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The Impact of Integrated STEM Equipment on Student Learning and Efficacy in the Fourth Grade Science Classroom

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Abstract

The purpose of this paper is to investigate the use of integrated STEM equipment in the Grade 4 science classroom and the impact student learning and efficacy. This study took place over the course of 4 weeks during a rotation of 61 grade students for 50 minute period class times in the science classroom. At the beginning of the school year, students were taught an unit on electricity and were instructed on how to make electrical circuits. Data was collected on student attitudes about STEM learning before Snap Circuit kits and LEGO Wedo 2.0 kits were introduced to students. Students investigated the use of creating a power source to make something work. Exit Tickets, a Flip Grid response board, and a post-survey were utilized to collect data measuring students' perception of learning experiences and sense of efficacy. Results were inconclusive in measuring efficacy. Positive outcomes were reported regarding attitudes and student learning. Plans for an after-school science club and ordering more STEM equipment for the elementary science classroom were initiated at the end of this study.

Keywords: STEM, student learning, efficacy, elementary science, integrated technology

The students of today are the leaders of tomorrow. Many elementary-aged students begin their educational careers with an innate curiosity and desire to learn all the important ideas and skills needed to achieve in each successive year of school (Noel and Liub, 2017). Along with language arts and mathematics, young learners must also attain pertinent scientific theory and develop age-appropriate knowledge of the scientific method through observation, inquiry, and hands-on experimentation. This scientific knowledge is essential in the development of higher-level thinking, problem-solving, and making sense of the rapidly changing world today's learners grow and live in. This field of learning is known as Science, Technology, Engineering, and Math (STEM) education (Corlu, Capraro, and Capraro, 2014). Corlu, Capraro, and Capraro (2014) define STEM education as knowledge, skills, and beliefs that intersect in more than one area of Science, Technology, Engineering, and Math.

In addition to appropriate science content, children should be offered learning opportunities that encourage students to utilize 21st Century skills such as critical thinking, creativity, collaboration, and communication on their journey as productive members of today's society. One area of content may be in the delivery of STEM instruction where children may engage in the design process and integrate their STEM knowledge into other areas of learning. Research in the emerging field of STEM education argues that to prepare for their future, children must acquire knowledge and valuable skills in this emerging field of education (DeJarnette, 2012).

Kurup, Li, Powell, and Brown (2019) stated that STEM education must begin in the primary grades in order to generate learners' interest. Also, science must continue to be taught through successive classes in school to produce students ready to pursue STEM-related careers that will be needed in today's society (DeJarnette, 2012). In 2010, The National Science Board (DeJarnette, 2012), found a correlation between students taking advanced STEM-related courses in high school and college due to early exposure to STEM instruction in the elementary grades. Several other studies (Becker & Park, 2011; DeJarnette, 2012; Swift & Watkins, 2004) also illustrated the importance of STEM education in the early grades. In Swift and Watkins' 2004 study, teachers devised elementary science lessons that were taught in conjunction with engineering students and faculty at the University of Missouri-Rolla. The purpose of these lessons were an attempt to establish a correlation between integrating physical activity to describe an abstract scientific concept (Swift & Watkins, 2004). In another study, DeJarnette, (2012) reported that "scientific problem-based activities promote critical scientific thinking and engagement in STEM learning" (p. 3). The design process and inquiry also have an important role in the integration of elementary STEM education. In his research, Sanders (2009) stated that the pedagogy of the design process engages students with a combination of technology design along with scientific inquiry.

Along with preparing students for future learning in STEM education, research has also shown that STEM instruction in the elementary grades has a positive effect on learner efficacy. Levine (2012) describes efficacy as "the belief that one plays a significant role in one's destiny and success" (p. 3). Efficacy can also be described as agency. Clapp, Ross, Ryan, & Tishman (2017) believe students exercise their agency in their chosen actions that result in certain effects. Efficacy also explores the relationship between intention, choice, and action. A strong sense of efficacy can have a positive impact on children's motivation, achievement, and success in future learning. Efficacy can be a difficult trait to measure in the ongoing development of elementary students. English (2016) believes that due to students making connections among different disciplines in STEM learning, the subsequent result may be interest and engagement in other areas of study. Sanders (2009) stated in his research that the integrative nature of STEM learning is learner-centered, and the collaborative nature of this learning will result in social interaction in the environment that this learning takes place in. Finally, DeJarnette (2012) concluded that elementary learners' confidence increases as they engage in STEM learning activities

Elementary students in the state of Minnesota are not tested on their comprehensive science knowledge until the fifth grade (Minnesota Department of Education ,2009), however, their formal science education must begin as soon as they enter school. A solid foundation in scientific knowledge may help children achieve as they go on to master more complex science content, and eventually be prepared to pursue STEM careers in the future if so desired as a career choice. As a specialist teacher in a Title I school located in Central Minnesota, I am responsible for teaching K-4 science content to all elementary students in the district. The technology integrationist and I also provide STEM learning opportunities to our students with the integration of hands-on experiences that enable them to construct knowledge about abstract ideas that are taught in the science classroom, along with the importance of applied science to real-life situations and problems.

Finally, it is essential for young learners to develop a sense of efficacy and a positive attitude toward their learning as they gain confidence in further science learning and if they are able to build upon prior knowledge. As an action researcher, my goal was to explore to what extent does the integration of STEM-focused equipment have on student efficacy and learning in the science classroom while providing hands-on STEM learning in collaboration with science and engineering instruction to fourth grade students.

Theoretical Framework

The theoretical frameworks that guided this study consisted of the Progressive education theory of John Dewey and the constructivist theories of Jean Piaget and Lev Vygotsky.

Education reformer, John Dewey, emphasized hands-on learning, critical thinking, and problem-solving in his advocacy of Progressive education in the early twentieth century (Dewey, 1902). Dewey was a strong proponent for a democratic society and believed that children's educational journey should prepare them for real life in the world they lived within (Dewey, 1916). In addition, Dewey (1938) believed that learning experiences should socialize children in collaboration with one another and engage with experiences of the world around them. Dewey's thoughts on progressive education and the development of children's learning influenced Jean Piaget and his theory of constructivism (Piaget, 1976). Piaget believed that children construct knowledge through a process known as assimilation and accommodation. This process continually allows children to build on existing knowledge and expand the structures of their minds as they refine and build new skills (Piaget & Inhelder, 1969). Developmentally appropriate concrete learning experiences are important in the child's construction of knowledge as children assimilate new information, develop higher thinking skills, and learn abstract concepts through hands-on discovery and further inquiry (Piaget, 1976). Lev Vygotsky expanded on Piaget's theory of constructivism to argue that learning is social in nature (Vygotsky, 1978). Vygotsky believed that some children learn through collaboration from more knowledgeable teachers or peers when the learner's knowledge is constructed and further scaffolded with the support and guidance from others with more advanced skills (Vygoysky, 1978). Vygotsky (1978) also believed that students master these tasks within a group setting before independent accomplishment of tasks. Vygotsky referred to this theory as social constructivism. When practicing social constructivism, children are empowered to problem-solve, create, and continually improve on their knowledge with one another. The teacher may provide materials and offer guidance, but the learner is ultimately responsible for finding meaning and purposefulness in their learning (Bruner, 1997).

