STEM careers that will become vacant due to retirements and a decrease in students interested in STEM (Wyss, Heulskamp & Siebert, 2012).

Next Generation Science Standards (NGSS) have three dimensions: disciplinary core ideas (content), scientific and engineering practices, and crosscutting concepts. The NGSS’s purpose is to set general, clear statements that articulate the knowledge and skills students should master at every grade level from kindergarten to 12th-grade (NGSS Lead States, 2013). Mitts (2016) states that STEM involves a seven-step problem-solving process. The first two steps, identify and define, are both science-oriented tasks. Steps three and four, document and understand, are technology tasks because they relate to a process. Step five includes the engineering processes of research and create. Finally, steps six and seven, implement and communicate, are referred to relationships which is a mathematical process. The acronym STEM appears to be the root of the thinking process.

The core courses of math and science already exist in schools while technology and engineering are not usually offered as separate classes in most schools across the nation. According to Dickman et al. (2009), Wisconsin is working to develop up-to-date, rigorous, and career-based curricula for the “T” and “E” components of STEM. They conclude that job growth predictions indicate STEM jobs will provide opportunities for future workers, but that state policies do not fully recognize the importance of STEM education for today’s students. Roche, O’Neill, and Prendergast (2016) found that, in rural areas, animal-based curricula can leverage the intrinsically appealing nature of animals to focus students on science and engineering concepts by making connections between animals and the curricular content. Hicks, (2015) suggests that for students to be scientifically literate, they must be able to: explain, evaluate, design, and interpret data or evidence accurately.

Establishing Community to Increase Student Interest

“Science is a subject that delivers non-negotiable, abstract knowledge using authoritarian pedagogy which is arguably insensitive to students’ needs” (Paige & Whitney, 2008, p.42). Mueller et al., (2018) argues that using animal-based curricula increases student interest in learning science and technology because lessons are engaging and intrinsically motivating for students, as they connect with personal interests. Basko & Hartman, (2017) mention when teaching STEM content, avoid teaching most content in an “authoritarian” manner. Authoritarian is described as using a loud voice to get the attention of the students and becoming shocked or angry when directions aren't followed. While working with math students, Askers (2017) realized math was too often taught in this way. To change this, he had his students create a hands-on model of a math concept to have his students' experience experiential learning.

Basko and Hartman, (2017) suggest that teaching technology that uses a hands-on approach increases student interest. Basko & Harman suggest that video conferencing is a hands-on practice that helps instructors teach technology. With creativity in their instruction, a teacher can more actively engage in the content with their students (2017). Hwang and Taylor (2016) attempted an experiential intervention to teach fractions when they added music to STEM to make learning fractions fun for the students. Hwang and Taylors reasoned music and fractions were related and were confusing to many, so by playing music with different beats, the students would then become familiar with fraction-related concepts (2016).

According to Barretti (2007), role models demonstrate for the individual how a task is performed. Hurd, Zimmerman, and Xue (2009) suggest that adolescents with role models are less likely to participate in criminal activity, are more likely to receive higher grades, and have higher self-esteem. Akbulut (2016) argues that a role model is an influential person such as a teacher, parent, manager, leader, or public figure for others to imitate (2016). In many cases, learners have been an inspired by people around them, including, aunts, uncles, moms, dads and teachers. Rose (2004) found that the education becomes "experiential" when children find a worthy role model in the classroom, and they "latch on to them as their ideals" (as cited in Kristjansson 2006 p. 37). Therefore, role models in STEM should increase students' interest in STEM content.

Farland-Smith (2015) found that females face a difficult struggle because they begin eliminating career choices as early as 5th grade. One of the main struggles females face as they progress through middle school to high school in STEM-related courses is that they feel like they are “invisible” in science classes. Brickhouse, Lowery and Schultz (2000) argue that this feeling can result from peer pressure causing girls to avoid participation or exhibit poor performance in STEM courses (as cited in Farland-Smith 2015). To help eliminate this feeling, Dasgupta and Stout (2014) found that mentors can help dispel young people’s stereotypes about who can do STEM and what can result from STEM studies and careers (as cited in Kekelis, Ryoo, and McLeod 2017). Children who have one or both parents who are engineers, research scientists, or science practitioners, either male or female, will be more likely to pursue careers in similar areas (Weber, 2011). However, if female students do not have a parental role model within the scientific community, they often find other role models, such as a teacher, to emulate.

Blemer and the University of California (2016), found after hiring a young female STEM professional at the university, there was a small enrollment increase in STEM related courses. Akbulut (2016) argues that role models even may expand the range of career options an individual perceives as feasible by setting norms and showing how the roles of the job can be achieved.

