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The Effects of Technology on Student Interest in STEAM Education

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Abstract

In recent years, there has been a decline in interest in STEAM (Science, Technology, Engineering, Arts, and Mathematics) subjects beginning around 3rd, 4th, and 5th grades. Interest was monitored before and after experiencing Texas Instruments' TI-Nspire calculators in conjunction with the TI-Innovator Hub and TI- Innovator Rover in an attempt to combat this problem. The calculators allow students to write their code and then are connected to the Hubs and Rovers to create colors and sounds on the Hub or to make the Rover move. Students begin by learning the basics of coding in this format, but they continually increase their knowledge as the units progress by writing more difficult codes in order to complete more complex tasks. Student interest in STEAM was gauged before and after the unit to determine if the model helped to increase student interest.

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Chapter 1: Introduction

Background of the Problem

Previous research indicates a decline in student interest around Science, Technology, Engineering, Arts, and Mathematics (STEAM) subjects during third, fourth, and fifth grades (Dickerson, Eckhoff, Stewart, Chappell, & Hathcock, 2014; Wegner, Strehlke, & Weber, 2014). This drop off limits the number of students interested in pursuing a profession in STEAM as they move forward through their educational careers. Students within this age range are known to retain information and enjoy learning STEAM content through hands-on, experiential learning (Bassford, Crips, O'Sullivan, Bacon, & Fowler, 2016; Moye, Dugger, & Starkweather, 2017; Casey, Gill, Pennington, & Mireles, 2018). The technology used through this study is typically implemented in Grades 6 and up, but not in elementary schools. Though elementary students may need more guidance working with the technology, it is believed they will be able to properly use the technology.

Statement of the Problem

Third, fourth, and fifth grade, or upper elementary, students have decreased interest in STEAM subjects and careers.

Purpose of the Study

This study has multiple purposes. The first is to determine if exposing students to the TI-Innovator Hub and TI-Innovator Rover will stimulate interest in STEAM subjects. The second is to determine if upper elementary students can properly use the TI-Innovator Hub and TI-Innovator Rover when the technology is aligned to grade level content standards.

Theoretical Framework

The theoretical framework for this study is based on literature findings and used to explore the decline of student interest in STEAM subjects in upper elementary grades. It is designed to support the assumption that children's exposure to STEAM subjects early in their educational career will impact their future interest in pursuing a STEAM related profession. Depending on the positive or negative nature of this exposure, student engagement in the content and willingness to learn could be affected.

Research Hypotheses

Using Texas Instruments' technologies in third, fourth, and fifth grade classrooms will increase student interest in STEAM subjects leading to more students wanting to pursue careers in STEAM subjects.

The Texas Instruments' technologies can be successfully used by third, fourth, and fifth grade students when aligned to content standards.

Importance of the Study

This study's importance lies in discovering the capabilities of students during the third, fourth, and fifth grade levels. Previous research demonstrates how students learn best through hands-on learning in the classroom especially in the upper elementary grades (Bassford, Crips, O'Sullivan, Bacon, & Fowler, 2016; Moye, Dugger, & Starkweather, 2017; Casey, Gill, Pennington, & Mireles, 2018). Using the Texas Instruments technology allows for hands-on application, which students tend to remember longer, but also integration of multiple subjects to maximize student learning. This research will also demonstrate if students in these grade levels are capable of successfully using the technology.

Scope of the Study

The four schools implementing this technology are Ohio, suburban, public schools. Each school operates with a STEAM classroom, which students attend once a week along with their general education class. The STEAM classroom is led by a STEAM teacher, though lessons are co-taught with the help of their general education teacher. The STEAM teacher prepares lessons with some elements pre-taught to the class by the general education teacher prior to going to the STEAM room each week.

Definition of Terms

Ohio Learning Standards (OLS). The Ohio Learning Standards (OLS) are content specific standards set by the Ohio Department of Education used to determine the content focus for each grade level.

STEM or STEAM. STEM or STEAM are the customary acronyms used to represent the content areas of Science, Technology, Engineering, and Mathematics or Science, Technology, Engineering, Arts, and Mathematics. This study focuses on STEAM education, but STEM is commonly used.

TI-Nspire. The TI-Nspire is a Texas Instruments calculator where students write code to be executed on the TI-Innovator Hub and TI-Innovator Rover.

TI-Innovator Hub (Hub). The TI-Innovator Hub (Hub) is the device used by students to create different colors or sounds that have been coded on the TI-Nspire calculator.

TI-Innovator Rover (Rover). The TI-Innovator Rover (Rover) is the device, which moves forward, backward, and on angles, dependent on what is coded on the TI-Nspire calculator.

Summary

In recent years, there has been a decline in interest in STEAM (Science, Technology, Engineering, Arts, and Mathematics) subjects beginning around third, fourth, and fifth grades. Interest was monitored before and after experiencing Texas Instruments' TI-Nspire calculators in conjunction with the TI-Innovator Hub and TI-Innovator Rover in an attempt to combat this problem. The calculators allow students to write their code, and then, when connected to the Hubs and Rovers, create colors and sounds on the Hub or to make the Rover move. Students begin by learning the basics of coding in this format, but they continually increase their knowledge as the unit progresses by writing more difficult codes in order to complete more complex tasks. Student interest in STEAM will be gauged before, during, and after the unit to determine if the model helped to increase student interest.

Chapter 2: Review of the Literature

In an attempt to establish a more comprehensive background, articles were pulled focusing on students' interest in STEAM and STEM subjects during the upper elementary years. Through these articles, four major findings were identified. The first, centers on the previously acknowledged loss of interest beginning in grades three through five. Numerous articles reference research supporting this, and two looked within the schools to validate this claim (Dickerson, Eckhoff, Stewart, Chappell, & Hathcock, 2014; Wegner, Strehlke, & Weber, 2014). The second finding emphasizes ways to combat this loss of interest. Various programs were implemented inside and outside of school to combat the loss of interest with each proven effective by students, teachers, and/or parents (Vaidyanathan, 2012; McGrew, 2012; Dillivan & Dillivan, 2014). While each program attacked the problem in a different manner, the constant was additional implementation of STEM or STEAM learning. Within programs, one approach was to integrate the subjects (Graham & Brouillette, 2016). This links each subject's content with another's in order to maximize student learning. The integration of learning engages students across disciplines simultaneously and was proven to increase interest in STEM or STEAM learning, dependent on the study (Ekong, 2011). The final finding from the articles related to hands-on or experiential learning. This type of learning was identified as beneficial to students allowing them to gain knowledge through doing and retain it better than traditional classroom learning (Bassford, Crips, O'Sullivan, Bacon, & Fowler, 2016; Moye, Dugger, & Starkweather, 2017; Casey, Gill, Pennington, & Mireles, 2018).

Multiple studies identified students losing interest in the STEM subjects beginning in the upper elementary grades. The first study was conducted in Germany and worked to determine this by taking students out of their classes once a week to participate in this program (Wegner, Strehlke, & Weber, 2014). The program had a focus on a single project throughout the entire school year. Each week's plan is built upon the previous week's ideas each time. The study had participants varying in ages, from nine to eleven, which is equivalent to the typical American third through sixth grader. The study looked at students' overall frustration, boredom, and insecurities in STEM subjects and compared boys and girls at this age. The results displayed that the loss of interest in these subjects begins young. Girls also appeared to have more insecurities leading to a loss of interest even younger than boys in order to prevent potential embarrassment. While frustration and boredom remained almost equivalent before and after the program, insecurity in STEM subjects went down, especially in girls. This shows that programs similar to "Kolumbus-Kids" are helping decrease the gender gap in STEM fields by raising girls' confidence and sparking interest at younger ages (p. 35).

A second study focused on a pullout, STEM program containing fourth, fifth, and sixth grade students (Dickerson, Eckhoff, Stewart, Chappell, & Hathcock, 2014). The study identified a loss of interest in STEM subjects beginning in these grades and implemented a STEM program in order to combat this. Overall, interest of each student was examined before and after participation in the pullout STEM program during the school day. Test scores of the subjects they missed were also examined to determine if they would go down while the students were in the pullout STEM program. The scores of subjects they missed to participate in the program appeared to be unaffected while interest in STEM subjects went up.

Looking at this research, it is apparent students are losing interest in STEM subjects during the upper elementary years. Various programs have been successfully implemented to deter this by drawing focus to STEM subjects. In these studies, the time to implement STEM lessons was typically found during planned classroom activities. Though students missed this instructional time, their test scores remain unaffected while their interest in STEM went up. One program was especially effective for young girls, in an effort to decrease the gender gap commonly found in STEM fields.

Three articles discovered how implementing various programs excited students about STEM subjects in different ways. One study had fourth through sixth grade students learn how to create designs using Google Sketchup and similar programs, merging their creativity with new technology that is accessible on the majority of computers (Vaidyanathan, 2012). Students went beyond drawing shapes by learning about the different RGB (Red, Green, Blue) values to change the color and add dimension to their creations. This allowed students to continuously create while building their computer science skills young. Student and parent responses were both overwhelmingly positive, and the researcher urges other teachers to implement similar programs so interest is sparked in students at a younger age.

Likewise, another teacher allows students to fully participate in creating and engineering items for the classroom (McGrew, 2012). Students work to “solve” problems which are centered around skills they will use in their real lives, or books they read as a class (p. 21). Rather than having a set answer for students to regurgitate, students think outside the box about the problems at hand and solve them in whatever way they choose. Quotes from both third and fourth graders show that it is not only enjoyable, but also fruitful beyond the problem solving session. The school where this program was piloted has launched a stronger STEM initiative to continue the development of STEM tasks in all grade levels due to the increased interest after the study began.

Another program held a three-day summer camp designed for students in grades three through six which worked to increase interest in STEM subjects (Dillivan & Dillivan, 2014). The camp focused primarily on inquiry-based learning, giving students the freedom to slowly discover things rather than being taught information explicitly. Students were given surveys to fill out after the three days to gauge which activities students enjoyed the most and if the activities increased STEM interest. The activities centered primarily on inquiry-based learning were determined to be student's favorites. Parents were also asked to fill out a survey about their child's experiences following the camp, and the results demonstrated how interest in STEM subjects went beyond the three days of camp.

Of the previous three articles, each centers around the desire for students to create something new in order to increase their STEM skills. Each time students are building upon their previous knowledge, so the learning scaffolds itself. Within each of these programs implemented, student interest in STEM subjects increased, and this continued after the programs ended, or as the programs continued due to the found success.

Another key strategy used to combat loss of interest in STEM or STEAM subjects is to implement an integrated curriculum. This merges the learning with other subjects, thus further engaging students in the content. A robotics after-school program worked at an introductory level to teach robotics, programming, and engineering through the use of LEGOs for fifth graders (Ekong, 2011). Initially, students were asked to build the

"Tankbot" after an introductory robotics presentation, and then they continued programming the next day to make their "Tankbot" move (p. 352). As the program progressed, students were given more difficult challenges. The researcher would like to incorporate more subjects if the experiment were to be conducted again. This integration would challenge students to go beyond base-level knowledge and inquire more about the subjects.

A similar study was conducted in Malaysia and researched the varying levels of interest in STEM careers after implementation of an integrated STEM curriculum (Shahali, Halim, Rasul, Osam, & Zulkifeli, n.d.). Previous studies led these researchers to believe the loss in interest in STEM was beginning as young as elementary school. The study went on to implement one of the Bitara-STEM Modules, which integrate all aspects of STEM, science, technology, engineering, and mathematics in one large project spanning multiple days. After the study was completed, researchers discovered interest had not only gone up, but comprehension of the subjects also went up.

A final study focused on ten Title I elementary schools in California, noting the differences between achievement after a STEM curriculum transitioned into a STEAM curriculum in grades three through five (Graham & Brouillette, 2016). The STEAM curriculum was compiled as a way to implement core ideas in an interdisciplinary method allowing for creativity and the development of knowledge to come naturally. Adding the arts to STEM created lessons centered around hands-on learning and allowed for students to generate their own knowledge. Looking at students' standardized test scores, there was an improvement in scores from students who were exposed to STEAM lessons, as opposed to the traditional STEM lessons predominantly centered around physical science. Teachers were able to note student improvement, as well as visible enjoyment from these lessons when compared to traditional lecture-style learning. This integration of subjects allows students to stretch their knowledge in multiple ways and grow as learners.

The integrated approach to STEM and STEAM is identified as beneficial for students within these studies and allows students to construct their learning across disciplines. Each of these studies recognizes enjoyment and comprehension as improving for students across the four or five disciplines. The studies also focus on students in the upper elementary grades to ensure they are the target of these lessons due to previously identified loss of interest at this age.

Hands-on learning was further distinguished as another way to combat the loss of interest in STEM and STEAM. Students were posed a problem and then asked to manipulate objects, or the situation, to direct their learning. The first study was aimed at eight to twelve-year-old UK students working with CrashED (Bassford, Crips, O'Sullivan, Bacon, & Fowler, 2016). CrashED is a company which brought wrecked cars and set up crime scenes for students to analyze. An animated film came with the cars and showed the students what happened next as they went through a simulation. After the film, students analyzed what happened and "solved" the crime (p. 1). Response from students identified how this hands-on learning opened up career opportunities that students did not know about before. It was also clear students had a stronger grasp on the material than with traditional classroom learning.

A different survey of teachers across grades K-12 was given over a span of four years about whether or not students benefited from experiential learning and what kind of experiential learning they were exposed to that year (Moye, Dugger, & Starkweather, 2017). The survey looked at what types of experiential learning teachers were planning for their students and how effective the teachers believed it to be after teaching the lesson. The option which "used a computer program to model and simulate a solution to a problem" had the lowest response of people saying their elementary students experienced this (p. 34). This was also 20% lower than average responses to questions asked in the survey. The reason most teachers attributed for the lack of experiential learning in their classrooms was centered around funding and resources. There was a general consensus about how difficult it was to receive materials necessary, and these lessons take more prep time as well as more human involvement for the teacher, which is difficult to give to all students at one time.

In the final study, an investigator determined English Language Learners or ELLs were struggling with a programming portion of the curriculum subjects, seemingly due to the language barrier (Casey, Gill, Pennington, & Mireles, 2018). A hands-on program incorporating floor robots worked to close the gap between ELLs and typical students in fourth and fifth grade classrooms. Using these hands-on methods helped students gain a greater understanding of the content they needed to learn, and the researchers are working to incorporate similar studies across the area to benefit students.

In each of these studies, the hands-on approach was able to engage students further and give students a deeper understanding of the content. This also worked to close the learning for students previously identified as struggling, most likely due to a language barrier.

These four major findings, STEM interest decreasing at this age, structured programs helping increase interest, integrated curriculum preferences by students and teachers, and hands-on learning being more effective, found while reviewing the literature, set a basis for my thesis study. One supports the previously identified background of students losing interest beginning in these grades. The other three, implementing programs and integrating subjects through the use of experiential learning, support the hypothesis that student exposure to Texas Instruments technology will increase interest in STEAM in third, fourth, and fifth grade students.