Using the theoretical frameworks of constructivism, along with Dewey's ideals of progressive education, the important components in STEM pedagogy and student learning can be seen in the STEM classroom. This integrative approach enhances my elementary students' learning as they approach lessons and engage in learning challenges full of anticipation and enthusiasm upon discovering the hands-on equipment available for use during class time. Elementary STEM equipment includes age-appropriate engineering and science materials like Snap Circuits, etc. that promote project-based learning and opportunities to enhance skills and hone developing abilities based on interest and motivation. The social environment of the STEM classroom also presents opportunities for collaboration and creativity as children's work is also shared with one another and improved on to be displayed and used as models for other STEM students. Most importantly, children's construction of knowledge is tested through use of the design process and inquiry as the learner applies important academic content to real life problems and designed solutions that pertain to their futures and the modern world in which they live and grow.

Review of Literature

This literature review explored the integrative approaches used in elementary STEM education to promote student learning and efficacy as today's learners prepare for their futures.

Elementary STEM Integrative Approaches to Promote Students' Learning

To determine the relationship between the positive impact on student learning, achievement, and interest in STEM as a result of STEM education, Yildirim (2016) analyzed 33 studies from the empirical research in STEM education. The study design was meta-synthesis, and the data collection included studies from a ten-year span that researched integrative approaches in STEM education across different grade levels. Of the 33 studies, there was a mixture of qualitative and quantitative studies. The meta-synthesis reviewed studies that investigated whether STEM education had a positive effect on student interest and motivation and if STEM education had a positive impact on creative thinking. The researchers also wondered what impact STEM education had on the development of the scientific process. Outcomes of the meta-synthesis revealed that students who received STEM education enjoyed better academic results and success compared to students who did not receive STEM education. Yildirim (2016) also discovered students showed improvement in creative thinking, motivation, and there was a significant effect on the development of scientific process skills.

Becker and Park (2011) analyzed twenty-eight studies on their meta-analysis of the effects of the integration of science, technology, engineering, and math and the impact on student learning. Criteria for the meta-analysis included integrative STEM education studies from 1989 through 2009. The published studies were searchable from several academic databases with keywords pertaining to STEM education, and each study utilized empirical quantitative data to study student achievement (Becker and Park, 2011).

Becker and Park (2011) define integrative approaches as approaches that explore one or two STEM subjects in learning between STEM disciplines and other school subjects. Becker and Park (2011) looked at combinations such as science and technology education, science and mathematics education, engineering and mathematics education, and mathematics and technology education. The twenty-eight database chosen studies were from elementary school, middle school, high school, and college. Statistical analysis of students' achievement scores in STEM subjects showed that integrative approaches had a positive effect on student learning and achievement. Becker and Park (2011) also found that the integration of Math-Science-Technology and Engineering-Math had small effect sizes on student learning and achievement. The combination of Science-Technology into Engineering-Math-Science-Technology, Engineering-Technology, and Science-Technology were the approaches that showed the most significant effect on student learning and achievement. Becker and Park (2011) concluded that the types of integration should be considered in the impact and effect on student learning.

In their 2004 study, Swift and Watkins demonstrated the pedagogy of the engineering design process and inquiry in an outreach project (Swift and Watkins, 2004). In this study, a lesson was devised with the intent to be delivered in two different methods to elementary-aged students. Two lesson plans were created in a project called "Engineering My Town" (p. 69). One lesson focused on the topic of measurement, while the other topic taught students about scientific careers. Learning about measurement incorporated design elements, along with auditory, visual, and kinesthetic components, while teaching students about scientific careers featured an engineering professional from the community. The researchers concluded that the hands-on application increased student motivation and interest in STEM learning due to the fact that the elementary teachers are experts on how children learn and what is needed to succeed in the classroom, rather than listening to technical information from engineering experts (Swift and Watkins, 2004).

Barker and Ansorge (2007) used the approach of offering children an opportunity for hands-on exploration in a study that utilized robots to help children learn abstract STEM concepts and apply their learning to concrete relevance in their world. In this study, Nebraska 4-H worked with thirty-two students between the ages of nine and eleven years in an afterschool program. A robotics curriculum was introduced, along with LEGO Mindstorm kits that included a programmable microcomputer chip, motors, and sensors. These various parts of the LEGO Mindstorm kits teach children about different skills needed in STEM related fields (Barker and Ansorge, 2007). A pretest was first administered before children learned about the kits through the design process of building a robot and programming it. Students also shared observations, analyzed and reflected on their projects, and applied their knowledge to what they learned (p. 232). A posttest was then given and quantitative data was analyzed to see how children developed an understanding of Science-Engineering-Technology with the use of robotics. Barker and Ansorge found an improvement on the posttest of the students who used the robotic kits, thus allowing the researchers to conclude that the use of robots enhances student learning and achievement in STEM education, however, Barker and Ansorge felt that more research was needed to see how effective the use of robotics would be in different settings in enhancing children's STEM learning experiences (Barker and Ansorge, 2007).

Elementary STEM Integrative Approaches to Promote Students' Efficacy

Research in STEM education has provided data regarding the many positive outcomes for students. The enhancement of student learning and achievement has proven to be a benefit in student agency and helping children develop healthy attitudes toward their learning. One of the outcomes of Yildirim's (2016) study was the finding of a positive effect on attitude (p.28). Becker and Park (2011) conclude that the implementation of STEM integration may aid in the improvement of children's achievements and interests. Clapp, Ross, Ryan, and Tishman (2017) identify this attitude as a "can do spirit" or sense of agency (p. 19). This sense of agency will help inform children how they see themselves outside of the classroom. Finally, Martinez and Stager, (2019) invite children to become agents of change as they become more independent in their learning and "follow their passions in non-traditional educational ways (p.57)".

Methodology

To understand the impact of introducing hands-on equipment, the experimental design consisted of opportunities to explore STEM integrated equipment in the fourth grade science classroom after the completion of an unit of study on electricity in the fall of the 2019-2020 school year. To increase the validity of this action research study, triangulation was used in the form of pre- and post-assessments, an exit ticket, and student self-assessment video recorded from FlipGrid. These instruments were designed to assess children's engagement in purposeful activities that supported their knowledge of science when applied to a real life problem. In addition, the instruments also questioned students on their attitudes toward learning and their increasing sense of efficacy in preparation for further STEM education in school.

Participants

The research study took place in a rural Title I elementary school in central Minnesota. The sample was sixty students in fourth grade from three different classrooms. Thirty-five students were boys and 25 students were girls. The age range of the students was between nine and ten years old. Parental consent (Appendix A) was obtained for all sixty students to participate in the action research study.

Materials

A local cooperative purchasing agency provided the use of the equipment on loan for the study to ensure that all students had equal opportunities exploring self-chosen learning with the kits. When the equipment arrived at school, Snap Circuit kits and LEGO WeDo 2.0 kits were placed on tables in the STEM classroom. Children could work individually, as a pair, or part of a group. classroom. Students were allowed to make choices with the equipment and chose where they worked in the room. Students also decided when a project was complete, how it worked, and what they wanted to build next. Some students went back to rebuild and improve on a creation, while others chose different activities during their next class session. Upon completion of a project or the end of a class session, children were asked to fill out an exit ticket or record a FlipGrid video.