Herrmann et al. (2016) mention that role models are important for motivational processes because they help to indicate particular goals and to suggest the path that one should follow to achieve those goals. Herrmann et al. continue that interaction of role models with high school students can convey positive images through visits, guest lectures, after-school programs, weekend workshops, and summer camps to raise motivation and interest in STEM for all students, including women (2016).

Establishing the Practice of STEM by Using Real-World Examples

Solving problems that relate to the real world is another way of increasing students' interest in STEM. Problem-solving is considered the most significant cognitive activity used in both professional and everyday life (Bayazit, 2013). In 2000 Bayazit conducted a study to see if real-world questions answered with real-world answers increased student interest and found that the students did not consider the relationships between the questions and real-life contexts. Most students acted uncritically and applied their prior knowledge (Bayzit, 2013). STEM could be a remedy to have students think critically about real-world problems.

Erwin (2015) suggests that students will accomplish real intellectual work when an activity is has meaning to the individual. Erwin found that when students were asked to compute data, students that collected and processed that data of a topic that interested them, an increase of interest occurred. Mueller and others state the use of computers are one way of connecting students with real-world problems (2018).

Intentional usage of real-world examples when introducing content in class can be another way of engaging students. Akcay (2017) reports that accomplished teachers encourage students to plan projects that are relevant to them and others in the real world. This ownership helps them to see and understand the connections between classroom activities and the world outside the school. Budinski and Milinkovic (2017) encourage teachers to teach to their region, (e.g., students from rural areas may be more interested in real-world agricultural problems, while students from urban communities may be more curious about traffic or population problems).

Conclusion

This study will investigate the three areas of the Communities of Practice. The domain in STEM has been established with the STEM unit of energy and simple machines. The intent of the role models is to bring community to the group and providing hands-on opportunities and real-world applications of STEM. Students have the opportunity to practice their learned skills with simple machines by creating a Rube Goldberg machine and applying their learned knowledge to STEM.

Methodology

The purpose of this six-week study was to investigate the effect of role models and the use of real-world STEM content on increasing sixth-grade students' interest in STEM. Specifically, this study examined whether parent volunteers, all STEM professional role models, talking about their work increased students' interest in STEM careers. Before beginning this study, a letter was sent out to all parents informing them about this study (Appendix A). After all forms were returned, baseline data was collected about interest in STEM careers by a Student Attitude Toward STEM Survey. Each student's response was used to determine their interests in the separate areas of STEM (Appendix B). While teaching a science unit, student knowledge was assessed using a traditional test and a hands-on project. During the unit, four guest speakers visited the classes, bringing with them a hands-on, real-world STEM activity. A Role Model Ratings Survey was given after each role model's visit to see if the activity/career talk had an impact on students' interest in STEM (Appendix C). At the end of the six-week study, the survey (Appendix B) was given to the students again to determine the overall change of the students' interest in STEM careers. During the fourth week of the study, students were encouraged to look deeper at STEM career by a STEM Role Model Research (Appendix D). Students described what they thought their STEM role model did for a career, explored the educational route they would need to take to be in their role models position, starting salary, and what a day on the job would be like. After their research concluded, the students mentioned if they still had interest in this STEM career. During the sixth week, students had a unit test (Appendix E). This test questioned students with the real-life situations on topics of work, power, watts, force, and all simple machines. Lastly, a Rube Goldberg Project (Appendix F) required students to complete a project at home: to create a machine that completes a task, is of reliable construction, uses at least six simple machines, and to make a video describing the machine's construction.

The population of this action research study was sixth grade students enrolled at a large middle school in a large Midwestern city (N = 152). The sample of students who received the interventions were 81 sixth graders ages 11-13, enrolled in general science. This sample featured 41 females and 40 males. Due to this course being a required class, and all content covered in the classes was required by the school district, 71 students did not receive the role model interventions due to a having a different teacher, but completed all other projects (Appendices B & E). This sample was representative of the middle school population.

Pre- and post-assessments (Student Attitude Toward STEM Survey) were used to determine the change in students' interest in STEM. The assessment used a 5-point Likert scale rating from strongly disagree to strongly agree. The assessments were designed to gather information about the students' interest in the four areas of STEM. Once a baseline was established, the same survey was given on the last day of the study to determine the effectiveness of the study. All students had two days to respond to the pre- and the post-assessment online surveys. Students pre- and post-assessments were then analyzed to determine any change in career interest.