Chapter 3: Research Methods

Research Design

Looking to support the hypothesis, the research was designed to see how students feel about this technology and their interest in STEAM careers moving forward. Initial interest was measured through an electronic pre-assessment about students' favorite subject in school, extracurricular activities, and dream job (Appendix A). In addition, students were asked if they believe they are good at and/or enjoy STEAM subjects. Most questions prompted students to rate their agreement on a five-point scale, but others were open-ended, requiring students to type their response. Students also identified their grade level and which elementary school they attend, so their responses could be analyzed accordingly.

Prior to implementation of lessons, teacher interest was also measured on a separate electronic pre-survey (Appendix B). Teachers were asked about their attitudes towards STEAM education, if and how it is applied in their classrooms, and what challenges they typically face if STEAM education is implemented. Similar to the student pre-assessment, teachers were asked to rate their agreement on a five-point scale or type an open-ended response.

Development of lesson plans began after each researcher gained an understanding of what the technology can do before analyzing each grade level's OLS. During this time, standards across subjects were highlighted as possibilities for lessons. Following this, a preliminary plan was written with an outline of the content standards for each grade level, materials, and a summary of procedural steps. From there, the lesson plans were developed writing codes and creating lesson plan materials to go with each. After the introduction, the remaining three lessons were tailored to each grade level, dependent on content standards, and primarily focused on math and art.

Third Grade

Week One. Following the electronic pre-assessments, an Introduction to Coding was implemented (Appendix C). During this, students were shown how frequently coding is seen in their lives while working to answer the essential question "What is coding?". Students were also given the chance to explore STEAM careers and see how prevalent STEAM is in occupations. Students were divided into groups of three, where they independently answered the essential question. Following their independent brainstorming, students watched a *DK Books* YouTube video, which answers the essential question (DK Books, 2014). Students independently reviewed their initial thoughts before collaborating with their group to answer the essential question. These final answers were then shared with the class. Following the class discussion aimed at defining coding, students watched a second video previewing the technology they are about to work with(Texas Instruments Education, 2017). This introduction did not incorporate students using any Texas Instruments technology but rather set the framework for the next three weeks of lessons.

Week Two. Through this lesson, students were introduced to using the TI-Nspire calculator and TI-Innovator Hub as they were tasked with coding for colors and sounds (Appendix D). In small groups, students explored how to mix RGB (Red, Green, and Blue) to create different colors and how a sound's frequency relates to its pitch. Beginning with RGB, each group followed specific steps to create the colors red, green, and blue to determine what RGB stands for (Appendix E). Following this, students practiced coding RGB on the calculator and Hub to create different colors. To guide their learning, students were given a chart to fill in with slots for color and the R, G, and B values (Appendix F). Sections either have the RGB values or a color for students to create. There were also blank rows on the chart for students to create their own colors and then write the code they input.

After coding for colors, groups moved into coding for sound. Codes for two different frequencies were input, and students used these, and any other frequencies they created, to guide their discovery of whether a higher frequency results in a higher or lower pitch (Appendix G). Students used this information to fill out an exit slip for teachers to assess learning (Appendix H).

Week Three. Third grade students were introduced to using the TI-Innovator Rover during their third week during the Coding for Area and Perimeter Lesson (Appendix I). Students were grouped and given butcher paper and markers to use in conjunction with the TI-Nspire calculator, Innovator Hub, and Rover. Each group followed step-by-step instructions for coding a rectangle on the calculator (Appendix J). Before running the program, a marker was placed into the pen hole on the Rover. Upon the program's completion, students moved the Rover and marker aside before they measured and calculated the area and perimeter of the shape. This information, along with side lengths, was placed in a guided chart for students to fill out as a form of assessment (Appendix K). Students also labeled side lengths and angles, as well as parallel and perpendicular lines on the butcher paper.

Week Four. The final lesson allowed for students to create different shapes and practice measuring lengths and angles. Students were given butcher paper and markers to use again along with the TI-Nspire, Innovator Hub, and Rover. Students worked in groups to follow instructions for inputting the number of sides, length of sides, number of angles, and degree of angles to the calculator in that order before placing the marker into the pen hole on butcher paper (Appendix L). The calculator then ran the code for their shape, and after, students moved the Rover and marker out of the way to view their shape. Following the shape's creation, students were tasked with measuring the length of sides and angles and labeling these along with the shape on butcher paper. Students also had to identify the shape's name on their response sheet (Appendix M).

Fourth Grade

Week One. Fourth grade's first lesson was the same Introduction to Coding third grade did. During this time, students responded to the essential question "What is coding?" individually before viewing a video to give them more information (DK Books, 2014). After watching the video, students revised their initial thinking and collaborated with their group to come up with a definition. These definitions were then shared with the whole group before viewing a second video demonstrating the TI-Nspire calculator, Innovator Hub, and Rover working together (Texas Instruments Education, 2017).

Week Two. This lesson was also the same as third grade's week two, incorporating the TI-Nspire and Innovator Hub to code for colors and sounds. Students worked in small groups to determine the meaning of RGB before coding for it. Following this, students worked to determine the relationship between frequency and pitch.

Week Three. The next week, students were introduced to using the TI-Innovator Rover along with the TI-Nspire calculator and Innovator Hub. During this lesson, students were coding different angles, lines, line segments, and rays in alignment with the

OLS (Appendix N). Groups followed instructional steps to have the Rover perform the code for a line on butcher paper using a marker (Appendix O). Afterwards, they added a point or arrow to finish the line, line segment, or ray accordingly and labeled the creation. Following this, students received a chart to fill in with a list of angle degrees and a blank slot to label each angle as acute, obtuse, or right (Appendix P). Students coded for the angle, then placed the marker in the Rover before running the program. Upon its completion, students moved the Rover and marker in order to measure the angle they created with their protractors. Students then labeled the angle as acute, obtuse, or right with the degree of the angle. When students finished these two projects, they read a grade-appropriate Newsela article about a woman's career as a data engineer (Romain, 2018). This article was used to help students see what coding looks like in a potential, future career.

Week Four. The final lesson for fourth grade students combined lessons three and four from third grade. During this lesson, students first coded for area and perimeter, just as the third graders did. They coded different rectangles in groups and placed a marker into the Rover, so the shape was drawn on to butcher paper. Once the code was completed, students measured and calculated the area and perimeter of each rectangle. Students then worked to code for different shapes. Just as the third graders did, students coded for the number of sides, length of sides, number of angles, and degree of angles before running the code on the Rover with the marker on butcher paper. Afterwards, students measured and labeled the shape and filled in the name of the shape next to the number of sides, length of sides, number of angles, and degree of angles in their individual charts.

Fifth Grade

Week One. Fifth graders started the unit the same way as third and fourth graders-answering the essential question "What is coding?". This followed the same format as the other grade levels with students beginning independently and moving into small group work. Students then began working with the TI-Nspire calculator and Innovator Hub. They worked in groups to code for colors and sounds.

Week Two. The second lesson implemented the Rover by having students code the Rover to move forward. Students worked in groups to do this following pre-written instructions (Appendix Q). Once their Rover ran their code, students measured the distance the Rover traveled and timed how long it moved using a stopwatch. With this data, students used the formula for speed (distance divided by time) to calculate the overall speed of the Rover over multiple trials. Students altered the distance their Rover traveled to see if the Rover's speed was constant, or changing, and filled in a chart with distance, time, and speed (Appendix R).

Week Three. For their third lesson, fifth grade students coded for different shapes similar to third and fourth grade students. They followed the same instructions as other students to create and label shapes and their features. For rectangles, students coded their calculators before running their program on the Rover over butcher paper with a marker in the pen hole. The students then labeled the shape and calculated area and perimeter for their individual charts. After this, groups worked to code for shapes by inputting the number of sides, length of sides, number of angles, and degree of angles in line with the provided instructions for constructing the code. Students then labeled their created shapes with these features and the shape's name.

Week Four. The final day consisted of fifth grade students completing a track challenge. During this lesson, the skills students had previously worked on, coding lengths and angles, were challenged as they were presented with a tape line, or track, which consists of different lengths and angles. Students measured each distance and angle before writing a code to have their Rover complete the course. Students were provided with instructions to code for the Rover to move forward and turn different directions, but they had to measure the track and write the code as a group (Appendix S). Students' codes were then tested by running the program on the track to determine if it was accurate or needed adjustments.

Following the units, an electronic post-assessment was administered to determine if interest levels changed in students (Appendix T). Questions were similar to that of the pre-assessment and required students to label their agreement on a five-point scale or provided a space for an open-ended response. The post-assessment also allowed students to give their feedback on the lessons, asking for students' favorite and least favorite aspects of the lessons.

The teachers' electronic post-assessment followed the same structure of questions allowing for a five-point scale rating or open-ended response (Appendix U). Questions asked teachers about the impact these lessons had on their attitudes toward STEAM and the likelihood of implementing it in the future. Teachers were also asked to identify their favorite and least favorite aspects of the units, in order to help adapt future implementation of lessons.

Following this, the data was analyzed centering on student interest levels after the completion of the unit. The statements of focus for student data are as follows:

- After using this technology, my interest in Math has increased.
- This technology has increased my curiosity about how electronics work.
- After using this technology, I believe I can be successful in engineering.
- This technology has increased my interest in STEAM.
- This project has increased my interest in coding.

Students were also given an opportunity to identify their likes and dislikes of the unit in open-ended response questions. These responses were analyzed for trends.

Teacher data was first focused on if a teacher identified having knowledge of how to implement STEAM on the pre-assessment. This data was compared to teachers' answers of the same question on the post-assessment. Another question of interest on both the pre- and post-assessments was if teachers feel prepared to implement STEAM lessons in their classroom. Teachers' opinions on STEAM education were also examined to determine if they believe STEAM benefits student understanding more than traditional classroom learning. Following the project, teachers were asked if they are more likely to implement technology into their future teaching. Teachers' responses to the open-ended questions of their favorite and least favorite aspects of the lessons were also analyzed along with challenges teachers when it comes to the implementation of STEAM lessons in their classroom.

Participants

The participants in this study were third, fourth, and fifth grade students and teachers in three suburban, public schools. Data was collected and analyzed from 450 students and 15 teachers spanning the three, upper elementary grade levels involved in the project.

Instrumentation

This instrumentation was adapted from the Student's Attitudes towards STEM (STEM-S) Survey (Friday Institute for Educational Innovation, 2012). Both the pre- and post-assessments for students were read orally as they completed them electronically with each student having their own computers. Each had students identify their demographic information for later data analysis. This information consisted of gathering student's names, grades, and schools. Student names were not connected to assessment answers, but rather used to ensure the same students were taking the pre- and post-assessments. Following this information on the pre-assessment, students were asked a series of questions regarding their attitudes toward STEAM subjects. This was the bulk of the assessment with students answering on a five-point scale ranging from "Strongly Disagree" to "Strongly Agree".

Students were first asked eight questions about their outlook on math both in school and if they see themselves pursuing a career using math. This same format was used with nine questions regarding student outlook on science. Students were then provided with a definition of engineering and technology saying "Engineers use math and science to invent things and solve problems. Engineers design and improve things, like bridges, cars, machines, foods, and computer games. Technologists build, test, and take care of the designs that engineers create." (Appendix A). This definition was provided, so students had a general understanding of the two subjects which they may not have been as familiar with. Six questions were posed about student outlook toward engineering followed by one question each on electronics, creativity, and the integration of subjects. Eleven questions were then presented asking students about their teamwork abilities and personal attitudes towards school. All of these questions were used to determine students' initial interest in STEAM subjects on the pre-assessment. Students were then given twelve STEAM careers and asked to rank their interest in these careers on a four-point scale ranging from "Not Interested at All" to "Very Interested". The careers selected were considered to be common enough that students would know them, but definitions were provided to help students answer the question honestly. These questions were included to monitor the link between student interest in STEAM subjects and future careers.

Following the initial demographic information on the electronic post-assessment, students were posed with similar questions to the pre-assessment asking about attitudes towards STEAM subjects. The primary difference between the two assessments was the phrasing of the questions. On the post-assessment, questions were posed asking if after working with this technology their interest in STEAM subjects, as a whole and individually, has gone up. These questions also asked students to rate their agreement on a five-point scale ranging from "Strongly Disagree" to "Strongly Agree". Students were asked eight questions about their attitudes towards math with the technology and three questions about attitudes towards math without the technology. In the post-assessment, students were given the same definition for engineering and technology as in the pre-assessment. Then they were asked four questions about their attitudes towards engineering after using this technology and one not referencing the technology. Two questions were posed about group work with the technology, and six questions about students' personal attitudes towards themselves and their peers. Students were then asked one question each about their attitudes towards STEAM, coding, and careers in STEAM related to the technology as well as their overall enjoyment of the project. These questions were included to compare student interest and determine any trends in interest from the pre-assessment to the post-assessment. Students were then posed with three careers and definitions of said careers and asked to rank their interest in pursuing this career on a four-point scale ranging from “Not Interested at All” to “Very Interested”. The questions regarding careers were also written to monitor if interest went up from the pre-assessment to the post-assessment. The survey concluded with two open-ended questions asking students their favorite and least favorite aspects of the unit. These questions were included for the researchers to see what students enjoyed the most and least across the project in an attempt to make changes for future use.

The teacher pre-surveys were also completed electronically, and their demographic information was collected for future analysis of grade level, school, and subject trends. Teacher emails were also collected to compare individual pre- and post-surveys, but their identity was not associated with their answers. Teachers were posed thirty-five questions where they were asked to rank their agreement on the same five-point scale as their students. These questions asked about their preparedness to teach STEAM subjects individually as well as relative to other subjects. Teachers were also asked about their education in teaching STEAM subjects, both during their time as pre-service teachers and at professional development opportunities. All of these questions were used to determine if teachers feel ready to teach STEAM to their students. Teachers were also asked about their opinions and beliefs on integrated, STEAM education related to student learning. This was followed up by asking about how frequently STEAM education is used in their classroom and how they prefer to receive professional development regarding STEAM education. The final six questions to the pre-assessment were open-ended. These questions asked about challenges and methods used to teach STEAM as well as assessment of students and which professional development options were preferred. Teachers were also asked to define STEAM. The open-ended questions were used to gather teacher opinions towards STEAM and analyze trends across grade levels and buildings.

The electronic post-assessment for the teachers followed a similar format to the pre-assessment. Just as was with the student's post-assessment, emails were collected, but not associated with participant answers. Twenty-eight of the thirty-three questions followed the same five-point scale used by teachers and students previously. Of these twenty-eight, fifteen asked teachers about their opinions and outlooks toward teaching STEAM subjects after using this technology. The other thirteen, asked about teacher attitudes, methods, and resources for teaching STEAM without mentioning the used technology. These questions were used to gauge their beliefs and to note any changes in these after participating in this study. The final four questions of the study were open-ended. They asked teachers about challenges they face teaching STEAM before relating questions to this project. Teachers were asked their personal definition of STEAM after using this technology as well as their likes and dislikes of this project. Teachers were asked these open-ended questions to help identify the strongest and weakest elements of the units. Teachers were also asked a yes or no question about if they would participate in a similar study in the future to determine attitudes towards participation in the study.