The STEM equipment that was integrated into the classroom consisted of Snap Circuit kits and LEGO WeDo 2.0 kits over a period of four weeks during four 50 minute class periods. Snap Circuits are plastic electronic components that include a motor, fan, lamp, and many other pieces. These pieces snap together with plastic coated wires on a grid and are intended to expand children's knowledge of building series and parallel circuits to turn things on and do something. LEGO WeDo 2.0 kits are used to build models and then coded to move, make sound, or have a sensor activated to flash lights. A blue-tooth hub is used to make these actions happen wirelessly by connecting to an iPad and children must problem-solve how to use a power source to make something work. Chromebooks were also set up for children to independently complete online activities from previously learned science content regarding the use of batteries to store energy and the construction of circuits that enable us to use electricity in our everyday lives.

Procedures

Before exploring hands-on with the STEM equipment, children were given the Students Attitudes Toward STEM Survey (Friday Institute for Educational Innovation, 2012; Appendix B) as a pre-assessment. This assessment tool is a Likert scale survey designed to measure quantitative data from 26 questions regarding children's attitudes about Math, Science,Engineering, and Technology. The questions asked children specifically if they liked a STEM related subject, if they thought the STEM subjects were easy or hard for them, and if the knowledge and skills used in STEM subjects would be beneficial in further learning or career choices. The results were tallied and entered into a spreadsheet for further analysis at the end of the research study. The post-assessment was administered after students had worked with the Snap Circuit kits and LEGO WeDo 2.0 over the course of several sessions during a four week period. This assessment was also tallied and entered into a spreadsheet for analysis and comparison to determine the effect on students' attitudes and sense of efficacy after applying previous scientific knowledge to hands-on learning.

The exit ticket (Appendix C) was a tool designed by myself to provide qualitative data for students to self-report their sense of agency in approaching a STEM challenge and the learning strategies used for success. The exit ticket was formatted as a Google form to analyze students' responses and determine if positive behavior might indicate a correlation between STEM integration activities and students' sense of efficacy. Children were encouraged to fill out exit tickets several times during the four weeks to measure their problem-solving skills and sense of efficacy.

The FlipGrid self-assessment video (Appendix D) allowed students to use a Chrome book to record themselves. Qualitative data was collected as students were encouraged to share their thoughts on what interested them during the building process of working with Snap Circuits or LEGO WeDo 2.0 kits, how they solved problems when designing or improving on a project, and the motivations behind their creative thought processes. FlipGrid videos were viewed at the end of the study, and 14 videos were chosen in which children specifically answered the questions presented in the FlipGrid. The 14 videos were then transcribed and the individual responses were cut into individual strips of paper to be grouped into common themes concerning participants' perspective of problem-solving strategies, student interest, and success. The responses were then tallied according to shared ideas about activity interest, use of problem-solving they engaged in, their problem-solving skills, and their use of creativity and the design process. In addition, the impact that these skills had on their sense of efficacy and interest in further STEM related tasks and learning were also considered in the student responses.

Analysis of Data

The purpose of this action research study was to identify to what extent does the integration of STEM equipment increase student efficacy and learning in the 4th Grade science classroom. The action research study took place in the science classroom during 50 minute periods among 61 students on different days during a four-week period. Students were introduced to Snap-Circuits and WeDo LEGO 2.0 sets to apply their knowledge of electricity and circuit building, and were asked to fill out an exit ticket or record a FlipGrid video sharing their thoughts in order to study the impact of hands-on experience on student efficacy and learning.

Baseline data was collected in the form of a pre-survey to be compared to a post survey at the end of the study. Exit tickets and FlipGrids were utilized over the course of four weeks as students completed choice activities with Snap-Circuits and WeDo LEGO 2.0 kits at the end of a 50 minute class period. At the end of the four week period, raw data was compiled by entering survey data on a spreadsheet and viewing FlipGrid responses that specifically talked about using the Snap Circuits or WeDo LEGO 2.0 kits to assess the effect on students' learning through the interaction with hands-on materials during STEM exploration. Data sources were then triangulated in order to reach conclusions and support findings to determine if the integration of STEM equipment has an impact on student efficacy and learning in the science classroom.

Student Attitudes Toward STEM Survey

The study began with a survey (Appendix A) to assess students' attitudes toward STEM subjects, abilities, and interest in future learning in order to examine student efficacy and learning. Base-line data was collected that described how students felt in the areas of math, science, and engineering and technology. All students filled out the survey (Appendix A) before the Snap Circuit and WeDo LEGO 2.0 kits were dropped off to the science classroom for exploration and application of previously learned science content about electrical circuits. Post survey data was collected after a period of four weeks to see if students' attitudes toward STEM learning had changed since the experience with the equipment. After collecting all the pre and post surveys (Appendix A), the raw data was entered into a spreadsheet to be broken down into different graphs to display data from each STEM subject area.

Math

The first section of the Student Attitudes Toward STEM had students rate themselves in attitudes concerning the subject of math and math attitudes on a scale of strongly disagree (5), disagree (4), uncertain (3), agree (2), and strongly agree (1).