On days when STEM role models taught a lesson, a Role Model Ratings Survey was given to students asking both Likert scale questions and short answer questions to determine if the role model had any influence on students' interest in a STEM career. The purpose of inviting the role models to the classroom was to help students increase their interest in the STEM unit's content and help them make real-world connections between the content and STEM careers.
To encourage students to develop an interest in a particular area of STEM and STEM careers, the students researched an area of STEM by choosing a role model in science, technology, engineering, or mathematics. They used a guide to help them understand the career: and the route to that career (courses in high school, college, and apprenticeship), researched salary ranges, and looked up what a day on the job would be like to determine if that was a feasible choice for them.

Following the unit, students demonstrated their understanding of the STEM content by completing a unit test, "Rube Goldberg Project", a hands-on STEM project. Attendance was also recorded to help maintain the reliability of the study. A student who missed 25% of the days (absent for six days or more), was excluded from the study. No students were removed from this study.

Data Analysis

This study measured sixth-grade students' attitudes toward STEM before and after the interventions provided in this unit of study. On the first day, student baseline data was collected for both non-intervention and intervention students by using the Student Attitude Toward STEM Survey. Three content areas were focused on in the survey: Math, Science, and combined Engineering & Technology. Tabulation of the survey results was calculated by giving each response value of 1 to 5. The assigned values were: 1 - Strongly Disagree, 2 - Disagree, 3 - Neutral, 4 - Agree, and 5 - Strongly Agree. All responses to each category were then averaged and compared; the higher the average, the higher the students' career interest in that STEM content area.

Intervention students were given a Role Model Ratings Survey to complete after each of the four guest speakers who visited the class and taught students about STEM careers. One speaker visited the classroom with a focus from each of the content areas of STEM. Students responded to four Likert scale questions. Values of 1-5: 1 - Strongly Disagree, 2 - Disagree, 3 - Neutral, 4 - Agree, and 5 - Strongly Agree were assigned to each question to calculate an average score for the presentation to see if the students felt the role model helped them understand STEM careers. The higher the average, the better the students understood the careers, the more their attention was captured, and the more the speaker related content to the real-world and helped the students understand STEM. Students also had the opportunity to comment about each speaker about the following topics: what you did and didn't like about this lesson, and any suggestions to improve this lesson.

Intervention students completed a STEM Role Model Project and it was used to maintain student interest in STEM careers. Students used a grading rubric to pick a role model in any STEM area and write about the following: What is the career, describe the route to the job (high school requirements, college, and/or training), investigate salary, describe a typical day on the job, and could they see themselves doing that job in the future. Interest in a STEM career was tabulated after project completion by students' responses to the question of: "Do you see yourself doing this job after 15 years?"

Students completed a Rube Goldberg Project. Only intervention student data was used since this study does not compare teaching methods. The project was used to assess student learning of simple machines, by comparing test score data to a hands-on demonstration in an area of STEM's (Physical Science) content. The rubric assessed what the students learned about simple machines which they demonstrated the following idea by the following: the machine accomplished the chosen task by transferring energy at least six times from one simple machine to another, dependability of the machine, and the verbal explanation of the project. Due to the varying complexities of the Rube Goldberg the score percentage was used to express the learned skills of simple machines.

Findings

The purpose of this study was to explore the effects of role models and real-world STEM experiences on 6th-grade students' interest in STEM careers and learning. Surveys, feedback forms, projects, and rubrics were used to determine the student interest in STEM careers STEM learning.

Attitude Toward STEM Survey

The primary data collection tool of this study was the Attitude Toward STEM Survey by measuring the change in sixth-grade students' attitudes toward STEM. The survey was given on the last day of the 6-week study. Survey results were compared to the baseline data collected at the beginning of the project. The survey results were averaged, meaning the higher the average, the higher the career interest of the STEM content. Using an ANOVA Single factor test on the science, math, and technology and engineering sections of the intervention, a p-value <0.05 meant that the intervention had a statistically significant result. In the area of science, the intervention groups' average response increased from 2.42 to 2.89, an increase of 0.47. Meanwhile the control group had a decrease from 2.77 to 2.70, a decrease of 0.07. This resulted in a science p-value of 0.043105, a statistically significant result. Interest in a Math career in the intervention group increased from 2.8 to 3.3, an increase of 0.5, while the control group only increased from 3.14 to 3.5 which was an increase of 0.36. This resulted in a math p-value of 0.003316, a statistically significant result. Student interest in Technology & Engineering slightly decreased with the intervention group from 3.73 to 3.69 a loss of 0.04, while the control group went from 3.65 to 3.59, a loss of 0.06. This resulted in a Technology & Engineering p-value of 0.885321, not a statistically significant result (Figure 1).

Because this is a STEM intervention, another ANOVA Single Factor test (p-value <0.05) was run to look at all of the content areas of STEM. The p-value for STEM resulted in 0.031239, which is less than 0.05 resulting in the intervention having a statistically significant impact on the students in this study.