Research Procedures and Pilot Study

This study began with a pilot where the researchers were going through OLS and working to determine which could be addressed through the use of this technology. When the technology was received, the researchers created lessons incorporating it in alignment with OLS as they learned how to best use and teach the technology. Before all lesson plans were created, the researchers created a sequence for how the lesson plans would scaffold student learning and what standards were to be addressed each week. Then, they developed electronic pre- and post-assessments for students to fill out discussing their interest in STEM subjects. In conjunction with these, pre- and post-assessments were created for teachers to determine their beliefs on student learning of STEAM subjects and their attitudes towards STEAM education. The lessons were co-taught by the lead, STEAM teacher and general education teachers in the STEAM classroom following the pre-assessment in one public elementary school.

When the four weeks of lessons were completed, the electronic post-assessment was administered to students by reading it orally as they completed it on individual computers. Data was then analyzed and general education teachers as well as the lead, STEAM teacher were asked their opinions to determine the most successful aspects of the unit. After the pilot study, the lessons and materials were adjusted according to these trends before they were implemented in three more schools along with the pre- and post-assessments for both students and teachers following the same format. The data from these three schools was analyzed for the purposes of this study.

Data Analysis

For the purposes of this study, questions were selected from the student's post-assessments to be analyzed. These questions were not compared to initial responses from the pre-assessment. This was because students of this age are known to have opinions and emotions that vary greatly each day (Austrian, 2008). The questions selected for this study are as follows:

- After using this technology, my interest in Math has increased.
- This technology has increased my curiosity about how electronics work.
- After using this technology, I believe I can be successful in engineering.
- This technology has increased my interest in STEAM.
- This project has increased my interest in coding.

Each question asked students their interest in an aspect of STEAM or STEAM as a whole, while relating it to the previously taught lessons and technology. This gave the researchers a clearer picture of change in student interest levels with the consistency of students answering the questions on one specific day. For data analysis, the researchers looked to determine how many students identified "Strongly Agree" or "Agree" on the assessment. These students were considered to have increased interest. Students open-ended responses to likes and dislikes of the units were also considered by the researchers to enhance the lessons for future use.

For analysis of teacher surveys, the pre- and post-assessments of the same teachers were compared. Three questions were selected from each assessment for the purposes of this study and are as follows from the pre- assessment:

- I feel prepared to teach STEAM.
- In my opinion, students' understanding will increase more using STEAM education.
- I know how to teach STEAM.

These questions from the pre-assessment were then compared to the following from the post-assessment:

- After this project, I feel more comfortable incorporating technology into my teaching.
- This project has helped me feel more prepared to teach using technology.
- After this project, I know how to better teach STEAM.

Similar to the questions selected for student analysis, the post-assessment questions selected for teachers identified the project as the reason for any changes in opinions or beliefs. For analysis, teacher responses of "Strongly Disagree" and "Disagree" as well as "Strongly Agree" and "Agree" were grouped to determine a majority for or against the statement.

Assumptions of the Study

One assumption of this study was that there were no other aspects of a teacher's or child's life that were impacting their beliefs and interest in STEAM education. For our purposes, student responses were also limited to the post-assessment and reference the technology specifically, so it can be further assumed this technology is what did or did not change students' opinions. The same was true for teachers' responses from the post-assessment used for this study. Each question referenced this project and the technology used.

It was also assumed students and teachers were honest in their answers to both pre- and post-assessments. Both were reassured at the beginning of the assessments their identity would remain anonymous and their answers would only be used for research purposes.

Limitations of the Study

Since STEAM class was offered once a week for students, if a student was absent on the day their class went to STEAM, they would miss that week's lesson. For this study, we were unable to document students who missed one or more lessons.

Another limitation for this study was the number of adults in the room to aid students. Typically, there were two adults in the room and eight to ten groups of students. If multiple groups were struggling, they would have to wait for the next available adult to come help them through their code instead of moving ahead on the project.

Summary

For this study, the technology was received, and aligned with OLS to develop three units, one for each grade. Pre- and post-assessments were developed for both students and teachers to gauge interest and attitudes towards STEAM education. Beginning first with one school, pre-assessments were administered prior to implementation of the lessons, which were co-taught by the general education teacher and the lead, STEAM teacher. At the conclusion of the four-week unit, the post-assessments were given to both teachers and students. The data from the pilot study was used to adapt lesson plans to ensure they were as effective as possible. Following these changes, the pre-assessments were administered at three other schools before the implementation of the four-week units. Following the units, post-assessments were given for future data analysis. Five questions from the student assessments and six questions from the teacher assessments were selected and analyzed for the purposes of this study along with both teachers' and students' open-ended responses.

Chapter 4: Research Findings

Students

A total of 450 students, across the upper elementary grade levels, completed the post-assessment in its entirety. Looking at the data collected from the student surveys, five questions on the post-assessment were examined for the purposes of this study. One trend seen consistently across students' post-assessment responses is a high percentage of students, ranging from 17.1-30.9%, identifying "Neither Agree Nor Disagree". This could be contributed to students not hearing the question as it was read aloud or being unsure of their thoughts regarding the question and not wanting to get it wrong. As was previously stated, students in this developmental stage have "increased awareness of themselves" and are "easily embarrassed" which may have led them to be self-conscious in their opinions regarding the technology while responding to the survey (Austrian, 2008, p. 95). Even with assurance from researchers regarding the confidentiality of results, students may have been concerned to answer the survey agreeing or disagreeing with the prompt.

Table 1

Students' responses to "After using this technology, my interest in Math has increased."

Response		Third Grade	Fourth Grade	Fifth Grade	Total
Strongly Agree	Count	17	27	10	54
	% of Total	3.7	6	2.2	12
Agree	Count	32	63	66	161
	% of Total	7.1	14	14.7	35.8
Neither Agree Nor Disagree	Count	33	40	66	139
	% of Total	7.3	8.9	14.7	30.9
Disagree	Count	10	16	36	62
	% of Total	2.2	3.6	8	13.8

Table 1 (Continued)

Response		Third Grade	Fourth Grade	Fifth Grade	Total
Strongly Disagree	Count	12	10	12	34
	% of Total	2.7	2.2	2.7	7.6
Total	Count	104	156	190	450
	% of Total	23.1	34.7	42.2	100

Of the 450 students participating, 115, or 47.8% of students identified "Strongly Agree" or "Agree" as their response in Table 1 to whether their interest in math increased after using the technology. While this is not over 50% of participants in the study, it does make up the largest section of responses with 30.9% neither agreeing nor disagreeing and 21.4% disagreeing or strongly disagreeing.

Table 2

Students' responses to "This technology has increased my curiosity about how electronics work."

Response		Third Grade	Fourth Grade	Fifth Grade	Total
Strongly Agree	Count	33	43	47	123
	% of Total	7.3	9.6	10.4	27.3
Agree	Count	29	61	63	153
	% of Total	6.4	13.6	14	34
Neither Agree Nor Disagree	Count	21	22	34	77
	% of Total	4.7	4.9	7.6	17.1
Disagree	Count	16	21	28	65
	% of Total	3.6	4.7	6.2	14.4
Strongly Disagree	Count	5	9	18	32
	% of Total	1.1	2	4	7.1
Total	Count	104	156	190	450
	% of Total	23.1	34.7	42.2	100

Table 2 displays 61.3% of students claiming this technology has increased their curiosity in how electronics work when students who answered “Strongly Agree” or “Agree” are combined. This is the majority of students participating in the study and is dispersed across the three grade levels. As consistent across each question asked, 17.1% of students did not agree nor disagree. This leaves only 21.5%, less than one fourth, of students identifying their interest in technology not increasing.

Table 3

Students’ responses to “After using this technology, I believe I can be successful in engineering.”

Response		Third Grade	Fourth Grade	Fifth Grade	Total
Strongly Agree	Count	20	22	20	62
	% of Total	4.4	4.9	4.4	13.8
Agree	Count	19	53	64	136
	% of Total	4.2	11.8	14.2	30.2
Neither Agree Nor Disagree	Count	28	49	56	133
	% of Total	6.2	10.9	12.4	29.6
Disagree	Count	18	17	31	66
	% of Total	4	3.8	6.9	14.7
Strongly Disagree	Count	19	15	19	53
	% of Total	4.2	3.3	4.2	11.8
Total	Count	104	156	190	450
	% of Total	23.1	34.7	42.2	100

Combining the “Strongly Agree” and “Agree” categories 44% of students identified that they believe they will be successful in a career in engineering. As is seen previously in regard to math interest, the “Strongly Agree” and “Agree” categories hold the majority of students with 29.6% of students neither agreeing nor disagreeing and 26.5% of students strongly disagreeing or disagreeing. The researchers believe the reason this prompt provided the lowest amount of students identifying the responses “Strongly Agree” or “Agree” is due to students’ perception of, or lack of knowledge in engineering. The definition of engineering was embedded into the survey in an effort to combat this, but the researchers still believe this effected student response. This is also believed to be the reason for the high amount of students responding, “Neither Agree Nor Disagree”.

Table 4

Students’ responses to “This technology has increased my interest in STEAM.”

Response		Third Grade	Fourth Grade	Fifth Grade	Total
Strongly Agree	Count	26	61	48	135
	% of Total	5.8	13.6	10.7	30
Agree	Count	32	48	60	140
	% of Total	7.1	10.7	13.3	31.1
Neither Agree Nor Disagree	Count	22	35	47	104
	% of Total	4.9	7.8	10.4	23.1
Disagree	Count	11	6	19	36
	% of Total	2.4	1.3	4.2	8
Strongly Disagree	Count	13	6	16	35
	% of Total	2.9	1.3	3.6	7.8
Total	Count	104	156	190	450
	% of Total	23.1	34.7	42.2	100

Table 4 demonstrates how 61.1% of students identified their interest in STEAM increasing following the use of this technology. This is the majority of students surveyed and only 15.8% of students identified this technology not increasing their interest in STEAM.

Table 5

Students' responses to "This project has increased my interest in coding."

Response		Third Grade	Fourth Grade	Fifth Grade	Total
Strongly Agree	Count	36	63	49	148
	% of Total	8	14	10.9	32.9
Agree	Count	28	48	70	146
	% of Total	6.2	10.7	15.6	32.4
Neither Agree Nor Disagree	Count	26	29	31	86
	% of Total	5.8	6.4	6.9	19.1
Disagree	Count	8	9	25	42
	% of Total	1.8	2	5.6	9.3
Strongly Disagree	Count	6	7	15	28
	% of Total	1.3	1.6	3.3	6.2
Total	Count	104	156	190	450
	% of Total	23.1	34.7	42.2	100

Once again combining the "Strongly Agree" and "Agree" categories, 65.4% of students identified an increased interest in coding. This is well over half of the students participating, and only 15.5% of students disagreed or strongly disagreed with this prompt.

Looking at student responses across all five prompts, a few trends are apparent. As noted previously, a strong percentage of students selected "Neither Agree Nor Disagree" making their responses difficult to analyze within this study. Across all five tables, it is noted that the majority of students responded in the "Strongly Agree" and "Agree" categories as opposed to "Neither Agree Nor Disagree" or "Strongly Disagree" and "Disagree". Though their responses did not make up 50% or more of the students, they were the largest grouping of students. Due to this, it is believed that this technology did increase interest in STEAM subjects. This is especially noted when it comes to student interest in coding with this category showing the highest group of individuals across all five prompts analyzed in this study.

Students were also asked their favorite and least favorite elements of the project with an open-ended response on the post-assessment. The most common answers for dislikes of the project were nothing, the math calculation students were asked to do, and collaborating with their groups. One child indicated "people hoging the stuff" on their post-assessment. This statement is consistent with teacher responses, saying behavior management was a struggle, but they enjoyed seeing students practice their collaboration and teamwork skills. Students' favorite aspects of the project were predominantly using the Rover as well as the Coding for Shapes and Coding for Colors lessons. Multiple students also identified enjoying the integration of content areas with one saying, "I liked how we got to draw and use art and math at the same time!!!".

Teachers

When looking at data collected from teachers, 15 teachers' responses were analyzed for the purpose of this study with these 15 completing both the pre- and post-assessments. These 15 teachers span across the upper elementary grades and the three schools participating in this study.

Table 6

Teachers' responses to "I know how to teach STEAM." on the pre-assessment.

Response		Total
Strongly Agree	Count	0
	% of Total	0
Agree	Count	7
	% of Total	46.7

Table 6 (Continued)

Response		Total
Disagree	Count	6
	% of Total	40
Strongly Disagree	Count	1
	% of Total	6.7
Not Applicable	Count	1
	% of Total	6.7
Total	Count	15
	% of Total	100

Table 6 breaks down teachers' opinions on whether or not they know how to teach STEAM to students. 46.7% of teachers claimed they did not know how to teach STEAM to their students prior to completing this study.

Table 7

Teachers' responses to "I feel prepared to teach STEAM." On the pre-assessment.

Response		Total
Strongly Agree	Count	0
	% of Total	0
Agree	Count	5
	% of Total	33.3
Disagree	Count	8
	% of Total	53.3
Strongly Disagree	Count	1
	% of Total	6.7
Not Applicable	Count	1
	% of Total	6.7
Total	Count	15
	% of Total	100

Looking at Table 7, 60% of teachers disagree with the statement, meaning they do not feel prepared to teach STEAM to their students. When comparing this Table 6, multiple teachers claim they know how to teach STEAM, but they do not feel prepared to do so. These teachers also responded to a prompt asking what some challenges were when it comes to teaching STEAM in their classrooms. Four to five teachers answered time, gathering of materials, or getting started/feeling prepared.

Table 8

Teachers' responses to "In my opinion, students' understanding will increase more using STEAM education." on the pre-assessment.

Response		Total
Strongly Agree	Count	1
	% of Total	6.7
Agree	Count	12
	% of Total	80
Disagree	Count	1
	% of Total	6.7
Strongly Disagree	Count	0
	% of Total	0
Not Applicable	Count	1
	% of Total	6.7
Total	Count	15
	% of Total	100

Continuing to Table 8, 86.7% of teachers agree or strongly agree that STEAM education increases student understanding. Despite this being the majority of teacher's belief, it can be concluded the aforementioned challenges teachers are facing to implement STEAM education are causing them to not integrate it into their regular teaching practices.

Table 9

Teachers' responses to "After this project, I know better how to teach STEAM." on the post-assessment.

Response		Total
Strongly Agree	Count	3
	% of Total	20
Agree	Count	7
	% of Total	46.7
Disagree	Count	4
	% of Total	26.7
Strongly Disagree	Count	0
	% of Total	0
Not Applicable	Count	1
	% of Total	6.7
Total	Count	15
	% of Total	100

Moving on to the post-assessment, two-thirds of teachers responded saying implementing this project helped them to know how to better teach STEAM. The researchers believe this will encourage teachers to engage students through STEAM education more frequently in their classrooms.