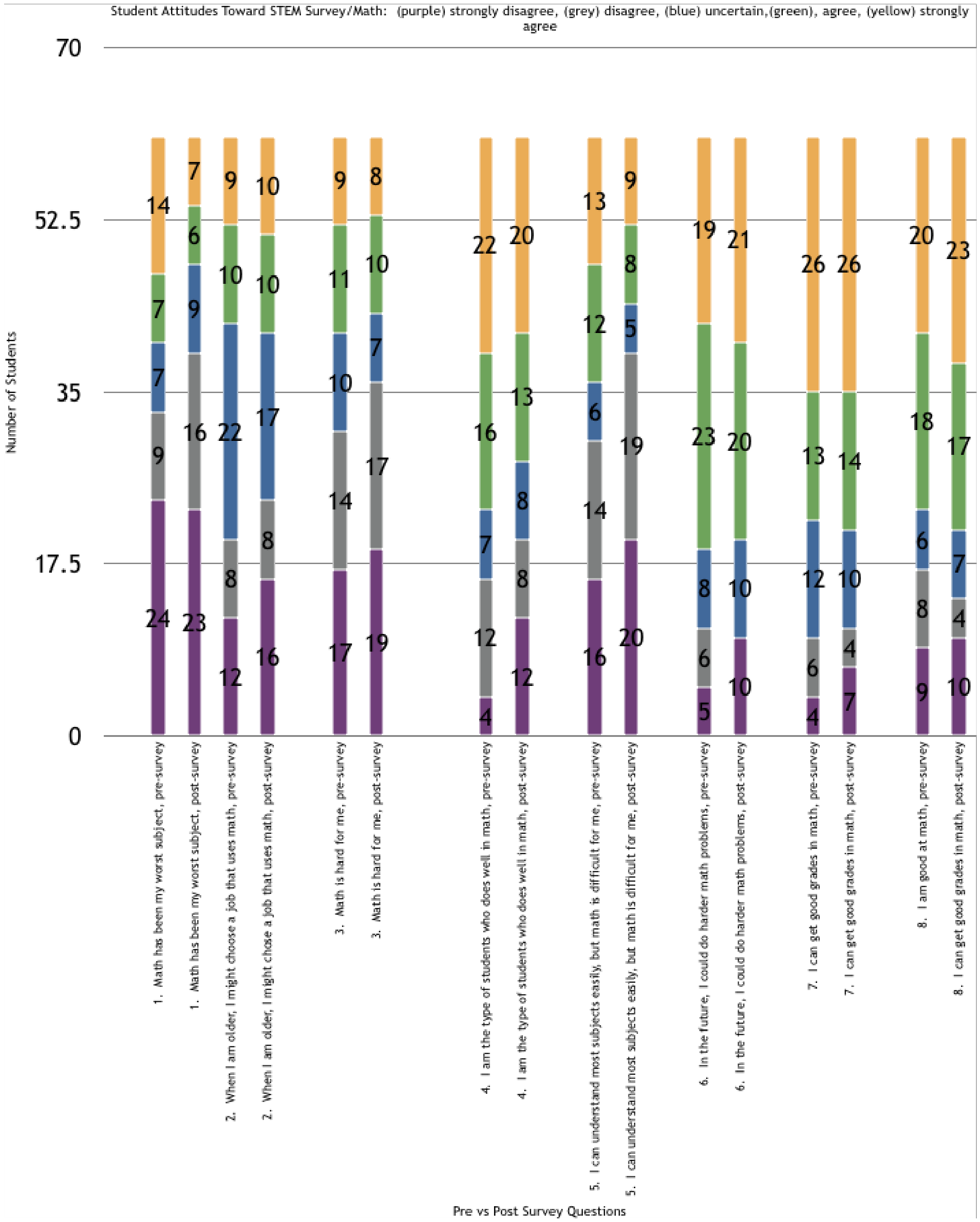
Student Attitudes Toward STEM Survey/Math: (purple) strongly disagree, (grey) disagree, (blue) uncertain,(green), agree, (yellow) strongly agree
70
52.5
35
17.5
0
Number of Students
24 9 7 7 14
23 16 9 6 7
12 8 22 10 9
16 8 17 10 10
17 14 10 11 9
19 17 7 10 8
4 12 7 16 22
12 8 8 13 20
16 14 6 12 13
20 19 5 8 9
5 6 8 23 19
10 10 20 21
4 6 12 13 26
7 4 10 14 26
9 8 6 18 20
10 4 7 17 23
1. Math has been my worst subject, pre-survey
1. Math has been my worst subject, post-survey
2. When I am older, I might choose a job that uses math, pre-survey
2. When I am older, I might chose a job that uses math, post-survey
3. Math is hard for me, pre-survey
3. Math is hard for me, post-survey
4. I am the type of students who does well in math, pre-survey
4. I am the type of students who does well in math, post-survey
5. I can understand most subjects easily, but math is difficult for me, pre-survey
5. I can understand most subjects easily, but math is difficult for me, post-survey
6. In the future, I could do harder math problems, pre-survey
6. In the future, I could do harder math problems, post-survey
7. I can get good grades in math, pre-survey
7. I can get good grades in math, post-survey
8. I am good at math, pre-survey
8. I can get good grades in math, post-survey
Pre vs Post Survey Questions

Figure 1: Pre vs. Post Survey Results: Student Attitudes Toward STEM/Math

In Figure 1 pre-test survey math data, 23 of the students strongly disagreed and 9 of the students disagreed that math had been their worst subject, while 14 of the students strongly agreed that math was their worst subject, and 7 students agreed that math was their worst subject. Seven of the students were uncertain of how they felt about math as a subject. Post-test data indicated no difference in the number of students that math was their worst subject, however, more students, from 9 to 16, now disagreed that math had been their worst subject. Nine students now indicated that they were uncertain about how they felt about math as a subject, while 6 students now strongly agreed that math was their worst subject, a decrease of 1, and there was no difference in the number of students that agreed math was their worst subject.

When children were asked if they thought they could do harder math problems in the future, 69% of the students strongly agreed and agreed in the pre-test data compared to 67% of students in the post-test data. In addition, pre-survey data shows 64 % of the students strongly agreed and agreed that they could get good grades in math compared to 66% of students in the post-test *data.*

Science

The second section of the Student Attitudes Toward STEM had students rate themselves in attitudes concerning the subject of science and science attitudes on a scale of strongly disagree (5)*,* disagree (4), uncertain (3), agree (2), and strongly agree (1).