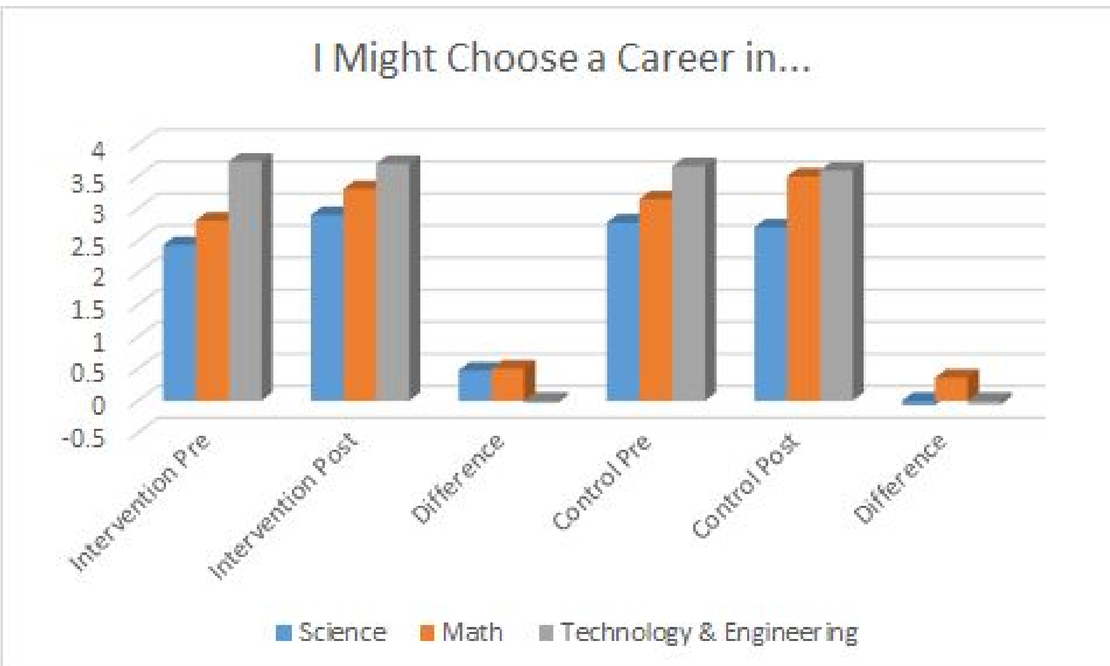

Figure 1. Average response from the intervention group pre (n=63), post (n=76) and control group pre (n=71), post (n=54) on the STEM Student Interest Survey.

Student Lesson Feedback Form

Another significant component of this study was enabling students to experience "real-world STEM" by having role models (parents of students) in the classroom talking about their STEM careers and providing hands-on experiences for the students.

The first role model visited the classroom on Friday of the 2nd week of the unit. This role model worked with the fabrication of metal alloy parts and focused on the content areas of chemistry, engineering and technology by discussing the periodic table and the fabrication process. Students were given clay to create a mold that would later be made into a "metal part." Results from the survey students completed after the role model's visit indicated that this intervention had a neutral to a positive result (Table 1). One student suggested that, "My favorite part was making a clay duck." another responded with "I liked learning about her job with chemistry." Others had a negative response, "The clay got all over my hands." and "It was hard to think about what to make."

Table 1.

Role Model Visit #1 – Average Student Response

	The topics of this lesson were helpful in my understanding of STEM.	*Today's topic related to something that I have seen or heard about in the real world.*	*The lesson held my attention.*	*The lesson was easy to understand.*
Average Responses (75)	*3.78*	*3.41*	*4.05*	*3.94*

Note: All values are rounded to the 0.01 position.

The second role model visited the classroom on Monday of the 5th week. This role model worked as a flight nurse, and she focused on the technology and tools used by of nurses and pilots. Students watched a video about being a pilot and were able to use some emergency tools that nurses would use if at an accident. Overall, this was a positive experience for the students

(Table 2). Students positively commented that “Doing CPR on the dummy was fun.” and “It’s exciting to know that you can travel places as a nurse.” Meanwhile, some students negatively commented saying, “I wish I had more time.” and “I wish we would have had a chance to be inside the plane and try out the night vision goggles.”

Table 2.

Role Model Visit #2 – Average Student Response

	The topics of this lesson were helpful in my understanding of STEM.	*Today’s topic related to something that I have seen or heard about in the real world.*	*The lesson held my attention.*	*The lesson was easy to understand.*
Average Responses (68)	3.69	4.11	4.07	4.16

Note: All values are rounded to the 0.01 position.