Table 10

Teachers' responses to "This project has helped me feel more prepared to teach using technology." on the post-assessment.

Response		Total
Strongly Agree	Count	3
	% of Total	20
Agree	Count	8
	% of Total	53.3
Disagree	Count	2
	% of Total	13.3

Table 10 (Continued)

Response		Total
Strongly Disagree	Count	0
	% of Total	0
Not Applicable	Count	2
	% of Total	13.3
Total	Count	15
	% of Total	100

Table 10 demonstrates how 73.3% of teachers feel more prepared to teach STEAM following this experience. In the pre-assessment, teachers indicated they did not feel prepared or they did not know where to begin when planning STEAM instruction along with other challenges. The same question was posed in the post-assessment, where previously five teachers indicated they did not feel prepared or did not know where to start, but only two teachers indicated this as a challenge on the post-assessment. The challenge of a lack of time was acknowledged five times on the pre-assessment, and then six times on the post-assessment.

Table 11

Teachers' responses to "After this project, I am more comfortable incorporating technology into my teaching." on the post-assessment.

Response		Total
Strongly Agree	Count	4
	% of Total	26.7
Agree	Count	6
	% of Total	40
Disagree	Count	3
	% of Total	20

Table 11 (Continued)

Response		Total
Strongly Disagree	Count	0
	% of Total	0
Not Applicable	Count	2
	% of Total	13.3
Total	Count	15
	% of Total	100

Table 11 demonstrates how two-thirds of teachers identified they are more comfortable using technology in their classrooms following this project. Just as with Table 9, the researchers believe that teachers being more comfortable with the technology will encourage them to incorporate it more into their teaching of STEAM subjects as well as others.

When teachers were asked their favorite aspect of the project, all of them identified student enthusiasm or collaboration as their favorite part. In addition to this, multiple teachers commented saying they enjoyed team teaching and learning this new skill of coding themselves. Teachers were also asked about improvements which could be made to the units. Five teachers asked that they be taught the technology prior to its implementation with students, so they are better able to anticipate problems and help students. Six other teachers said they would not change the project.

Chapter 5: Conclusions, Discussion, and Suggestions for Future Research

Summary

Student findings. From the post-assessment, students agreeing or strongly agreeing made up the majority of the 450 participants for all five prompts used in this study. Math interest had 12% of students strongly agreeing and 35.8% agreeing their interest had gone up after the implementation of this technology. In addition, 44% of students believe they would be more successful as a future engineer after using this technology. Over sixty percent of students responded saying the Texas Instruments' technology increased their interest in how electronics work, STEAM, and coding. This leads researchers to believe this technology did increase student interest in STEAM subjects. In addition, student observation and responses to the post-assessment, allow researchers to believe students in the upper elementary grades are capable of successfully using this technology in guided lessons to further learning.

Teacher findings. Looking at the results from the pre-assessments teachers completed, 60% of teachers believed they were unprepared and 46.7% did not know how to teach STEAM prior to the implementation of the units. The pre-assessment also informed the researchers about teachers' perceptions of STEAM. While they believed it was beneficial for students' understanding of these subjects, many challenges such as time and materials, stopped the implementation of STEAM education. Following the unit, 73.3% of teachers believed they were more prepared, and 66.7% of teachers felt they knew better how to teach STEAM. Two-thirds of teachers also believed themselves to be more comfortable incorporating technology into their classrooms. Due to these responses, it is believed these units were beneficial to teachers in addition to students.

Conclusions

This project worked to determine if upper elementary students were capable of using Texas Instruments' technology in an effort to increase student interest in STEAM subjects. The researchers were able to successfully design and implement three units across the upper elementary grades along with pre- and post-assessments for teachers and students to measure interest. The data identified that students found themselves more interested in how electronics work, STEAM subjects, and coding with over sixty percent of students identifying increased interest. Teachers also found themselves to be more prepared to implement STEAM methods in their classroom following the units.

Discussion

The analysis confirms the majority of students and teachers responded positively to the implementation of this technology. Observations also indicate students in these age and developmental ranges are capable of successfully using this technology with guided lessons to support them. Both of these outcomes suggest support of the hypotheses of this study.

These results also build on existing evidence of instructional programs helping decrease the pre-established loss of interest in STEAM subjects during this time in a student's life (Vaidyanathan, 2012). This study also implements an integration of subjects along with hands-on learning to increase interest, which have also been determined to be effective in this study as well as others (Ekong, 2011; Moye, Dugger, & Starkweather, 2017). Due to this, methods, such as the ones implemented in this study, should be taken into account when teaching STEAM in the classroom seeing as interest was increased in this case.

Teacher concerns regarding time and access to materials were also further confirmed. Previous research indicates this is a challenge for teachers with STEAM education, and multiple teachers reported this concern continuing across the pre- and post-assessments of this study (Moye, Dugger, & Starkweather, 2017). While this study does not resolve this issue for teachers, it further supports the previously made claim.

Suggestions for Future Research

For future research and implementation of this technology, a checklist format with screenshots of what student's code should look like is suggested to guide student learning rather than paragraphs of text. Adjustments were made regarding the formatting of student resources following the pilot study, but it is believed students who struggle to read would benefit from more support.

It is also recommended to interview students rather than using an electronic pre- and post-assessment. Interviews are believed to give researchers a clearer picture of students' interests in STEAM subjects both before and after the implementation of technology. This will also give students the opportunity to further explain their thinking to the researcher.

Training general education teachers prior to the implementation of the units would also help support students further and lead to more confident adults assisting them in their learning. This would also give students more time to practice the skill since adults could navigate student issues faster.

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Appendix A: Student Pre-Assessment

Please answer the following questions. Your answers will only be seen by the researchers and your name will not be connected to your answers. Thank you!
* Required

1. **What is your name? ***

   [ ]

2. **What elementary school do you attend? ***
   - A Elementary
   - B Elementary
   - C Elementary

3. **What is your grade level?**
   - 3^{rd}
   - 4^{th}
   - 5^{th}

For the next part, answer the questions dependent on your current feelings. There are no right or wrong answers.

4. **Math has been my worst subject. ***
   - Strongly Disagree
   - Disagree
   - Neither Agree nor Disagree
   - Agree
   - Strongly Agree

5. **When I'm older, I might choose a job that uses math. ***
   - Strongly Disagree
   - Disagree
   - Neither Agree nor Disagree
   - Agree
   - Strongly Agree

6. **Math is hard for me. ***
   - Strongly Disagree
   - Disagree
   - Neither Agree nor Disagree

- Agree
- Strongly Agree

2. I am the type of student who does well in math. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

3. I can understand most subjects easily, but math is difficult for me. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

4. In the future, I could do harder math problems. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

5. I can get good grades in math. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

6. I am good at math.*

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

7. I feel good about myself when I do science. *

- Strongly Disagree

- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree
-

8. I might choose a career in science. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

9. After I finish high school, I will use science often.*

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

10. When I am older, knowing science will help me earn money. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

11. When I am older, I will need to understand science for my job. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

12. I know I can do well in science.*

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

13. Science will be important for me in my future career. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

14. I can understand most subjects easily, but science is hard for me to understand. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

15. In the future, I could do harder science work. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

Engineering and Technology: Please read this paragraph before you answer the questions. Engineers use math and science to invent things and solve problems. Engineers design and improve things, like bridges, cars, machines, foods, and computer games. Technologists build, test, and take care of the designs that engineers create.

16. I like to imagine making new products. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

17. If I learn engineering, then I can improve things that people use every day. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree

- Strongly Agree

18. I am good at building of fixing things. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

19. I am interested in what makes a machine work. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

20. Designing products or structures will be important in my future jobs. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

21. I am curious about how electronics work. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

22. I want to be creative in my future jobs. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

23. Knowing how to use science and math together will help me to invent useful things. *

- Strongly Disagree

- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

24. I believe I can be successful in engineering. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

25. I can lead others to reach a goal. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

26. I like to help others do their best. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

27. In school and at home, I can do things well. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

28. I respect all children my age even if they are different from me. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

29. I try to help other children my age. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

30. When I make decisions, I think about what is good for other people. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

31. When things do not go how I want, I can change my actions for the better. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

32. I can make my own goals for learning. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

33. I can use time wisely when working on my own. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

34. When I have a lot of homework, I can choose what needs to be done first. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

35. I can work well with other students, even if they are different from me. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

Your Future: Below is a list of jobs that you could have when you are older. As you read about each job, you will know if you think the job is interesting. Choose the words that describe how interested you are in having that job when you are older. There are no “right” or “wrong” answers! The only correct responses are those that are true for you.

41. Physics: People study motion, gravity and what things are made of. They also study energy, like how a swinging bat can make a baseball switch directions. They study how different liquids, solids and gas can be turned into heat or electricity. *

- Not interested at all
- Not so interested
- Interested
- Very Interested

42. Environmental Work: People study how nature works. They study how waste and pollution affect the environment. They also invent solutions to these problems. *

- Not interested at all
- Not so interested
- Interested
- Very Interested

43. Biology: People work with animals and plants and how they live. They also study farm animals and the food that they make, like milk. They can use what they know to invent products for people to use. *

- Not interested at all
- Not so interested
- Interested
- Very Interested

44. Veterinary Work: People prevent disease in animals. They give medicines to help animals get better for animal and human safety. *

- Not interested at all
- Not so interested

- Interested
- Very Interested

45. **Mathematics: People use math and computers to solve problems. They use it to make decisions in businesses and government. They use numbers to understand why different things happen, like why some people are healthier than others. ***

    - Not interested at all
    - Not so interested
    - Interested
    - Very Interested

46. **Medicine: People learn how the human body works. They decide why someone is sick or hurt and give medicines to help the person get better. They teach people about health, and sometimes they perform surgery. ***

    - Not interested at all
    - Not so interested
    - Interested
    - Very Interested

47. **Earth Science: People work with the air, water, rocks, and soil. Some tell us if there is pollution and how to make the earth safer and cleaner. Other earth scientists forecast the weather. ***

    - Not interested at all
    - Not so interested
    - Interested
    - Very Interested

48. **Computer Science: People write instructions to run a program that a computer can follow. They design computer games and other programs. They also fix and improve computers for other people. ***

    - Not interested at all
    - Not so interested
    - Interested
    - Very Interested

49. **Medical Science: People study human diseases and work to find answers to human health problems. ***

    - Not interested at all
    - Not so interested
    - Interested

- Very Interested

50. Chemistry: People work with chemicals. They invent new chemicals and use them to make new products, like paints, medicine, and plastic.*

- Not interested at all
- Not so interested
- Interested
- Very Interested

51. Energy/Electricity: People invent, improve and maintain ways to make electricity or heat. They design the electrical and other power systems in buildings and machines. *

- Not interested at all
- Not so interested
- Interested
- Very Interested

52. Engineering: People use science, math and computers to build different products (everything from airplanes to toothbrushes). Engineers make new products and keep them working. *

- Not interested at all
- Not so interested
- Interested
- Very Interested

Appendix B: Teacher Pre-Survey

You have been asked to participate in a research project conducted by Lindsay A. Gold, Ph.D. from the University of Dayton, in the Department of Teacher Education.

The purpose of the project is to determine if exposing students to the TI Innovator Hub and TI Rover will help stimulate interest and increase student learning in STEAM Education. The study will also explore teachers' perceptions for teaching using an integrated STEAM approach and their perceptions of the TI technology.

Read the information below, and ask questions about anything you do not understand, before deciding whether or not to participate.

- Your participation in this research is voluntary. You have the right to stop participating at any time for any reason. Answering the questions will take about 10 minutes.
- All of the information you tell us will be confidential.
- Any information collected during the research project will only be accessed by the researchers and it will be kept in a secure place.
- Only the researchers will have access to your responses. We will not report identifying information, but we cannot guarantee the security of the computer you use or the security of data transfer between that computer and our data collection point. We urge you to consider this carefully when responding to these questions.
- You understand that you are ONLY eligible to participate if you are over the age of 18.

Please contact the following investigator with any questions or concerns:
Lindsay A. Gold, Lgold1@udayton.edu, 937-229-3378:

You are consenting to participate by filling out the survey. By completing this survey, you agree that:
1. You have read the information above.
2. You have had a chance to ask questions and all of your questions have been answered to your satisfaction.
3. You certify that you are at least 18 years of age.

If you feel you have been treated unfairly, or you have questions regarding your rights as a research participant, you may contact Candise Powell, J.D., Chair of the Institutional Review Board at the University of Dayton, IRB@udayton.edu; Phone: (937) 229-3515.
* Required

1. **Email address** *

[ ]

2. **I feel prepared to teach Science.** *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

3. **I feel prepared to teach using technology.** *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

4. **I feel prepared to teach engineering.** *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

5. **I feel prepared to teach Art.** *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

6. **I feel prepared to teach using Math.** *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

7. **No matter how hard I try, I will not be able to teach STEAM units as well as I would teach individual subjects.** *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree

- Agree
- Strongly Agree

8. **I have never been exposed to STEAM content related to k-12 education in my own academic experience or pre-service course work.** *

    - Strongly Disagree
    - Disagree
    - Neither Agree nor Disagree
    - Agree
    - Strongly Agree

9. **I am likely to teach STEAM in the future.** *

    - Strongly Disagree
    - Disagree
    - Neither Agree nor Disagree
    - Agree
    - Strongly Agree

10. **My school expects me to teach STEAM.** *

    - Strongly Disagree
    - Disagree
    - Neither Agree nor Disagree
    - Agree
    - Strongly Agree

11. **I have never received professional development on STEAM education.** *

    - Strongly Disagree
    - Disagree
    - Neither Agree nor Disagree
    - Agree
    - Strongly Agree

12. **I am comfortable using project based learning in my classroom.** *

    - Strongly Disagree
    - Disagree
    - Neither Agree nor Disagree
    - Agree
    - Strongly Agree

13. **I have access to an ample amount of STEAM resources.** *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

14. I am comfortable incorporating technology into my teaching. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

15. I am excited to teach STEAM. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

16. I am comfortable integrating subjects when I am teaching. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

17. STEAM education is not appropriate for my grade level. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

18. I have never taught using STEAM. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

19. I do not understand why STEAM is beneficial. *

- ○ Strongly Disagree
- ○ Disagree
- ○ Neither Agree nor Disagree
- ○ Agree
- ○ Strongly Agree

20. When teaching STEAM, I have no control over my students' learning. *

- ○ Strongly Disagree
- ○ Disagree
- ○ Neither Agree nor Disagree
- ○ Agree
- ○ Strongly Agree

21. I wonder if I have the necessary skills to teach STEAM. *

- ○ Strongly Disagree
- ○ Disagree
- ○ Neither Agree nor Disagree
- ○ Agree
- ○ Strongly Agree