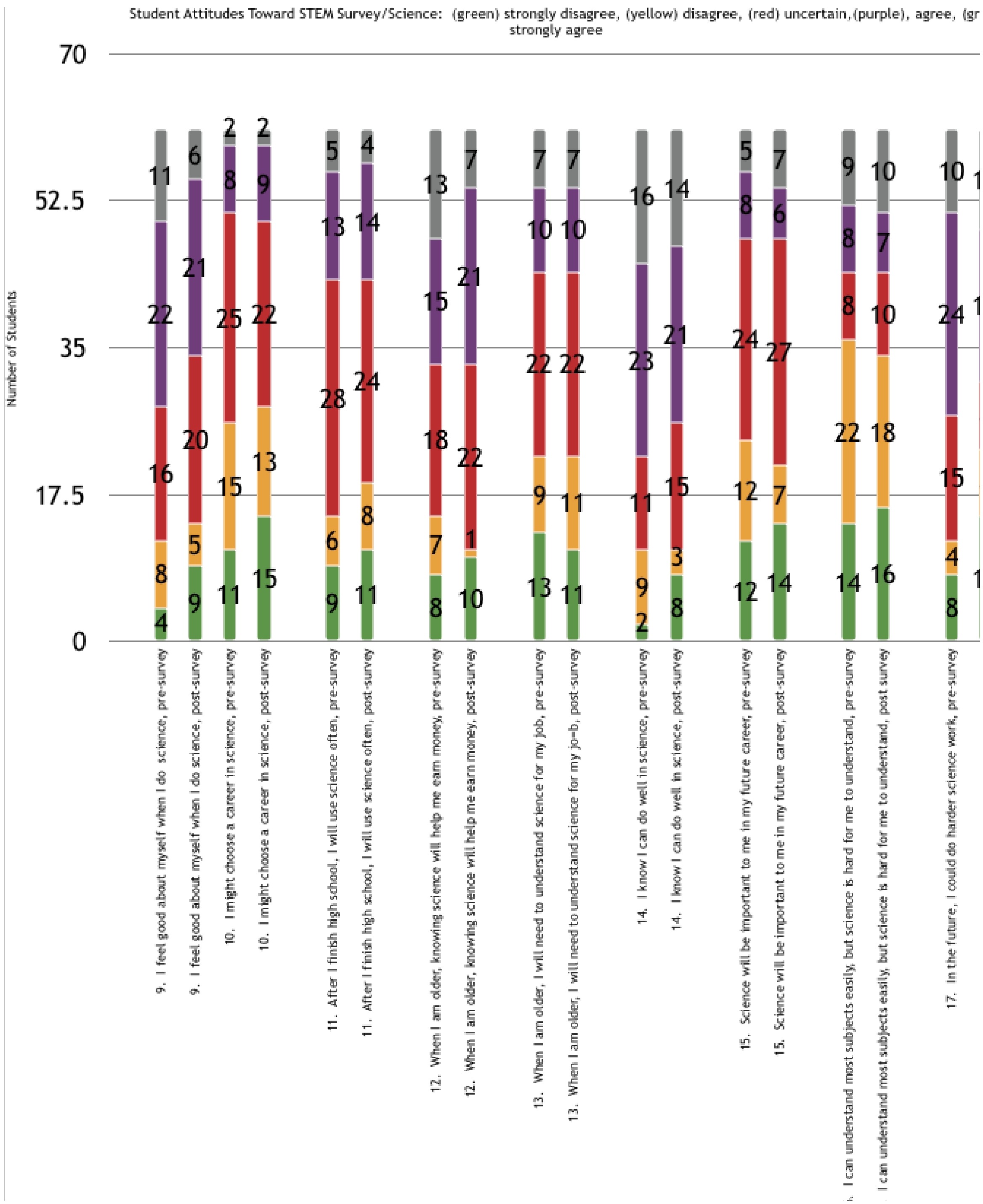

Figure 2. Pre vs Post Survey Science

Figure 2 pre-test data showed that 18% of the students strongly agreed and 36% of the students agreed that they felt good about themselves when they did science compared to post-test data which showed that 34% of the students now strongly agreed and 10% of the students agreed that they felt good about themselves when they did science. Figure 2 pre-test data also indicated that 26% percent of the students were uncertain about how they felt about doing science compared to post-survey data of 33% of the students. Finally, 7% of the students strongly disagreed and 13% of the students said that they felt good about themselves doing science pre-test while 15% of the students and 8% of the students now strongly disagreed and disagreed that they felt good about themselves doing science post-test survey.

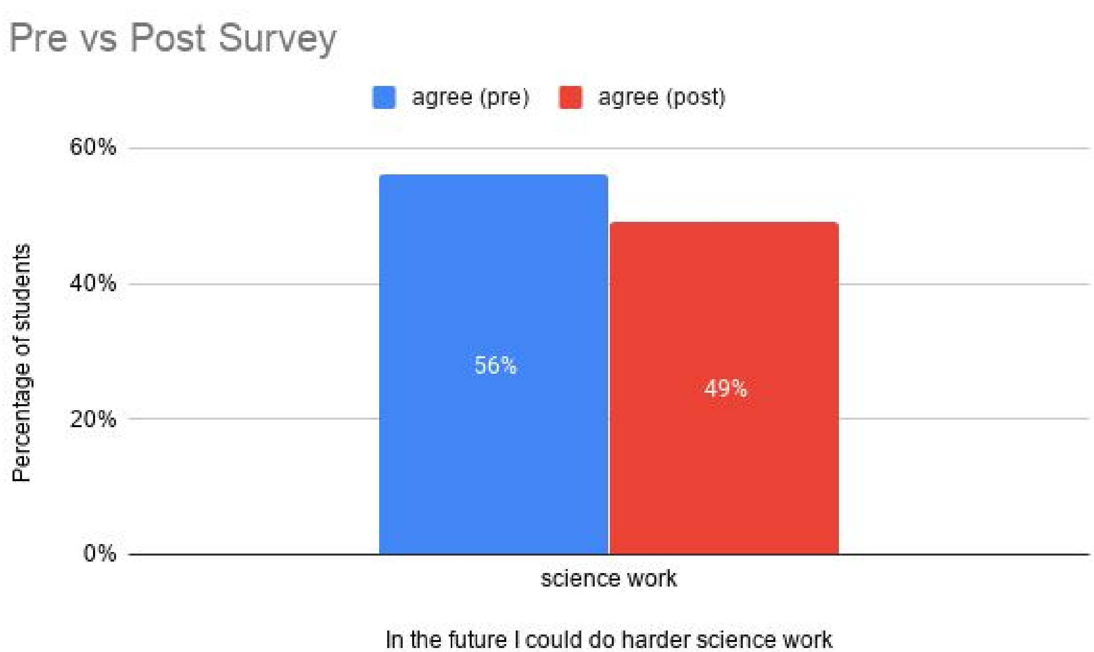

Figure 3. Pre vs Post Survey

Figure 3 data shows that when students were asked about doing harder science work in the future, 56% of students agreed that was possible in the pre-survey compared to 49% of students after the 4 week study

Engineering and Technology

The third section of the Student Attitudes Toward STEM had students rate themselves in attitudes concerning the subject of engineering and technology attitudes on a scale of strongly disagree (5), disagree (4), uncertain (3), agree (2), and strongly agree (1).