The third role model visited the classroom on Wednesday of the 6th week. This role model gave the students the opportunity to learn about a company that makes heart surgery supplies and how the technology has changed. Students used a model heart to maneuver the tools in and out of the heart and used an ablation tool to cauterize meat (chicken breast at room temperature to represent the human heart). Student responses to this intervention was average (Table 3). Students added “I liked doing the procedure on the chicken.” and “I liked how we could use the medical tools. I know I have a lot of work if I want to be a surgeon.” Others responded, “I didn’t like learning about the history of the company.” and “We only had time to do the chicken burning once.”

Table 3.

Role Model Visit #3 – Average Student Response

	The topics of this lesson were helpful in my understanding of STEM.	*Today's topic related to something that I have seen or heard about in the real world.*	*The lesson held my attention.*	*The lesson was easy to understand.*
Average Responses (44)	*3.77*	*3.34*	*3.95*	*3.56*

Note: All values are rounded to the 0.01 position.

The fourth role model visited the classroom on Friday of the 6th week. This civil engineer brought a model of the street that showed students how potential and kinetic energy worked to bring water to their homes. The students learned about the different jobs of a civil engineer. She taught the students about the processes that go into building a new housing development, street repairs, and how water is transported to homes from the city water supply. The intervention had an average response (Table 4). The students commented positively, "I liked how the model showed me how stuff works." and "It was fun to see all the pipes that are underground." Others responded, "There was too much information." and "Going through the handouts was boring."

Table 4.

Role Model Visit #4 – Average Student Response

	The topics of this lesson were helpful in my understanding of	*Today's topic related to something that I have seen or*	*The lesson held my attention.*	*The lesson was easy to understand.*

Table 4 (continued).

	STEM.	*heard about in the real world.*		
Average Responses (71)	*3.63*	*3.71*	*3.36*	*3.63*

Note: All values are rounded to the 0.01 position.

STEM Role Model Research Project

The next component of my research was to allow students to learn about a specific role model in a career that they were currently interested in pursuing college. A rubric was given to the students to make sure they researched specific material in learning about a STEM career. After learning about their role model, student data was collected about the question, "*Do they see themselves doing this job after 15 years?"*

Even though 25 students that said they didn't want to do the career that they researched, eight students mentioned that if they researched someone other than the CEOs of a company, they would have been more interested in the career and they still had the intent of entering a STEM career (Table 5).

Table 5.

STEM Role Model Research Project Results

	Hour 5	*Hour 6*	*Hour 7*
Count	*17*	*12*	*20*
Yes	*10*	*7*	*7*
No	*7*	*5*	*13*

Note: A "no" was assigned to responses unanswered or left blank.

Unit Test

A unit test given to students allowed the student to express summative content knowledge through a unit test. Content tested dealt with work, force, power of simple machines. Even though a pretest wasn't given to students to directly measure the growth of learning, the comparison between a paper/pencil test vs. a hands-on assessment measured how students did on the two types of summative assessments (Table 6). 5th hour scored an average of 14.46/25 or 57%. Similarly, 6th hour scored 14.12/25 or 56% and the 7th hour scored a 12.5/25 or 50%. All class test averages were lower than 60% which meant that on average all classes had a failing grade. Two things stood out when analyzing the test results. The first item that stood out, was that over 60% of the students gave the incorrect units for work and power. The class spent two class periods working through problems and omitting the units is a common practice among the middle school students. Not knowing the proper unit for a problem is an area for improvement. The second item that stood out was the 50% of the students couldn't identify mechanical advantage. This subject had only one lesson devoted to it and students were asked to write the information down in their notes and on the review guide for the test. Being early in the school year, many students don't understand the advantage of a review guide, and many didn't fill it out or write down what they needed to be successful with the test. These two topics (units and mechanical advantage) made up 6 of the 25 questions. Test outcomes would have shown passing results if more students had used the tools provided.

Table 6.

Unit Test Results.

	Hour 5	*Hour 6*	*Hour 7*
Count	*26*	*26*	*27*
Mean	*14.46*	*14.12*	*12.5*
Median	*15*	*13.5*	*12*
Mode	*15,24*	*11*	*10,17*
Standard Deviation	*6.85*	*5.41*	*4.11*
Minimum Score	*2*	*5*	*5*
Maximum Score	*25*	*24*	*24*
Range of Scores	*23*	*19*	*19*

Note: The test was out of 25 points.