22. Given the choice, I will not invite the principal to evaluate my STEAM teaching. *

- ○ Strongly Disagree
- ○ Disagree
- ○ Neither Agree nor Disagree
- ○ Agree
- ○ Strongly Agree

23. When a student has difficulty understanding a STEAM concept, I will usually be at a loss as to how to help the student understand it better. *

- ○ Strongly Disagree
- ○ Disagree
- ○ Neither Agree nor Disagree
- ○ Agree
- ○ Strongly Agree

24. I am interested in STEAM education. *

- ○ Strongly Disagree
- ○ Disagree

- Neither Agree nor Disagree
- Agree
- Strongly Agree

25. I do not know what to do to turn students on to STEAM related fields. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

26. I feel prepared to teach STEAM. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

27. In my opinion, students' understanding will increase more using STEAM education. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

28. I am comfortable incorporating STEAM activities into my classroom. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

29. It is important to teach STEAM at my grade level. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

30. I am comfortable using problem solving in my classroom. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

31. I would likely contact my district STEAM leader for resources and materials. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

32. I have no idea where to even begin to teach STEAM. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

33. My school frequently conducts after school programs to promote STEAM education. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

34. It is important to attend professional development opportunities to learn more about STEAM. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

35. I would prefer online professional development on STEAM rather than face-to-face. *

- Strongly Disagree
- Disagree

- Neither Agree nor Disagree
- Agree
- Strongly Agree

36. I know how to teach STEAM. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

37. How long (in years) have you been teaching? *

[ ]

38. What is the current grade level(s) that you are teaching? *

[ ]

39. What subject areas do you teach? *

[ ]

40. In what building do you teach? *

[ ]

41. What methods do you, or would you use to teach STEAM in your classroom? *

[ ]

42. How often do you , or would you incorporate STEAM activities into your classroom? *

- Daily
- Weekly
- Monthly
- Other: _______________

43. How do you, or would you assess your students on STEAM activities? *

[ ]

44. What are some challenges you face when teaching STEAM activities? *

[ ]

45. What types of professional development regarding STEAM are you most interested in attending? *

[ ]

46. How do you define STEAM? *

[ ]

Appendix C: Introduction to Coding Lesson Plan

5th, 4th and 3rd Grade Coding Lesson 1

Complete prior to STEAM Team Teaching
Complete during STEAM Team Teaching
Complete after STEAM Team Teaching

Standards: (This lesson is designed to reinforce the State Standards. Student mastery of the standards is not expected to be accomplished with this lesson.)

Nature of Science

1. Develop and communicate descriptions, models, explanations and predictions.
2. Think critically and ask questions about the observations and explanations of others.
3. Communicate scientific procedures and explanations.
4. Apply knowledge of science content to real-world challenges.
5. Scientists often work in teams.
6. Science affects everyday life.
7. Science requires creativity and imagination.

Technology

1. Identify and use appropriate digital learning tools and resources to accomplish a defined task.
2. Demonstrate an understanding of technology's impact on the advancement of humanity – economically, environmentally and ethically.
3. Analyze the impact of communication and collaboration in both digital and physical environments.
4. Explain how technology, society, and the individual impact one another.
5. Define and describe technology, including its core concepts of systems, resources, requirements, processes, controls, optimization and trade-offs.
6. Demonstrate that solutions to complex problems require collaboration, interdisciplinary understanding, and systems thinking.

Language Arts

College and Career Readiness Anchor Standards for Speaking and Listening

1. COMPREHENSION AND COLLABORATION

a. 1. Prepare for and participate effectively in a range of conversations and collaborations with diverse partners, building on others' ideas and expressing their own clearly and persuasively.

b. 2. Integrate and evaluate information presented in diverse media and formats, including visually, quantitatively, and orally.

c. 3. Evaluate a speaker's perspective, reasoning, and use of evidence and rhetoric.

2. VOCABULARY ACQUISITION AND USE
   - . Acquire and use accurately a range of general academic and domain specific words and phrases sufficient for reading, writing, speaking, and listening at the college and career readiness level; demonstrate independence in gathering vocabulary knowledge when encountering an unknown term important to comprehension or expression.

Informational Text

1. RI.5.7 Draw on information from multiple print or digital sources, demonstrating the

ability to locate an answer to a question quickly or to solve a problem efficiently.

Writing

1. W.5.4 Produce clear and coherent writing in which the development and organization are appropriate to task, purpose, and audience.
2. W.5.8 Recall relevant information from experiences or gather relevant information from print and digital sources; summarize or paraphrase information in notes and finished work and provide a list of sources.

Speaking and Listening Standards

1. SL.5.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 5 topics and texts, building on others' ideas and expressing their own clearly

Social and Emotional Standards

Competency A: Self-Awareness

1. A1: Demonstrate an awareness of personal emotions
   a. A1. 2.b Identify that emotions are valid, even if others feel differently
2. A3: Demonstrate awareness of and willingness to seek help for self or others

. A3. 2.b Seek help and acknowledge constructive feedback from others that addresses challenges and builds on strengths

3. A4: Demonstrate a sense of personal responsibility, confidence and advocacy

. A4. 1.b Identify and describe how personal choices and behavior impacts self and others

a. A4. 3.b Identify ways to respectfully advocate for academic and personal needs

Competency B: Self-Management

1. B1: Regulate emotions and behaviors by using thinking strategies that are consistent with brain development

a. B1. 3.b Apply strategies to regulate emotions and manage behaviors

2. B3: Persevere through challenges and setbacks in school and life

. B3. 1.b Identify strategies for persevering through challenges and setbacks

Competency C: Social Awareness

1. C1: Recognize, identify and empathize with the feelings and perspective of others
2. C1. 2.b Identify and acknowledge others' viewpoints, knowing that both sides do not have to agree but can still be respectful

Competency E: Responsible Decision-Making

1. E1: Develop, implement and model effective decision and critical thinking skills

a. E1. 1.b Generate possible solutions or responses to a problem or needed decision recognizing that there may be more than one perspective

b. E1. 2.b Implement strategies to solve a problem

2. E4: Explore and approach new situations with an open mind and curiosity while recognizing that some outcomes are not certain or comfortable

. E4. 1.b Explore new opportunities to expand one's knowledge and experiences

ESOL Vocabulary:

1. Coding
2. Cooperate
3. Collaborate
4. Consensus

Speech/Language
Expanding Expression Tool: Have the student answer the following question by using the Expanding Expression Tool - *What is coding?* **Writing instructions in a determined sequence to make something work.**

Homeroom prior to STEAM Team Teaching -

1. Watch the following video: Coding

a. Give students time to take notes about the video/ask questions about the information presented.

2. Have students enrolled into homeroom teacher's Google Classroom.

STEAM Coach's responsibilities prior to STEAM Team Teaching Class:

1. Sending lesson to homeroom teacher prior to STEAM Team Teaching scheduled time.
2. Provide Collaboration boards.

Teacher Roles:
Homeroom Teacher (HT)
STEAM Coach (SC)
Both (B)

Procedures:

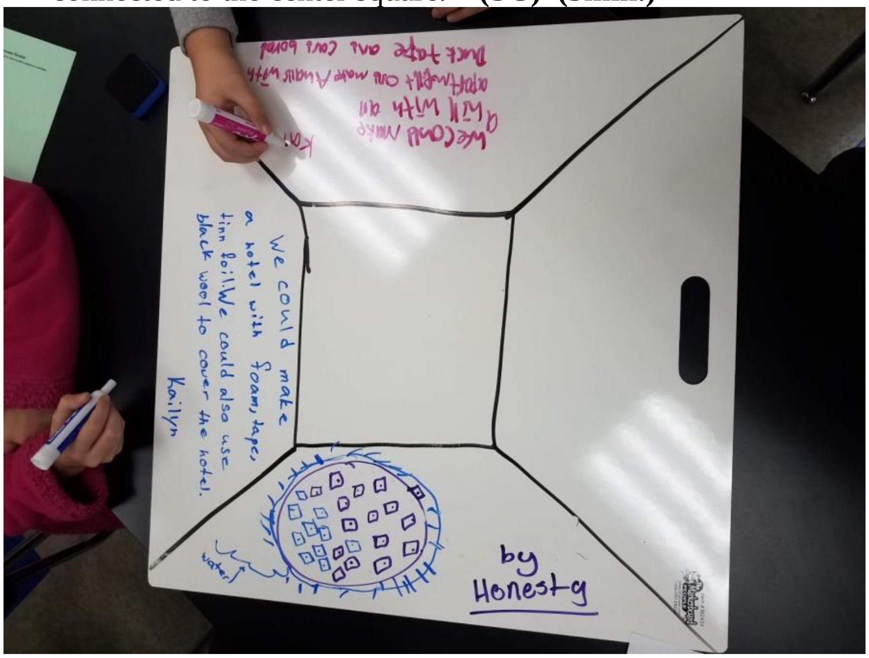
Student Pre Survey
Here is the shortened URL for the survey: https://tinyurl.com/snhf5dh (B) (25 min.)

1. Review or introduce the students to the 4C's. (communicate, cooperate, collaborate,

consensus) The 4C's enhances critical thinking. Woman running home from a masked man. **(SC) (2 min.)**

3. Divide the class into groups of three. Give each group a collaboration board, markers and erasers. **(HT) (2 min.)**

3. Have the students draw a square in the middle of the board and draw four trapezoids connected to the center square. **(SC) (5min.)**

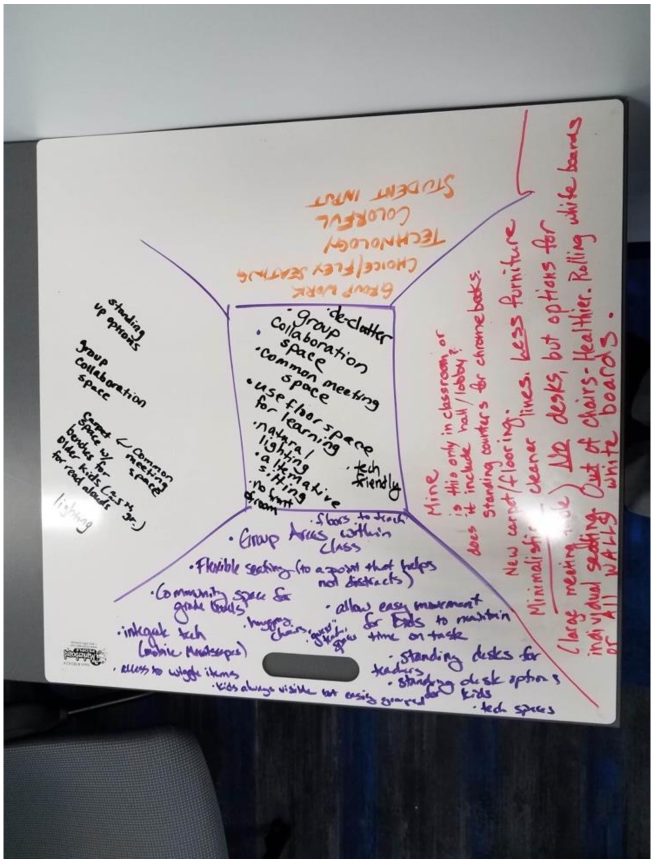


4. Display the question, [“What is coding?”]() somewhere in the classroom and ask the students to reflect what they think coding is all about. Have each student write what they think coding in their trapezoids. Give the students 3 minutes to reflect. There should be no talking. **(SC) (4 min.)**

5. Have the students watch the video [Coding for Kids 1: What is Computer Coding?]() **(HT) (2 min.)**

6. Now that the students have more information have them review their brainstorming and have them cross out ideas they no longer think is coding and write down new ideas. **(SC) (2 min.)**

7. Have the students communicate their brainstorming with the other students in their group. Then instruct them to collaborate their ideas to reach a consensus regarding the answer to the question, What is coding? Have them write their consensus in the middle square. Inform the students that they are not allowed to give examples of coding. (No voting or rock, paper, scissors for consensus.) **(B) (8 min.)**



8. Have one person from each group read their consensus answer. **(B) (5 min.)**

9. Inform the students that this video will give them an idea of what they will be coding. Have the students watch the following video. TI-Innovator Rover puts STEM into motion **(HT) (2 min.)**

10. Inform the students that we will be using the hub during our next class.

Post STEAM Team Teaching Class:

1. Have the students answer the following question: (Dimensions of Depth and Complexity: **Unanswered Questions**)
   What ideas remain unclear or incomplete about coding?

Appendix D: Coding for Colors and Sounds Lesson Plan

<table>
<tr><td>Standards:
Science:
3.PS.3: Heat, electrical energy, light, sound and magnetic energy are forms of energy. There are many different forms of energy. Energy is the ability to cause motion or create change. The different forms of energy that are outlined at this grade level should be limited to familiar forms that a student is able to observe.
Art:
2PE Identify the relationships between and among selected elements and principles of art and design.</td><td>M
M</td><td>T
B</td><td>W
Ab</td><td>H
Ah</td></tr>
<tr><td>ESOL Vocabulary:
1. Circuit
2. Energy
3. Loop
4. RGB</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Speech/Language:
1. Practice steps in a process.
2. Deepen students’ level of understanding of the concepts by using the Expanding Expression Tool.</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Week 2</td><td></td><td></td><td></td><td></td></tr>
<tr><td>(Optional)
Homeroom prior to STEAM -
1. Have students view the BrainPop video title Electric Circuit
2. Reinforce the concept of open and closed circuits by conducting a demonstration of open and closed circuits using the energy sticks.
3. Energy sticks will be provided.</td><td></td><td></td><td></td><td></td></tr>
<tr><td>STEAM Leader’s responsibilities prior to STEAM Class:
1. 2 programs will be coded for students to input frequencies and colors
2. Prepare energy sticks for classroom teachers.
3. Share BrainPop video on Google classroom.</td><td></td><td></td><td></td><td></td></tr>
</table>

Teacher Roles: **Homeroom Teacher (HT) (When present)** 1. Share prior to STEAM class activity. **STEAM Leader (SL)** 1. Lead class discussion. 2. Conclude lesson. **Both (B)** 1. Ensure students stay on task during lesson				
Procedures: Have students sit at tables.				
1. Review open and closed circuits with students. Connect to the prior to STEAM activities. **(HT) (3 min.)**				
2. Using document camera SL will go through the steps of how to code calculator to create light and sound with them just watching. **(SL) (5 min.)**				
3. Pass out hubs and calculators and have the class code together with the SL coding on the display calculator at the board. **(SL) (5 min.)**				
4. Groups will be tasked at attempting to make the hub work without connecting it to the calculator. When they say that this is impossible SL will explain how important loops are in circuits to ensure that there is a clear path for energy to be transferred. **(SL) (5 min.)**				
5. Groups will complete an activity sheet that goes through steps of how to code and determine if light energy and sound energy overlap at all. Students will be tasked at creating different colors and pitched sounds on the hub with instructions on the handout. **(SL) (30 min.)**				
6. SL leader will bring class back together as a whole group and share answers to problems on the worksheet that deduces that light energy and sound energy are both energy just in different forms. **(SL) (10 min.)**				

Appendix E: Coding for Colors Instructions

- ❑ Turn on your calculator or return to the home screen by pressing the **on**
- ❑ Press **2** to browse documents
- ❑ Using the arrow keys, scroll to select the document **color**
- ❑ Press **enter** to select it
- ❑ If asked if you would like to save, select **No**
- ❑ Press **menu**
- ❑ Press **2** to check and store the syntax
- ❑ Press **3** to run the program
- ❑ Your cursor should be in between the two parentheses. Press **enter**
- ❑ Create a color by typing ‘**255**’ for the ‘R Value?’
- ❑ Press **enter** for OK
- ❑ Type ‘**0**’ for the ‘G Value?’
- ❑ Press **enter** for OK
- ❑ Type ‘**0**’ for the ‘B Value?’
- ❑ Press **enter** for OK

  What color is created? ____________________

- In order to run the program again…
  - ❑ Press **var**
  - ❑ Select **color**
  - ❑ Press **enter** to run the program
  - ❑ Your cursor should be in between the two parentheses. Press **enter**
- ❑ Create another color by typing ‘**0**’ for the ‘R Value?’
- ❑ Press **enter** for OK
- ❑ Type ‘**255**’ for the ‘G Value?’
- ❑ Press **enter** for OK
- ❑ Type ‘**0**’ for the ‘B Value?’
- ❑ Press **enter** for OK

  What color is created? ____________________

- In order to run the program again…
  - ❑ Press **var**
  - ❑ Select **color**
  - ❑ Press **enter**
  - ❑ Your cursor should be in between the two parentheses. Press **enter**
- ❑ Create another color by typing ‘**0**’ for the ‘R Value?’
- ❑ Press **enter** for OK

- ❑ Type ‘**0**’ for the ‘G Value?’
- ❑ Press **enter** for OK
- ❑ Type ‘**255**’ for the ‘B Value?’
- ❑ Press **enter** for OK

  What color is created? ____________________

Form a hypothesis of what words are represented by the letters RGB.