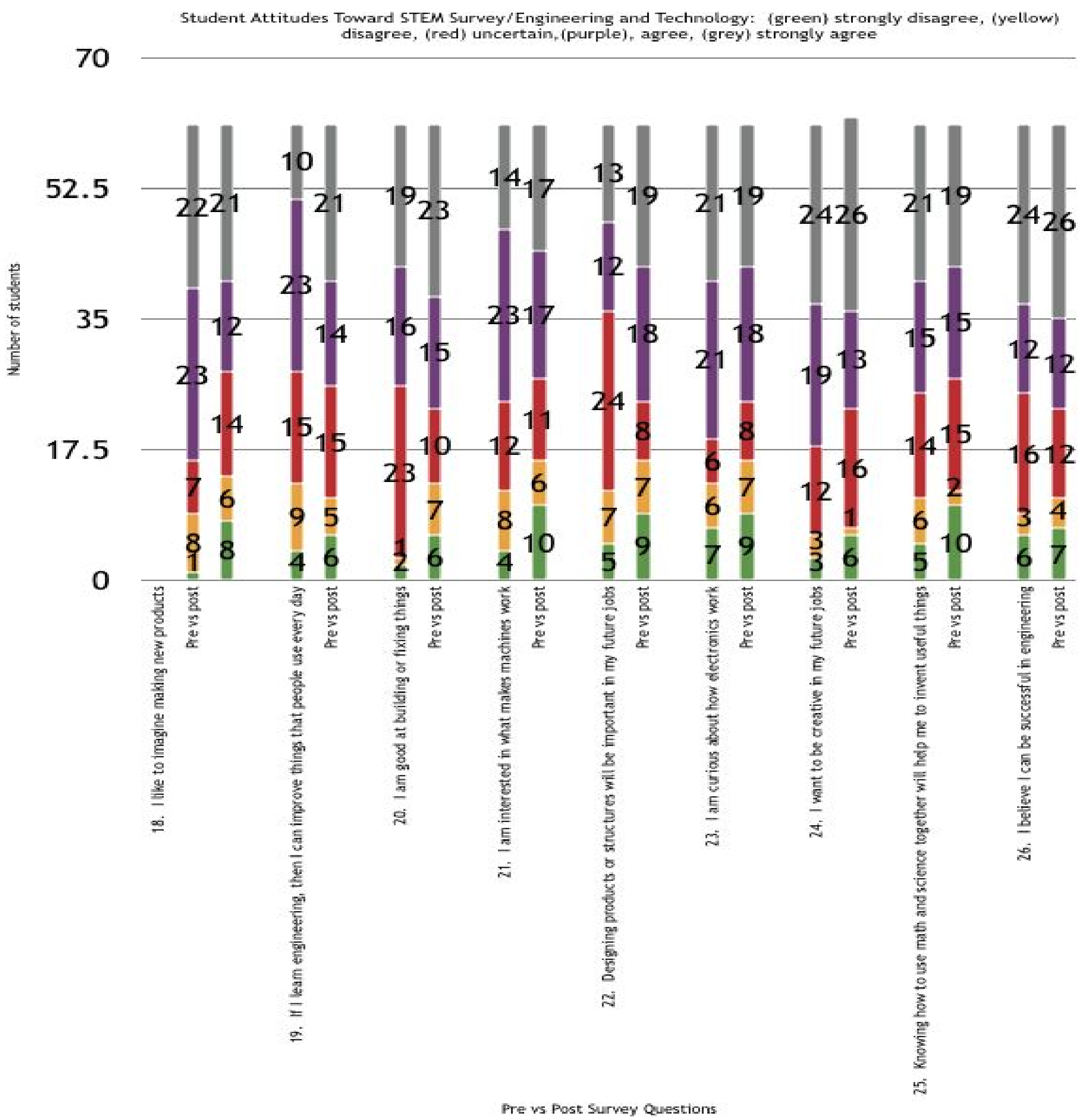

Figure 4. Pre vs Post Survey: Student Attitudes Toward STEM/Engineering and Technology.

In Figure 4, pretest vs posttest survey data shows that 59% of the students strongly agreed and agreed that they could be successful in engineering. After the four week study, 62% of the students now strongly agreed and agreed that they believed they could be successful in engineering. Figure 4 also shows that in the pretest survey , 74% and 71% of the students strongly agreed and agreed that they wanted to be creative in future jobs and they liked to imagine making new products. However, after four weeks, 64% of the students now strongly agreed and agreed that they could be creative in future jobs and 54% liked to imagine making new products.

Exit Tickets

After students had a chance to explore with the Snap Circuit kits and LEGO WeDo 2.0 kits during a 50 minute class period, they were encouraged to fill out an exit ticket on a google form.

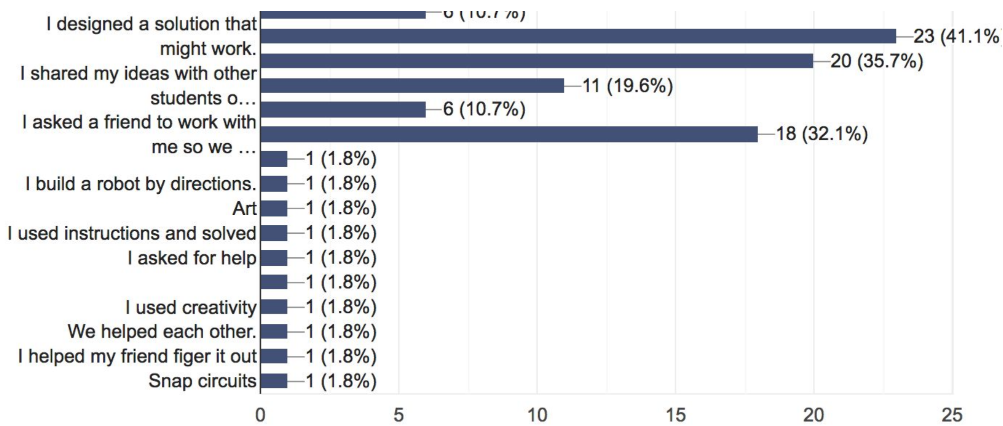

Figure 5. Google Exit Ticket Question

Students used an ipad that was linked to a QR code to ensure independence in filling out information. Students were invited to fill out as many exit tickets during the four week period. There were 56 responses recorded at the end of the data collection period.

The first question on the exit ticket asked “Which skills did you use to solve your STEM project today?”. Eight possible choices were given and students could mark as many boxes as they felt they needed to. The questions pertained to problem-solving solutions while using hands-on technology to design and solve problems that were based on previously learned science content that could be applicable to real life problems and solutions.

Figure 5 shows that of the 56 responses recorded, 23 respondents (41.1%) of students indicated that they were able to design a solution that might work, 20 (35.7%) of the respondents shared ideas with others or offered to help other students with their solutions and 18 respondents (32.1%) of the students asked a friend to work and problem-solve together. Percentages ranging from 19.6 % to 1.8% were reported in identifying problems to solve, brainstorming solutions, and testing what worked and what did not work. Students also opted to fill in the other box with a specific answer about what activity they chose or how they helped each other figure things out as illustrated in figure 6 and figure 7.

The next exit ticket question asked children to answer yes, no, not sure, and other to the statement of how they felt when working on a STEM challenge and how sure they were in finding a solution and sharing ideas with others.

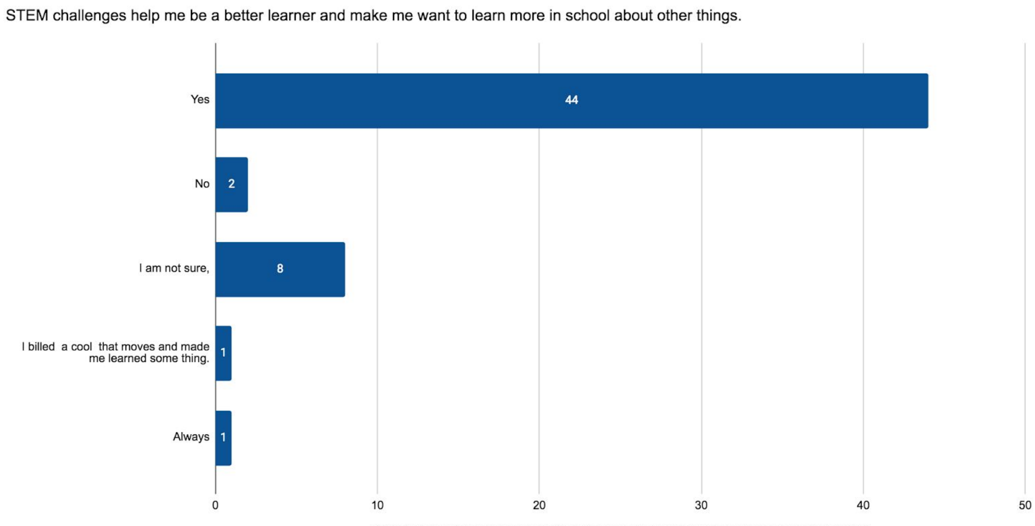

Figure 6. Google Exit Ticket Question 2

Figure 6 shows that out of 56 responses, 36 (64.3%) respondents felt sure of finding a solution and sharing ideas with other students compared to 16 (28.6%) respondents being unsure. Two (3.6%) respondents answered no to being sure of themselves and 2 (3.6%) respondents gave a specific answer to the question. The final question on the exit ticket asked students if STEM challenges helped them to be a better learner and if those challenges made them want to learn more in school about other things.