Rube Goldberg Project

A rubric given to students allowed students to demonstrate their learned skills about simple machines. Before the assigning of the project, students were shown past Rube Goldberg videos so they could see there is no correct way to make a Rube Goldberg Machine and that the complexity of their machines could vary as well. The project was assigned as a take-home project and students were given a full week to complete. When completing the Rube Goldberg Project the students were checked for learning by their explanation of energy transfers, naming of the simple machine, and using scientific terminology learned in class. The project grade had a maximum score of 30 points (Table 7). The 5th hour averaged 22/30 or 73%, 6th and 7th hours both averaged 18/30 or 60%. A lower than average score resulted when 2/3 of the classes averaged a D- while the other was a C-. Notice the mode score of 2 for both 6th and 7th hours; this indicates a lack of completion and is the main reason for the lower averages. Even though 5th hour didn't have a score of a 2 as their mode, five students didn't complete the Rube Goldberg Machine. The 6th hour had seven students not complete the machine and nine students in 7th hour didn't complete the task of successfully creating a working Rube Goldberg Machine. This was the last assignment/project for the quarter, and many students had good grades before the project and chose to take a lower grade rather than complete the Rube Goldberg Machine.

Table 7.

Rube Goldberg Project

	Hour 5	*Hour 6*	*Hour 7*
Count	*26*	*26*	*27*
Mean	*22*	*18*	*18*
Median	*27*	*23*	*24*
Mode	*27*	*2*	*2*
Standard Deviation	*9.95*	*10.61*	*11.57*
Minimum Score	*2*	*2*	*2*
Maximum Score	*30*	*29*	*30*
Range of Scores	*28*	*27*	*28*

Note: The project was out of 30 points. The mode scores of 2 occurred for both 6th and 7th hours, due to students not completing the take home assessment.

Conclusions & Recommendations

Based on the findings of this study, the following conclusion can be made:

- A statistically significant result occurred with student interest in STEM careers in tandem with the following interventions: Role models (hands-on experiences), Role model research, and a Rube Goldberg Project (knowledge expression).

Based on the finding and conclusions of this study, the following recommendations can be made:

- Role models should continue to visit STEM classes, explaining their jobs and providing real-world applications for students to experience and learn from.
- When having role models visit, have the guests who have large amounts of information either visit over a two-day period or guide them to hit certain points.
- When having students research a role model, advise them to research the career rather than the person themselves.
- Having a preassessment for the understanding of simple machines to compare student learning rather than using a chapter test could streamline and help focus students on their success with the Rube Goldberg Project.
- Many students didn’t complete the Rube Goldberg Project, having an option for them to work in pairs could help them to demonstrate their knowledge and could be beneficial to the struggling students.
- The last suggestion is to have students practice explaining simple machines ahead of actual making of the Rube Goldberg machine.

In this experience, role models were asked to share their career experiences and how they felt their careers related to STEM once again building a STEM community. Role models visitations throughout the year rather than just two units would be exciting for the students and continue to let the learners have their experiential learning and continue their level of interest in STEM. The interventions allowed students to experience activities that they wouldn't have normally experienced and allowed them to see jobs in the real-world therefore better preparing them for post middle school.

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Appendix A

Parent Letter

Interest of STEM Careers of 6th Grade Learners
Parental Permission Form

September 10, 2018

Dear Parents,

In addition to being your child's 6th grade science teacher, I am a St. Catherine University student pursuing a Masters of Education. As a capstone to my program, I need to complete an Action Research project. I am going to study the 6th grade student interest in Science, Technology, Engineering, and Mathematics (STEM) curriculum because there is a national demand for graduates being prepared for STEM as they enter the workforce.

In the past, I have noticed that students are very interested in STEM but not making connections between STEM content and the real world application in a STEM career. As I introduce new topics (content standards), I will be intentional with teaching to make those real world connections. I will also be bringing in role models to explain how they use STEM in their career. In the coming weeks, I will be asking students about their current interest in STEM careers. The unit is prepared to inform all students about what STEM is and possible career options. After the unit has been completed, I will again ask the students about their interest in STEM careers. All students participate as members of the class. In order to understand the outcomes, I plan to analyze the data obtained from the results of this unit to determine if student interest before and after this unit has changes. All strategies implemented and assessments given are part of normal educational practice.

The purpose of this letter is to notify you of this research and to allow you the opportunity to exclude your child's results and data from my study.

If you decide you want your child's data to be in my study, you don't need to do anything at this point.

If you decide you do NOT want your child's data included in my study, please note that on this form below and return it by September 18, 2018. Note that your child will still participate in the 6th grade STEM Unit but his/her data will not be included in my analysis.

In order to help you make an informed decision, please note the following:

- I am working with a faculty member at St. Kate's and an advisor to complete this particular project.