R: _______________________

G: _______________________

B: _______________________

- ❑ Using what you have learned about RGB, run the program again to fill in the chart below and continue creating new colors when finished!
- In order to run the program again…
  - ❑ Press **var**
  - ❑ Select **color**
  - ❑ Press **enter**
  - ❑ Your cursor should be in between the two parentheses. Press **enter**

Color	**R**	**G**	**B**
	255	255	0
Purple			
	255	20	147
Orange			
White			

For a list of more RGB color codes, check out tinyurL.com/yasum2oj

Appendix F: Coding for Colors Student Response Sheet

Name:______________________________ Teacher Name:_______________________

In this activity, what do the letters RGB represent?

R: _______________________

G: _______________________

B: _______________________

Color	R	G	B
	255	255	0
Purple			
	255	20	147
Orange			
White			

Appendix G: Coding for Sounds Instructions

- ❑ Turn on your calculator or return to the home screen by pressing the **on**
- ❑ Press **2** to browse documents
- ❑ Using the arrow keys, scroll to select the document **sound**
- ❑ Press **enter** to select it
- ❑ If asked if you would like to save, select **No**
- ❑ Press **menu**
- ❑ Press **2** to check and store the syntax
- ❑ Press **3** to run the program
- ❑ Your cursor should be in between the two parentheses. Press **enter**
- ❑ Create a pitch by typing the value '**450**' for 'Frequency'
- ❑ Press **enter** for OK
- ❑ Type '**1**' for 'Time'.
- ❑ Press **enter** for OK and listen carefully
- ❑ Create a second pitch by running the program again.
- In order to run the program again…
    - ❑ Press **var**
    - ❑ Select **sound1**
    - ❑ Press **enter**
    - ❑ Your cursor should be in between the two parentheses. Press **enter**
- ❑ Input the value '**550**' for 'Frequency'
- ❑ Press **enter** for OK
- ❑ '**1**' for 'Time'
- ❑ Press **enter** for OK

  Was the second sound higher or lower? ________________________________

- ❑ Continue to try different pitches and explore sound by running the program again.
- In order to run the program again…
    - ❑ Press **var**
    - ❑ Select **sound1**
    - ❑ Press **enter**
    - ❑ Your cursor should be in between the two parentheses. Press **enter**

Based on your discoveries, fill in the blanks for the following sentences:

__________________ determines the pitch of a sound. The _______________

the frequency of a sound, the higher the pitch.

Appendix H: Coding for Sounds Student Response Sheet

Name:______________________ Teacher Name:_____________________

Exit Ticket

__________________ determines the pitch of a sound. The _______________ the frequency of a sound, the higher the pitch.

Appendix I: Coding for Area and Perimeter Lesson Plan

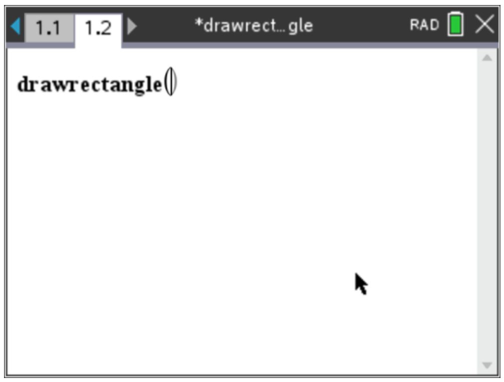
Standards **Math:** 3.MD.7 Relate area to the operations of multiplication and addition. 3.G.1 Draw and describe triangles, quadrilaterals (rhombuses, rectangles, and squares), and polygons (up to 8 sides) based on the number of sides and the presence or absence of square corners (right angles). **Technology:** Society and Technology: Topic 3 - Demonstrate how technology innovations/inventions can have multiple applications. Design and Technology: Topic 1 - Describe a process as a series of actions and how it is used to produce a result. Topic 2 - Generate, develop, and communicate design ideas and decisions using appropriate terms and graphical representations.	M M	T B	W Ab	H Ah
ESOL Vocabulary: 1. Perimeter 2. Area				
Speech/Language: 1. Practice steps in a process. 2. Deepen students' level of understanding of the concepts by using the **Expanding Expression Tool.**				
I Can Statements				
Week 3				
(Optional) **Homeroom prior to STEAM -** 1. Have the students watch the video How to find Area and Perimeter. (I shared this on the STEAM Google Classroom) 2. Gizmo Options: a. Have the students complete the Area and Perimeter Gizmo on their own or with a partner. b. Use the Area and Perimeter Gizmo Presentation Mode as a whole class lesson. Gizmo Teacher Guide. 3. Use GeoBoard Activities to reinforce the concept of area and perimeter. 4. Have students read the article California Fire and complete the quiz. The article has been assigned in their Google Classroom.				
STEAM Leader's responsibilities prior to STEAM Class: 1. Program will be coded for students to create rectangles and other				

shapes.				
Teacher Roles: **Homeroom Teacher (HT) (When present)** 1. Share prior to STEAM class activity. **STEAM Leader (SL)** 1. Lead class discussion. 2. Conclude lesson. **Both (B)** 1. Ensure students stay on task during lesson				
Procedures: Have students sit at tables.				
1. Pass out calculators and hubs. **(SL) (3 min.)**				
2. Give students time to finish last week's activity and exchange hubs with rovers as students finish the activity. **(SL) (15 min.)**				
3. Exchange hubs with rovers as students finish the previous week's activity. **(SL) (5 min.)**				
4. Make connection to the Newsela California Fire to area and perimeter by showing students how the government keeps track of the size of forest fires. US Wildfire Activity Map Incident Information System Southern California Fires				
4. Students will then follow along on handout to create rectangles of various sizes and then will calculate their area and perimeter. When they finish with this side of the sheet a teacher will check and they can move onto the back. **(B) (20 min.)**				
5. Students will then follow along on handout to create different shapes. **(SL) (15 min.)**				
6. SL leader will bring class back together as a whole group and share answers to problems and have students return materials. **(SL) (5 min.)**				

Appendix J: Coding for Area and Perimeter Instructions

- ❑ Turn on your calculator or return to the home screen by pressing the **on**
- ❑ Press **2** to browse documents
- ❑ Using the arrow keys, scroll to select the document **drawrectangle**
- ❑ Press **enter** to select it
- ❑ If asked if you would like to save, select **No**
- ❑ Press **menu**
- ❑ Press **2** to check and store the syntax
- ❑ Press **3** to run the program

Your screen will look like this:



- ❑ Your cursor should be in-between the parentheses. Press **enter**
- ❑ A box will pop up and ask you to input *length*. This will be the first number from your chart located on the back of this paper
- ❑ Press **enter**
- ❑ Another box will pop up asking you to input the *width*. This will be the second number from your chart (to the right of the first number). DO NOT PRESS ENTER YET!
- ❑ Place your marker in the Rover
- ❑ Now, press **enter**
- ❑ After the shape is drawn, remove the marker and pick up the Rover with two hands
- ❑ Using your ruler, measure to find the perimeter and area of each rectangle
- In order to run the program again…
    - ❑ Press **var**
    - ❑ Select **drawrectangle**
    - ❑ Press **enter**
    - ❑ Press **enter** again for the input box
    - ❑ Type numbers according to the chart

Appendix K: Coding for Perimeter and Area Student Response Sheet

How do you find the perimeter of a rectangle? ________________________________

How do you find the area of a rectangle? ___________________________________

Length	Width	Perimeter	Area
40 cm	10 cm		
30 cm	30 cm		
20 cm	10 cm		
10 cm	30 cm		

Can you create two rectangles with the same area but different perimeters. How?

____

____

Appendix L: Coding for Shapes Instructions

❑ Turn on your calculator or return to the home screen by pressing the **on**

❑ Press **2** to browse documents

❑ Scroll to select the document **drawShape**

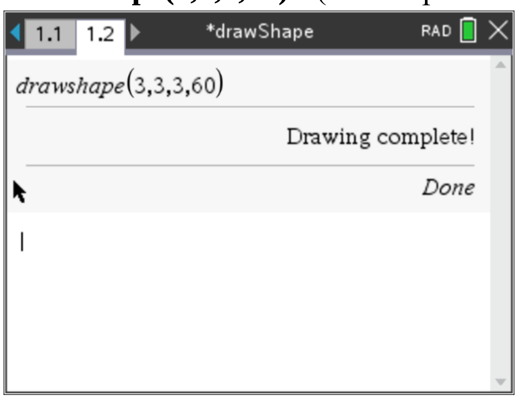
❑ If asked if you would like to save, select **No**

❑ Press **menu**

❑ Press **2** to check and store the syntax

❑ Press **3** to run the program

- In order to create a shape, you need to code the *number of sides, length of the sides, the number of angles, and the degree of the angles* with commas in between each number, by entering the numbers from the chart in order
- For example for the line on the calculator will read '**drawshape(3,3,3,60)**'. (Do not press enter yet!)



❑ Place your marker in the Rover

❑ Press **enter**

❑ After the shape is drawn, remove the marker and pick up the Rover with two hands

❑ Fill in the chart to name the shape

❑ With your marker, divide the shape into parts with equal areas. Write a unit fraction to represent each part of the whole

- For example, divide the triangle into 3 equal pieces, represented by $\frac{1}{3}+\frac{1}{3}+\frac{1}{3}=\frac{3}{3}$

- In order to run the program again…
  - Press **var**
  - Select **drawShape**
  - Press **enter**

Appendix M: Coding for Shapes Response Sheet

Coding Shapes

Number of Sides	**Length of Sides**	**Number of Angles**	**Degree of Angles**	**Shape**
3	3	3	60	
4	3	4	90	
5	3	5	108	
6	3	6	120	
8	3	8	135	

**Length and width are measured in centimeters. Each unit is equal to 10 cm, thus 3 = 30 cm.

Appendix N: Coding for Lines and Angles Lesson Plan

Standards:	MM	TB	WAb	HAh
Standards: **Math:** 4.MD.6 Measure angles in whole number degrees using a protractor. Sketch angles of specified measure. 4.MD.5 Recognize angles as geometric shapes that are formed wherever two rays share a common endpoint, and understand concepts of angle measurement. -Understand an angle is measured with reference to a circle with its center at the common endpoint of the rays, by considering the fraction of the circular arc between the points where the two rays intersect the circle. An angle that turns through 1/360 of a circle is called a "one-degree angle," and can be used to measure angles. -Understand an angle that turns through n one-degree angles is said to have an angle measure of n degrees. 4.G.1 Draw points, lines, line segments, rays, angles (right, acute, and obtuse), and perpendicular and parallel lines. Identify these in two-dimensional figures. **Language Arts**: RI.4.4 Determine the meaning of general academic and domain-specific words or phrases in a text relevant to a grade 4 topic or subject area. RI.4.8 Explain how an author uses evidence to support particular points in a text. RL.4.4 Determine the meaning of words and phrases as they are used in a text, including those that allude to significant characters found in mythology (e.g., Herculean). **Technology:** Society and Technology: Topic 3 - Demonstrate how technology innovations/inventions can have multiple applications. Design and Technology: Topic 1 - Describe a process as a series of actions and how it is used to produce a result. Topic 2 - Generate, develop, and communicate design ideas and decisions using appropriate terms and graphical representations.				
ESOL Vocabulary: 1. Angles				
Speech/Language: 1. Practice steps in a process. 2. Deepen students' level of understanding of the concepts by using the **Expanding Expression Tool.**				
I Can Statements				

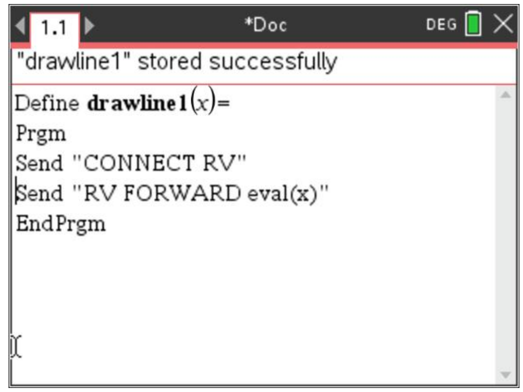
Week 3				
(Optional) **Homeroom prior to STEAM -** 1. Have the students watch the Brainpop Video Angles. (The video is located in the student STEAM Google Classroom.) 2. Using a protractor worksheet. (Copies will be placed in your mailbox.) 3. Measuring angle task cards. PDF (Task Card Set will be placed in your mailbox.) 4. Language Arts - Have the students read the Newsela article and take the quiz. ***I have assigned this to each student through Google Classroom.***				
STEAM Leader's responsibilities prior to STEAM Class: 1. 2 programs will be coded for students to input frequencies and colors 2. Copy Coding Angles Directions. 3. Prepare TI Inspire calculators and rovers. 4. Provide protractors for each classroom.				
Teacher Roles: **Homeroom Teacher (HT) (When present)** 1. Share prior to STEAM class activity. **STEAM Leader (SL)** 1. Lead class discussion. 2. Conclude lesson. **Both (B)** 1. Ensure students stay on task during lesson				
Procedures: Have students sit at tables.				
1. Pass out calculators and hubs. **(SL) (3 min.)**				
2. Give students time to finish last week's activity. **(SL) (15 min.)**				
3. Review how to use a protractor and exchange hubs with rovers as students finish the previous week's activity. Angles related to a circle. **(SL) (5 min.)**				
4. Students will use the program uploaded to the calculator to draw different angles. Students will then check the rover's work to ensure that it drew the proper angle. **(SL) (15 min.)**				
5. Students will then use the next program to use the rovers to draw lines. Students will add the proper points to make the lines line segments and rays. **(SL) (10 min.)**				
6. SL leader will bring class back together as a whole group and share				