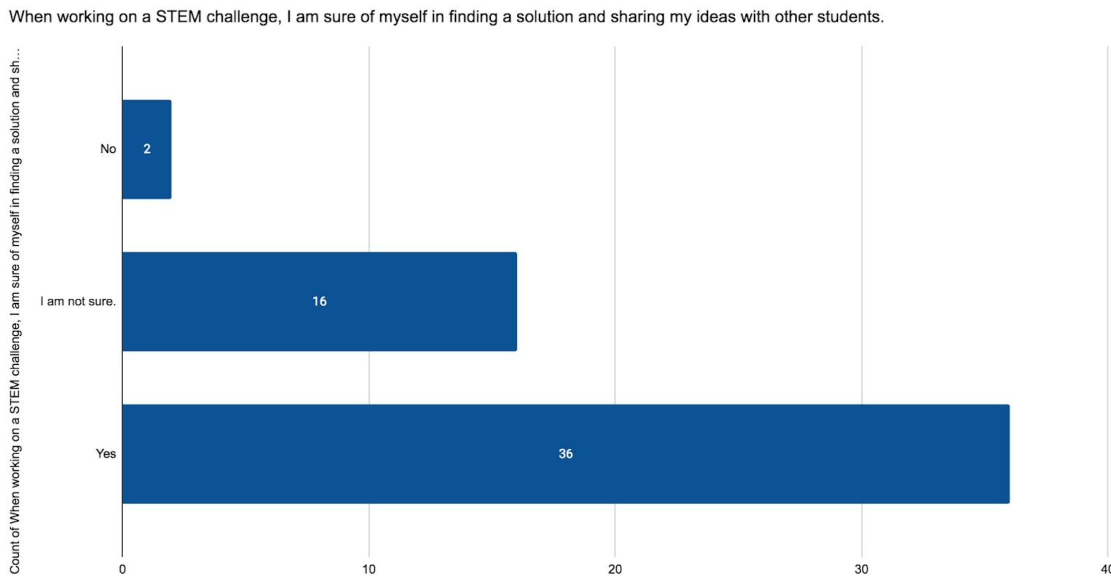

Figure 7. Google Exit Ticket Question 3

Figure 7 shows that 44 (78.6%) of 56 respondents felt that STEM challenges helped them to be better learners and interested in learning other things in school. Eight respondents (14.3%) were not sure how they felt, while 2 (3.6%) respondents answered no to STEM challenges helping them be better learners. Finally, 2 (3.6%) respondents gave a specific answer to the questions such as always and I built something cool and learned something.

FlipGrid Video Responses

A FlipGrid was set up to record student responses about their experiences building with the SnapCircuits and WeDo 2.0 LEGOs. Fourteen video responses were chosen from specific responses relating to the design process and problem solving. The video responses were then transcribed were then coded to answer the questions from the Flip Grid instruction screen that asked about student interest, problem-solving ability, success in the project, and additional student comments that may have indicated positive attitudes about hands-on experiences. The data was then compiled into a table for further analysis.

Table 1

FLIPGRID VIDEO RESPONSES

showed interest in today's activity	discussed creating and problem solving	discussed the design process
2	8	5

Discussion

Even though students were not interested in the Chrome books that were available to complete online activities from previously learned content, the use of the FlipGrid to record video responses proved to be a dynamic tool for the assessment of student efficacy and learning through the engagement of hands-on learning. Only one student mentioned interest in the activity, but all of the students talked about the problem-solving process and the steps they needed to be successful in the desired outcome of the project. Children demonstrated the building of closed circuits and the programming of robots made out of WeDo 2.0 LEGOs.

Students also ended their responses with descriptive words to describe their experience such as fun, amazing, and awesome. They also talked about problem-solving being tricky and hard, but they were willing to keep trying to see the end result. Students also helped each other use the FlipGrid tool by assisting other students how to sign in and record their responses. Children also collaborated on video responses and became more detailed in their video demonstrations throughout the course of the action research study.

What is the impact of integrated STEM equipment on Grade 4 student learning and efficacy in the science classroom? A strong sense of efficacy can have a positive impact on children's motivation, achievement, and success in future learning. However, efficacy can be a difficult trait to measure in the ongoing development of elementary students. The results of this study illustrate that Grade 4 students have a hard time assessing their own sense of efficacy in the areas of math, science, and technology. Even though efficacy was difficult to measure from the data collected throughout this action research study, results highlighted below, indicated that the integration of STEM technology and hands-on experiences had a positive impact on student learning and attitudes in the Grade 4 science classroom.

Conclusions from the Math Survey

Twenty (33%) students strongly felt they were good at math at the beginning of the study in comparison to 23 students (38%) when the study ended. Nineteen students (31%) strongly felt that they could do harder math problems in the future in the pre-assessment, while twenty one

(34%) students strongly felt that they could do harder math problems in the future after four weeks. Twenty two students (36%) were uncertain of the need for math in a future career study. The number of students dropped down to seventeen (28%) by the end of the study.

In the context of science instruction, I am interested in how students utilize mathematical thinking in the process of problem solving and the application of data collection in their science notebooks when writing about scientific investigations and drawing conclusions from their experiences. I do not know what mathematics they are learning in the 4th Grade classroom unless they talk about it during their scientific discovery such as students mentioning a connection during measurement and volume of water. My conclusion on the findings of student attitudes toward math is inconclusive as math instruction is taught in the regular classroom and as a science specialist, I may be unaware of the mathematical concepts and skills students are learning in their individual classrooms. However, my recommendation as a STEM educator is to continue to provide STEM integrated activities that allow students to use mathematical skills that will increase critical thinking, problem-solving, and assist students in developing the confidence in the use of mathematical knowledge in the construction of future learning.

Conclusions from the STEM Survey

Results from the pre and post Student Attitudes Toward STEM survey were inconclusive in the measure of efficacy due to the fact that results only changed slightly over the course of the four week action research study. Students were not as confident in their science and technology abilities and the use of their skills in future learning at the end of the four week action research study. The pre and post survey (Appendix A) about STEM attitudes was administered with pencil and paper to ensure participation of all students. Student responses were very close from the pre survey and post survey after the four weeks, however, due to the anonymity of the results it would be difficult to analyze individual student perceptions of efficacy and science ability. Results from the Exit Ticket and FlipGrid responses indicated a positive impact on student learning as students were motivated by the opportunity to use hands-on technology to create with the STEM materials and record responses that allowed them to share what they were doing in the classroom. Students also engaged in collaborative learning and shared their knowledge and skills with each other. The exit ticket turned out to be an excellent data tool to indicate how successful students felt in their abilities and confidence in finding solutions in working on a STEM challenge. The FlipGrid was the most popular tool for data collection over the course of four weeks and began a form of technology integration for students to engage in regardless of their chosen STEM project. My goal is to provide more opportunities for the use of FlipGrid in the classroom to encourage further collaboration and allow students to model ideas and share their learning with one another.

Conclusions and Recommendations

Noel (2017) hypothesizes that it is the development of 21st Century skills such as reasoning, curiosity, innovation, empathy, facilitation, and collaboration that may have a greater effect on student efficacy and achievement, along with design thinking and challenges in the elementary years due to students' natural curiosity and enjoyment of school. During the course of this action research study, a group of girls approached me to inquire about starting an after school science club in which we could research STEM projects and investigate scientific phenomena through hands-on learning. Monthly dates were picked out for the last few months of the school year and signs were posted to invite students who were interested in joining. Another recommendation of the research study is to look for grant opportunities to fund an after-school science club to encourage student engagement and extracurricular opportunities to learn about science outside of the classroom. The science club would create a space to increase student efficacy as children continue to develop the skills and knowledge that prepare them for future learning.