- Research has shown me that role models inspire students to enter the STEM fields. As science educator, I want all of our students here at (SMS) to have the same opportunity to learn about STEM. As many of you already know, SMS have the two Science, Technology, Engineering, Arts, and Mathematics (STEAM) 7 & 8 classes and I want the 6th grade science students to understand why SMS is putting interest into those classes. Ultimately, this is an introduction unit to STEM and will not take away any value of the classes that we already have in place.
- I will be writing about the results that I get from this research. However, none of the writing that I do will include the name of this school, the names of any students, or any references that would make it possible to identify outcomes connected to a particular student. Other people will not know if your child is in my study.
- I will be discussing my findings (no names will be discussed in any way, only numbers of responses and what student responses were will be discussed) with administration and the science department so that we can continue to make improvements to the direction and focus of STEAM 7 & 8 education here at SMS.
- The final report of my study will be electronically available online at the St. Catherine University library. The goal of sharing my research study is to help other teachers who are also trying to improve their teaching.
- There is no penalty for not having your child's data involved in the study, I will simply delete his or her responses from my data set.

Note: Data that is collected is password protected and can only be accessed by myself (Charles Huber).

If you have any questions, please feel free to contact me, (xxx)-xxx-xxxx. You may ask questions now, or if you have any questions later, you can ask me, or email my advisor Carol Knicker, email, who will be happy to answer them. If you have questions or concerns regarding the study, and would like to talk to someone other than the researcher(s), you may also contact Dr. John Schmitt, Chair of the St. Catherine University Institutional Review Board, at (xxx) xxx-xxxx.

You may keep a copy of this form for your records.

______________________________	09/10/2018
Charles Huber	Date

OPT OUT: Parents, in order to exclude your child's data from the study, please sign and return by September 18, 2017

I do NOT want my child's data to be included in this study.

______________________________	________________
Signature of Parent	Date

Appendix B

Student Attitude Toward STEM Survey

DIRECTIONS: There are lists of statements on the following pages. Please read *each* statement and think about your life and how you feel. Do you agree or disagree with the statement? How strongly do you agree or disagree? For each statement, please put an **X** in *one* box that is the best answer. There are no “right” or “wrong” answers!

MATH

	Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
Math has been my worst subject.					
When I am older, I might choose a job that uses math.					
Math is hard for me.					
I am the type of student who does well in math.					
I can understand most subjects easily, but math is difficult for me.					
In the future , I could do harder math problems.					
I can get grades in math.					
I am good at math.					

PLEASE REMEMBER! Put an **X** in *just one* box for each statement that is the best answer for your life and how you feel.

SCIENCE

	Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
I feel good about myself when I do science.					
I might choose a career in science.					
After I finish high school, I will use science often.					
When I am older, knowing science will help me earn money.					
When I am older, I will need to understand science for my job.					
I know I can do well in science.					
Science will be important to me in my future career.					
I can understand most subjects easily, but science is hard for me to understand.					
In the future, I could do harder science work.					

PLEASE REMEMBER! Put an **X** in *just one* box for each statement that is the best answer for your life and how you feel.

ENGINEERING AND TECHNOLOGY

	Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
I like to imagine making new products.					
If I learn engineering, then I can improve things that people use everyday.					
I am good at building or fixing things.					
I am interested in what makes machines work.					
Designing products or structures will be important in my future job.					
I am curious about how electronics work.					
I want to be creative in my future jobs.					
Knowing how to use math and science together will help me to invent useful things.					
I believe I can be successful in engineering.					

PLEASE REMEMBER! Put an **X** in *just one* box for each statement that is the best answer for your life and how you feel.

Appendix C

Role Model Ratings Survey (adapted from a Google Form)

This is a survey to see your opinion about our guest role model has had on your perception of STEM.

What is today's date?

The topics of this lesson were helpful in my understanding of the content.

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

The topics related to something that I have seen or heard about in the real world.

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

The lesson(s) held my attention.

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

The lesson(s) was easy to understand.

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

What did you like most about this lesson?

What didn't you like about this lesson?

Suggestions to improve this lesson.

Appendix D

STEM Role Model Rubric

STEM Role Model Research Project

What does a person in STEM actually do in their daily lives? With so many STEM careers, choose a role model that has chosen a STEM career that you may actually want to become later in life.

You will research and create a PowerPoint presentation (or Google Presentation) describing your role model and their career, and where you see yourself fitting in with this career in the future.

Your presentation should include the following 8+ slides.

Slide 1 "Title Slide:
……………………………………………………….………..…..……….….……____/3
Name of Role Model (1 pt.)
Picture of Role Model (include source on this page) (1 pt.)
Your Name (1 pt.)