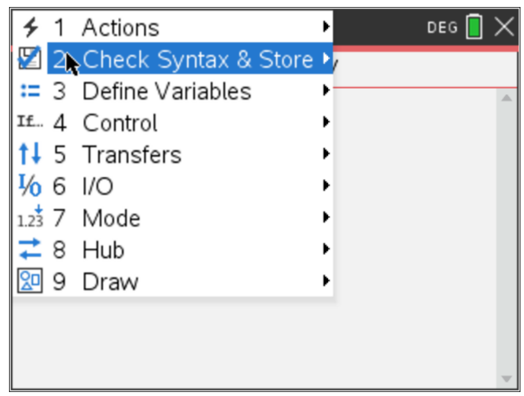
answers to problems on the worksheet and ensure that they can explain the differences between line segments and rays as well as how to measure angles. **(SL) (5 min.)**				

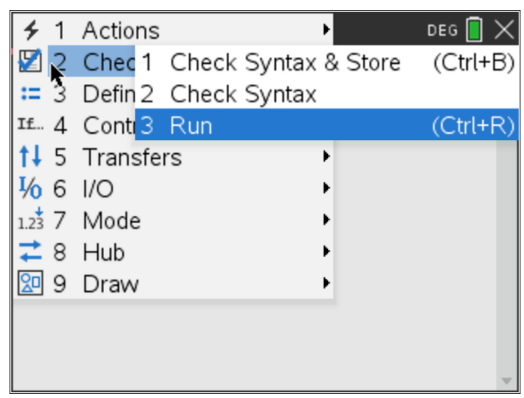
Appendix O: Coding for Lines and Angles Instructions

Turn on your calculator or return to the

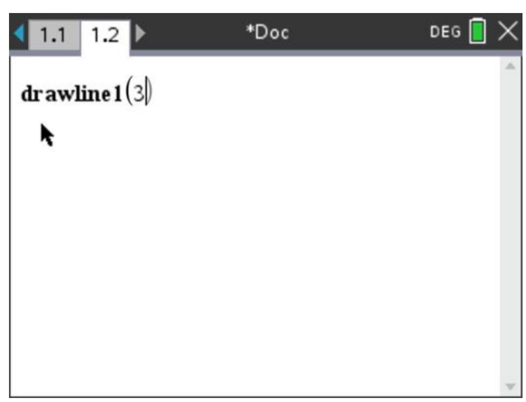
- ❑ home screen by pressing the **on**
- ❑ Press **2** to browse documents
- ❑ Scroll to select the document **drawline1**
- ❑ When asked if you would like to save select '**No**'
- ❑ Press **menu**
- ❑ Press **2** to save the syntax
- ❑ Press **3** to run the program



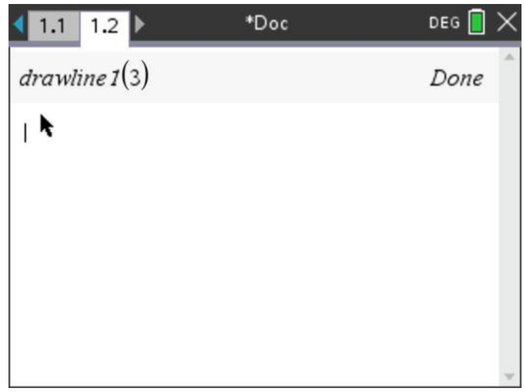


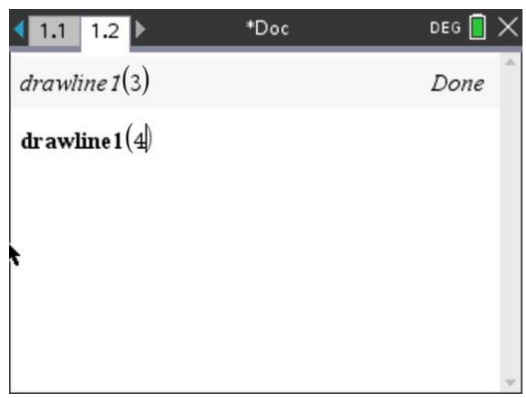


- ❑ Inside the parentheses put in the length of the line
  - For example, the line on the calculator will read '**drawline1(3)**' and then
- ❑ Press '**enter**' to run the program

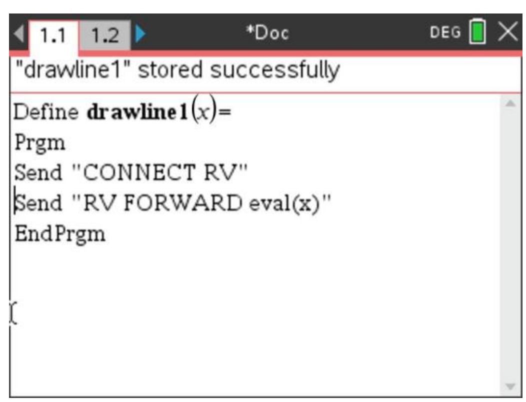


- ❑ Use your marker to add onto the line what is needed to make this a line segment
- ❑ Pick up the Rover with two hands and move it down the paper
- ❑ Press ‘**var**’
- ❑ Then select ‘**drawline1**’

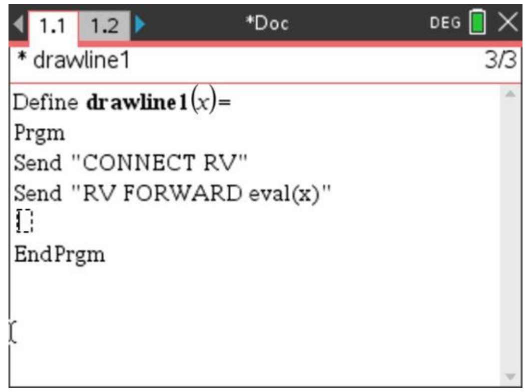




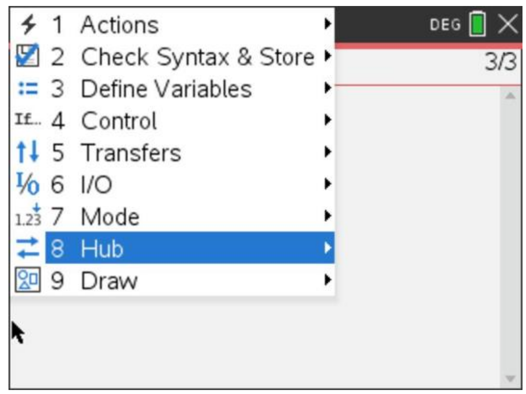
- ❑ Inside the parentheses put the number ‘**4**’
- ❑ Press ‘**enter**’ to draw another line
- ❑ Add onto the line what is needed to make this a ray
- ❑ Pick up the Rover with two hands and move it down the paper
- ❑ Move the mouse up to the ‘**1.1**’ in the upper left of the screen and click on it



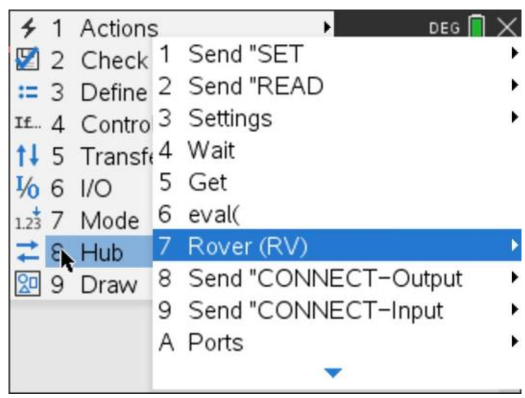
- ❑ Go to the end of the line that reads ‘Send “RV FORWARD eval(x)”’ and then push ‘**enter**’ to create a new line



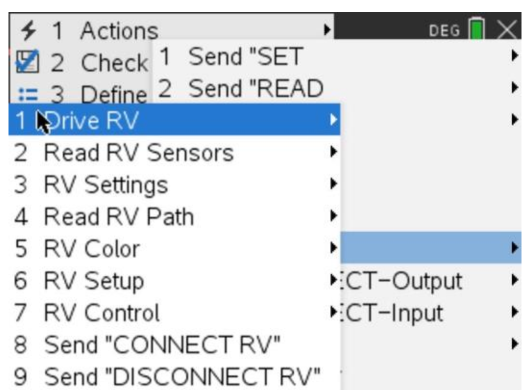
- ❑ Press ‘**menu**’ to write another line of code
- ❑ Press ‘**8**’ to connect to the Hub



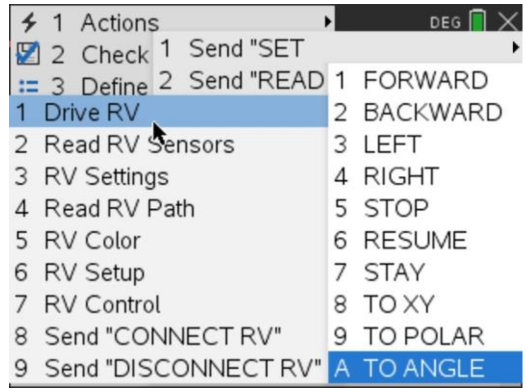
- ❑ Press ‘**7**’ to connect to the Rover



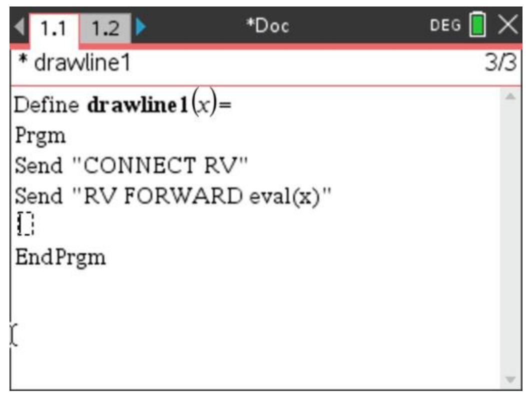
- ❑ Press ‘**1**’ to command to drive the Rover



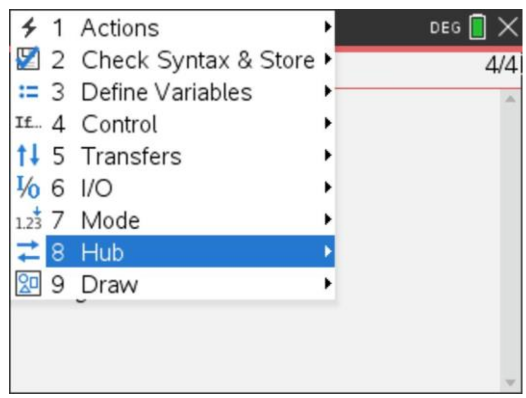
- ❑ Press ‘**A**’ to command to draw and angle



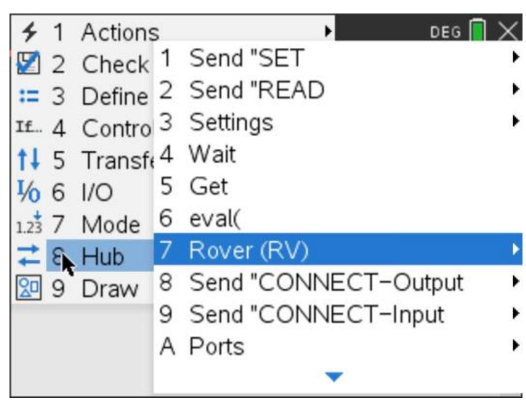
- ❑ Type the number ‘**90**’. Your calculator should read ‘Send “RV TO ANGLE 90”



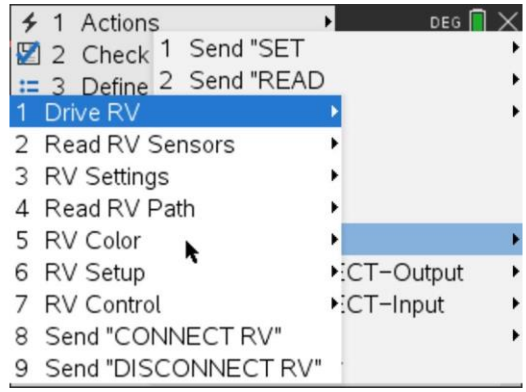
- ❑ Press ‘**enter**’ to create a new line
- ❑ Press ‘**menu**’ to write another line of code
- ❑ Press ‘**8**’ to connect to the Hub



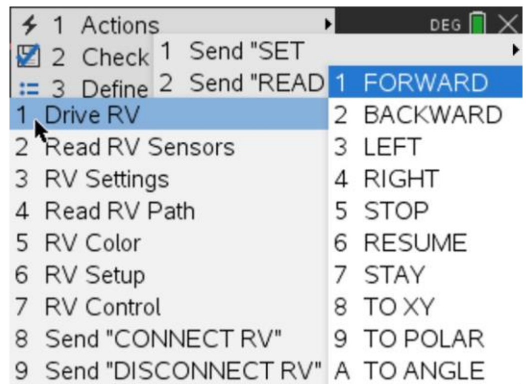
- ❑ Press ‘**7**’ to connect to the Rover



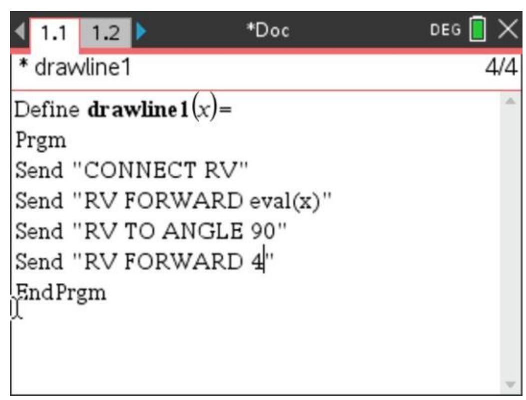
- ❑ Press ‘**1**’ to command to drive the Rover