The need for interactive STEM materials in the classroom also resulted in the Parent-Teacher connection donating $3,500 for equipment such as Snap Circuits, robotic materials, engineering kits, and 3D pens during this action research study. More STEM classroom materials will allow all of our elementary students ongoing hands-on opportunities to apply their developing knowledge, further their learning, and continue to collaborate and create with one another. This integrative approach of STEM education and experiences may be the foundation that sparks their interest, increases their sense of efficacy, and sets them on the path of discovery in mastering the skills and talents they will need throughout the ensuing years to succeed in life and society.

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Appendix A

Sample Letter of Informed Consent

[Title of Study]
Parental Permission Form

[Date]

Dear Parents,

In addition to being your child's [fill in subject or grade level] teacher, I am a St. Catherine University student pursuing a Masters of Education. As a capstone to my program, I need to complete an Action Research project. I am going to study [insert topic of study in simple language] because [explain research purpose in age-appropriate language].

In the coming weeks, I will be [describe the activity/lessons that will occur for all students] as a regular part of my [classroom activities]. All students will participate as members of the class. In order to understand the outcomes, I plan to analyze the data obtained from the results of this [activity/lesson] such as…[describe data] to determine [describe what you are hoping to learn]. All strategies implemented and assessments given are part of normal educational practice.

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

> **If you decide you want your child's data to be in my study,** you don't need to do anything at this point.
>
> **If you decide you do NOT want your child's data included in my study,** please note that on this form below and return it by [date]. Note that your child will still participate in the [lesson/activity] but his/her data will not be included in my analysis.

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

- I am working with a faculty member at St. Kate's and a project coach to complete this particular project.
- [Explain the benefits in clear age-appropriate language. If there are any risks note those as well. If there are minimal or no foreseeable, note that].
- I will be writing about the results that I get from this research. However, none of the writing that I do will include the name of this school, the names of any students, or any references that would make it possible to identify outcomes connected to a particular student. Other people will not know if your child is in my study.
- The final report of my study will be electronically available online at the St. Catherine University library. The goal of sharing my research study is to help other teachers who are also trying to improve their teaching.
- There is no penalty for not having your child's data involved in the study, I will simply delete his or her responses from my data set. Your decision of whether or not to allow use your child's data

will have no impact on your relationship with the school or any of the teachers involved in the research.

If you have any questions, please feel free to contact me, [xxxxx]. You may ask questions now, or if you have any questions later, you can ask me, or my project coach [name and email address], who will be happy to answer them. If you have questions or concerns regarding the study, and would like to talk to someone other than the researcher(s), you may also contact Dr. John Schmitt, Chair of the St. Catherine University Institutional Review Board, at (651) 690-7739.

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

________________________________ _________________
[Type your name here and sign above] Date

OPT OUT: Parents, in order to exclude your child's data from the study, please sign and return by [DATE]

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

________________________________ _________________
Signature of Parent Date

Appendix B

STUDENT ATTITUDES TOWARD STEM SURVEY

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

MATH

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

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

SCIENCE

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

ENGINEERING AND TECHNOLOGY

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

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Appendix C

Exit Ticket

Before you leave class today, answer the following questions.

* Required

1. **Name** *

____

2. **Which skills did you use to solve your STEM project today?** *
Check all that apply.

- [ ] I identifed the problem to solve. Example: How do you make a light bulb light up?
- [ ] I brainstormed possible solutions.
- [ ] I designed a solution that might work.
- [ ] I tested out what worked or kept trying until I found a soultion.
- [ ] I shared my ideas with other students or offered to help them with solutions.
- [ ] I couldn't figure it out, so I tried another activity that interested me more.
- [ ] I asked a friend to work with me so we could problem-solve together.
- [ ] Other:

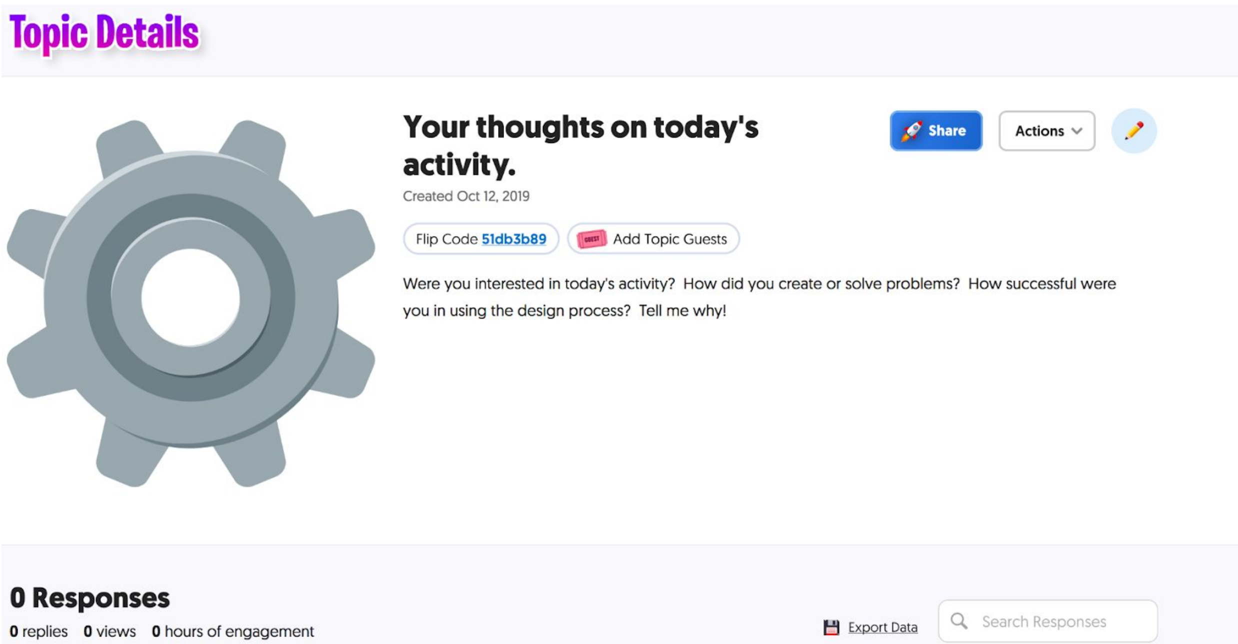
3. **When working on a STEM challenge, I am sure of myself in finding a solution and sharing my ideas with other students.** *
Mark only one oval.

- ( ) Yes
- ( ) No
- ( ) I am not sure.
- ( ) Other: _______________

4. **STEM challenges help me be a better learner and make me want to learn more in school about other things.** *
Mark only one oval.

- ( ) Yes
- ( ) No
- ( ) I am not sure,
- ( ) Other: _______________

Appendix D


Topic Details
Your thoughts on today's activity.
Created Oct 12, 2019
Share
Actions
Flip Code 51db3b89
Add Topic Guests
Were you interested in today's activity? How did you create or solve problems? How successful were you in using the design process? Tell me why!
0 Responses
0 replies 0 views 0 hours of engagement
Export Data
Search Responses