Slide 2
"Introduction"……………………………………….……..…….….…….….……____/2
In your own words, what does your role model do for a STEM career (two or three sentences). (2 pt)

Slide 3
"Career"……………………………………...…….…………….….…..…...……____/2
Describe the route to the career (high school, college, and training) (2pt)

Slides 4
"Benefits"…………………………………………………………………….….….……____/2
What is the average starting salary in this career? (2 pt)

Slides 5 "Day on the job"……………………………………….….……….….……….....….….……____/6
Describe a typical day on the job. (4 pt)

- Picture of them at work or of their career (include source on this page). (2 pt)

Slide 6 "Future Plans"……………………………………….…………………….…….….….……____/2
After researching this role model, do you see yourself doing this job after 15 years? Why? (2pt)

Slide 7 "Conclusion" ……………..……………………………………..…...……____/4
A brief wrap-up of your presentation. Highlight some of the key points. (3 pts)
Picture (include source) (1 pt.)

Slide 8+
"Sources"….……………………………….……….……………….……….…..……____/4
List all sources you used for your research (including photos on previous slides).

General……………………………..………………....……………..…..….….……____/5
Information is clear, concise and well researched and presented.
Presentation is laid out neatly with correct spelling and grammar (spell check or grammarly was used).

Total………………………………………………….……………....…..….….……____/30

Appendix E

Unit Test

1. For the activities below, please mark the activity if work is being done or no work is being done.

A. Looking through a microscope.

B. Lifting a box full of groceries.

C. Carrying a box of groceries.

D. Cutting a tree with a chainsaw.

E. Mowing the lawn with a push mower.

F. Weight lifting.

G. Hanging from the monkey bars.

H. Pushing against a locked door.

2. What unit do we use for work?

3. If a kid pushed another kid across the room 15 meters with 10N of force, how much work is done?

4. What is the formula for work?

5. One Joule is equal to _________of force moving ________ in the same direction.

6. What is power?

7. How do you know that you are calculating power? (What is the key unit?)

8. Watt is the unit for power?

9. Watts are used to measure

10. A train pulls a load 20 meters with 3000N of force. How much work is done?

11. A _____ makes work easier.

12. Force applied to a machine is the

13. Can you get more work output than input?

14. Please match the machine type with the picture.

15. What type of lever is the scissors?

16. Please match the machine type with the picture.

17. How do you increase the mechanical advantage of a wedge?

18. What is it called when two or more simple machines work together to make work easier?

Appendix F

Rube Goldberg Project Rubric

Name:____

Machine Name:______________________________

Rube Goldberg Rubric

Points	**4** **Excellent**	**3** **Good**	**2** **Poor**	**1** **Needs Improvement**
Task Accomplished!	Machine accomplished its task!	n/a	n/a	Machine did not work
Machine Process	Includes at least 6 distinct and separate steps to accomplish the task.	Includes at least 4-5 steps to accomplish the task.	Includes at least 3 steps to accomplish the task.	Includes less than 3 steps to accomplish the task.
Reliability	Machine works reliably every time and does not require human intervention.	Machine needed a nudge at some point to work properly	Machine failed to perform after 2 restarts	Machine does not really work.
Introduction	Machine **has a name** and the steps of the machine are explained to the viewer.	Machine **has a name** and the steps of the machine are not clearly explained to the viewer.	Has no name or the steps of the machine are not explained to the viewer.	Has no name and the steps of the machine are not explained to the viewer.
Creativity	Rube Goldberg Master! A novel and amusing idea!	A Rube Goldberg Apprentice! Interesting, but no “wows!”	A straightforward implementation.	A straightforward implementation.

Written Explanation	Picture and written explanation are well written, clear and follows Rube Goldberg's format.	Picture and written explanation are included and follows Rube Goldberg's format.	Picture and written explanation are included but does not follow Rube Goldberg's format.	Missing written explanation and/or picture.
Journal Entries	3 journal entries are submitted & follow the correct format	2 journal entries are submitted & follow the correct format	1 journal entry is submitted & follow the correct format	No journal entries are submitted

Rube Goldberg Write-up

This document is for you to type what occurred with your Rube Goldberg Machine. I am looking for the energy transfer names between the different machines.

Example:

Name of Project: Fans on lights out

Description of machine: I rolled the ball down the ramp (kinetic energy), and the ball hit the switch and turned on the fan (electrical and kinetic energy) which blew the broom over (kinetic energy) that hit the light switch that turned off the light (kinetic and electrical energy).

Project Name:

Describe your machine:

Video Attachment: To attach your video, copy your video address, highlight the words under this explanation called video attachment, then click the link icon up above and paste your address to link your video to the words.

Video Attachment