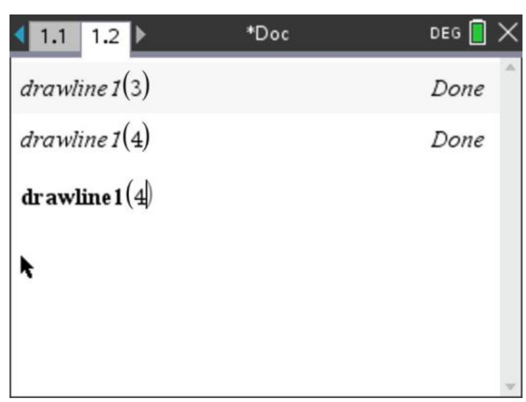
- ❑ Press ‘**1**’ again to send the Rover forward



- ❑ Type the number ‘**4**’ to command it to move 40 cm
- ❑ Press ‘**menu**’
- ❑ Press ‘**2**’ to save the syntax
- ❑ Press ‘**3**’ to run the program



- ❑ Type the number ‘**4**’ so your calculator reads ‘**drawline(4)**’
- ❑ Press ‘**enter’**



Appendix P: Coding for Angles Student Response Sheet

Name: ________________________Teacher Name: ________________________

Coding Angles

Degree	**Type of Angle**
150	
90	
60	
135	
45	
	Acute
	Obtuse

What is an acute angle? ____

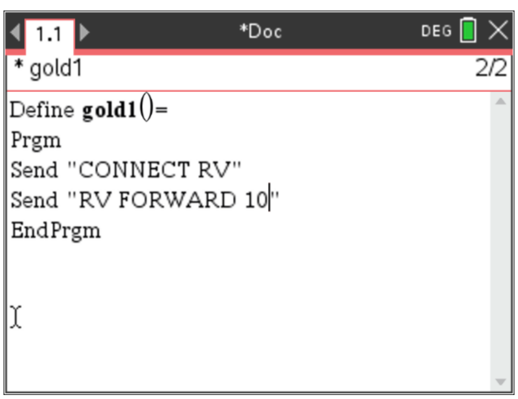
What is an obtuse angle?____

What is a right angle?____

Appendix Q: Coding for Speed Instructions

- ❑ Press **on**
- ❑ Press **1** to start a new document
- ❑ When asked if you would like to save, select **No**
- ❑ Press **9** to open the program editor
- ❑ Press **1** to begin a new program
- ❑ Name your program your teacher's last name and your table number and then press **enter** <u>or</u> click **OK**
- ❑ Press **menu** to write a line of code
- ❑ Press **8** to connect to the Hub
- ❑ Press **7** to connect to the Rover
- ❑ Press **8** to select the 'CONNECT RV' and add it to the line of code
- ❑ Press **enter** to start a new line of code
- ❑ Press **menu**
- ❑ Press **8** to connect to the Hub
- ❑ Press **7** to connect to the Rover
- ❑ Press **1** to select the 'DRIVE RV'
- ❑ Press **1** again to select the 'RV FORWARD' and add it to the line of code
- ❑ Type **10** at the end of the code line (each unit equals 10 cm, so 10 = 100cm)

Your program should look like the picture below!



- ❑ Press **menu**
- ❑ Press **2** to save the syntax
- ❑ Press **3** to run the program
- ❑ Press **enter** to run your program then follow the next directions!

- ❑ Do this once as a test and then, with your stopwatch, time how long it takes the Rover to move 10 (100 cm).
- ● In order to run the program again…
  - ❑ Press **var**
  - ❑ Select **(teacher name and table number)**
  - ❑ Press **enter**

How long did it take for the Rover to move 100 cm? ____________________

- ❑ Now, use the formula $speed = distance/time$ to determine the speed of the Rover.

What was the speed of the Rover? _________________________

- ❑ Try this again only use 20 (200 cm) this time and see if the Rover's speed changes (Hint: you'll have to edit your program on tab 1.1).
- ● In order to edit your program…
  - ❑ Pick up the Rover with two hands and move it down the paper
  - ❑ Move the mouse up to the '**1.1**' in the upper left of the screen and click on it
- ❑ Edit your program by placing the cursor after the RV FORWARD command
- ❑ Using the ← **del** key, delete the 10
- ❑ Use the number keys to type **20**
- ❑ Press **menu**
- ❑ Press **2** to save the syntax
- ❑ Press **3** to run the program
- ❑ Press **enter** to run your program

How long did it take the Rover to travel 200 cm?_____________________

What was the speed of the Rover for 200 cm?___________________

Did the speed change from before?________________________

Why do you think it did or did not change? __________________________________

You can change the speed of your Rover!

- ❑ Edit your program to change the speed of the Rover by following the directions (below the picture) to look like the picture below.

- ❑ Place the cursor after the RV FORWARD command
- ❑ Using the ← **del** key, delete the 20
- ❑ Press **menu**
- ❑ Press **8** to connect to the Hub
- ❑ Press **7** to connect to the Rover
- ❑ Press **3** to select the ‘RV SETTINGS’
- ❑ Press **1** to select ‘SPEED’
- ❑ Use the number key to type a **2**
- ❑ Press **menu**
- ❑ Press **8** to connect to the Hub
- ❑ Press **7** to connect to the Rover
- ❑ Press **3** to select the ‘RV SETTINGS’
- ❑ Press **3** to select ‘TIME’
- ❑ Use the number key to type a **10**
- ❑ Press **menu**
- ❑ Press **2** to save the syntax
- ❑ Press **3** to run the program
- ❑ Press **enter** to run your program
- ❑ You can change the speed number to anything between 1 and 5 and the time to anything between 1 and 10. Fill in your chart with the distance, speed, and time each time your Rover moves!

Appendix R: Code for Speed Student Response Sheet

Code for Speed

Distance (cm)	Time (cm)	Speed (cm/s)

Appendix S: Track Challenge Instructions

Track Challenge

Instructions: After completing all of the Rover and Hub challenges you are now tasked with driving the rover through a course! You will measure all of the angles and lengths that the rover be at in order to successfully drive it through the course.

- ❑ Turn on your calculator or return to the home screen by pressing the **on**
- ❑ Press **2** to browse documents
- ❑ Using the arrows, scroll to select '**trackchallenge**.
- ❑ Press **enter**
- ❑ If it asks you if you want to save another program, click '**No**'.
- ❑ The program should look like the picture below, and ensure that you begin by putting the first command under the line that says 'Send "SET RV.GRID.M/UNIT 0.01 M/grid unit"'

```
Define trackchallenge()=
Prgm
Send "CONNECT RV"
Send "SET RV.GRID.M/UNIT 0.01 M/grid unit"

EndPrgm
```

Some things you need to know before you begin!

- You will be using centimeters as your unit.
- To program the Rover to go forward:
  - ❑ Press '**menu'**
  - ❑ Press the number '**8**' to connect to the Hub
  - ❑ Press the number '**7**' to connect to the Rover
  - ❑ Press the number '**1**' to drive the Rover
  - ❑ Press the number '**1**' again to drive Forward
  - ❑ Then you will type in how many centimeters you want the rover to go and push '**enter**'.

- There are two ways to get the Rover to turn.
- To program the Rover to go to an angle:
  - ❑ Press '**menu'**

- ❑ Press the number ‘**8**’ to connect to the Hub
- ❑ Press the number ‘**7**’ to connect to the Rover
- ❑ Press the number ‘**1**’ to drive the Rover
- ❑ Press the letter ‘**A**’ to go to an angle
- ❑ Then you will type the degree of the angle you want the rover to go to and push ‘**enter**’.

- To program the Rover to go left or right:

- ❑ Press ‘**menu’**
- ❑ Press the number ‘**8**’ to connect to the Hub
- ❑ Press the number ‘**7**’ to connect to the Rover
- ❑ Press the number ‘**1**’ to drive the Rover
- ❑ Press ‘**3**’ for Left and ‘**4**’ for Right

Appendix T: Student Post-Assessment

Please answer the following questions. Your answers will only be seen by the researchers and your name will not be connected to your answers. Thank you!
* Required

1. **What is your name? ***

    [ ]

2. **What elementary school do you attend? ***

    - A Elementary
    - B Elementary
    - C Elementary

3. **What is your grade level?**

    - 3rd
    - 4th
    - 5th

For the next part, answer the questions dependent on your current feelings. There are no right or wrong answers.

4. **After using this technology, my interest in Math has increased. ***

    - Strongly Disagree
    - Disagree
    - Neither Agree nor Disagree
    - Agree
    - Strongly Agree

5. **After using this technology, when I'm older, I might choose a job that uses math. ***

    - Strongly Disagree
    - Disagree
    - Neither Agree nor Disagree
    - Agree
    - Strongly Agree

6. **Using this technology helped make math easier for me. ***

    - Strongly Disagree
    - Disagree

- Neither Agree nor Disagree
- Agree
- Strongly Agree

7. I would do well in math regardless of the technology used. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

8. I can understand most subjects easily, but math is difficult for me. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

9. Using this technology would help me do harder math problems. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

10. I am good math. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

Engineering and Technology: Please read this paragraph before you answer the questions. Engineers use math and science to invent things and solve problems. Engineers design and improve things, like bridges, cars, machines, foods, and computer games. Technologists build, test, and take care of the designs that engineers create.

11. After using this technology, I would like to imagine making new products. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree

- Agree
- Strongly Agree

12. If I learn engineering, then I can improve things that people use every day. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

13. This technology has increased my curiosity about how electronics work. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

14. This technology has made me realize that I want to be creative in my future jobs. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

15. After using this technology, I believe I can be successful in engineering. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

16. I found that when working in a group, I can lead others to reach a goal. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

17. During this project, I found that I like to help others do their best. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

18. In school and at home, I can do things well. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

19. I respect all children my age even if they are different from me. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

20. I try to help other children my age. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

21. When I make decisions, I think about what is good for other people. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

22. When things do not go how I want, I can change my actions for the better. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

23. I can work well with all students, even if they are different from me. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

24. I enjoyed working with this technology. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

25. I would like math more if I were able to learn using more technology. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

26. This technology has increased my interest in STEAM. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

27. After using this technology, I feel more confident in math. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

28. This project has increased my interest in coding. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree

- Strongly Agree

29. **After this project, I am more likely to consider a future career in a STEAM field.** *

   - Strongly Disagree
   - Disagree
   - Neither Agree nor Disagree
   - Agree
   - Strongly Agree

30. **This project helped me learn math.** *

   - Strongly Disagree
   - Disagree
   - Neither Agree nor Disagree
   - Agree
   - Strongly Agree

Your Future: Below is a list of jobs that you could have when you are older. As you read about each job, you will know if you think the job is interesting. Choose the words that describe how interested you are in having that job when you are older. There are no “right” or “wrong” answers! The only correct responses are those that are true for you.

31. **Mathematics: People use math and computers to solve problems. They use it to make decisions in businesses and government. They use numbers to understand why different things happen, like why some people are healthier than others.** *

   - Not interested at all
   - Not so interested
   - Interested
   - Very Interested

32. **Computer Science: People write instructions to run a program that a computer can follow. They design computer games and other programs. They also fix and improve computers for other people.** *

   - Not interested at all
   - Not so interested
   - Interested
   - Very Interested

33. **Engineering: People use science, math and computers to build different products (everything from airplanes to toothbrushes). Engineers make new products and keep them working.** *

- Not interested at all
- Not so interested
- Interested
- Very Interested

34. What did you like most about this coding project? *

35. What did you like least about this coding project? *

Appendix U: Teacher Post-Survey

Thank you so much for your participation in this research project. I have really enjoyed working with your school! Please contact me with any questions or concerns:

Lindsay A. Gold, Lgold1@udayton.edu, 937-229-3378:

If you feel you have been treated unfairly, or you have questions regarding your rights as a research participant, you may contact Candise Powell, J.D., Chair of the Institutional Review Board at the University of Dayton, IRB@udayton.edu; Phone: (937) 229-3515.
* Required

1. **Email address** *

   [ ]

2. **This project has helped me feel more prepared to teach using technology.** *

   - ○ Strongly Disagree
   - ○ Disagree
   - ○ Neither Agree nor Disagree
   - ○ Agree
   - ○ Strongly Agree

3. **This project has helped me feel more prepared to teach Engineering.** *

   - ○ Strongly Disagree
   - ○ Disagree
   - ○ Neither Agree nor Disagree
   - ○ Agree
   - ○ Strongly Agree

4. **This project has helped me feel more prepared to teach Math.** *

   - ○ Strongly Disagree
   - ○ Disagree
   - ○ Neither Agree nor Disagree
   - ○ Agree
   - ○ Strongly Agree

5. **No matter how hard I try, I will not be able to teach STEAM units as well as I would teaching individual subjects.** *

   - ○ Strongly Disagree
   - ○ Disagree

- Neither Agree nor Disagree
- Agree
- Strongly Agree

6. **After this project I am more likely to teach STEAM in the future. ***

    - Strongly Disagree
    - Disagree
    - Neither Agree nor Disagree
    - Agree
    - Strongly Agree

7. **I would like to receive more professional development on STEAM education. ***

    - Strongly Disagree
    - Disagree
    - Neither Agree nor Disagree
    - Agree
    - Strongly Agree

8. **After this project, I am more comfortable using project based learning in my classroom. ***

    - Strongly Disagree
    - Disagree
    - Neither Agree nor Disagree
    - Agree
    - Strongly Agree

9. **Through this project, I am learning more about STEAM resources. ***

    - Strongly Disagree
    - Disagree
    - Neither Agree nor Disagree
    - Agree
    - Strongly Agree

10. **After this project, I am more comfortable incorporating technology into my teaching. ***

    - Strongly Disagree
    - Disagree
    - Neither Agree nor Disagree
    - Agree
    - Strongly Agree

11. This project has increased my excitement for teaching STEAM. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

12. After this project, I am comfortable integrating subjects when I am teaching. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

13. I believe STEAM education is not appropriate for my grade level. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

14. I do not understand why STEAM is beneficial. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

15. When teaching STEAM, I have no control over my students' learning. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

16. I wonder if I have the necessary skills to teach STEAM. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree

- Agree
- Strongly Agree

17. Given a choice, I will not invite the principal to evaluate my STEAM teaching. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

18. When a student has difficulty understanding a STEAM concept, I will usually be at a loss as to how to help the student understand it better. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

19. After this project, I am interested in STEAM education. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

20. I do not know what to do to turn students on to STEAM related fields. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

21. After this project, I feel more prepared to teach STEAM. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

22. In my opinion, students' understanding will increase more using STEAM education. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

23. After this project, I am more comfortable incorporating STEAM activities into my classroom. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

24. It is important to teach STEAM at my grade level. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

25. After this project, I would likely contact my district STEAM leader for more resources and materials. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

26. I have no idea where to even begin to teach STEAM. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

27. It is important to attend professional development opportunities to learn more about STEAM. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

28. After this project, I know better how to teach STEAM. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

29. After this project, I know better how to assess my students on STEAM activities. *

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

30. What are some challenges you face when teaching STEAM activities? *

31. After this project, how would you define STEAM? *

32. What was your least favorite part about this project? What did not go well? *

33. What was your favorite part about this project? What went well? *

34. Would you consider doing a project like this in your classroom again? *

- Yes
- No
- Maybe

35. Any other comments?