THE EFFECTS OF A ROBOTICS PROGRAM ON STUDENTS SKILLS IN STEM, PROBLEM SOLVING AND TEAMWORK

by

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ABSTRACT

In this action research project a fifth grade robotics program was studied to determine student attitudes towards science, technology, engineering, math (STEM), problem solving and teamwork. The goal of the study was to determine the effectiveness of an after school robotics program. At the conclusion of the study, the research indicated an increased interest in STEM education, greater appreciation for teamwork and more positive attitude towards problem solving.

INTRODUCTION AND BACKGROUND

During the past twenty-two years, I have been teaching at Target Range School, located in Missoula, Montana. Target Range School is a K–8 school that has two principals and one superintendent. There are two classes of each grade level. I am currently a fifth grade teacher. However, I also taught first grade for 11 years and eighth grade at the school for 11 years before switching to teach fifth grade. K–5 teachers are responsible for providing instruction in math, reading, language arts, science and social studies. Students in grades six-eight receive instruction from four core teachers in mixed grade level groups for math, language arts, science and social studies. All K-8 students receive physical education and music education every day, and attend art on a six-week rotation throughout the year. Students in grades six-eight also receive keyboarding and technology instruction.

Target Range School serves the students in the Missoula Valley near the confluence of the Clark Fork and Bitterroot Rivers. This school district is comprised of middle income families in a rural setting. The district serves as the only state education facility for students in transition, those waiting for foster home placement. In addition, two full time employees work with emotionally disturbed children. The demographics of Target Range School are 96% White/Caucasian, <1% African American, 4% American Indian and 2% Asian (2010). (Retrieved October 23, 2010 from: http://realestate.aol.com/school-Missoula-MT-59804/Target_Range_School/id-302589000734.)

During the past eight years I have implemented an after school robotics program and have successfully coached teams from grades five-eight. The first year, the team consisted of eight middle school seventh graders, six boys and two girls. Now, I only coach fifth grade robotics. Each year, the interest in robotics has grown and I currently coach three fifth grade teams of ten members each.

Recently I read an article in the 2010 *Eurasia Journal of Mathematics, Science & Technology Education* entitled "Using the TOSRA to Assess High School Students' Attitudes Toward Science after Competing in the FIRST Robotics competition: An Exploratory Study." The article piqued my curiosity about the effects of a robotics program on student achievement. I wondered why classroom teachers were not using robotics in their regular classrooms to enhance math, science and technology and to address state standards in these curricular areas. My goal for this study was to determine what kind of impact robotics is making on students in the classroom, especially in the areas of problem solving, teamwork, the challenge topic of Food Factors, and attitudes towards science and robotics and STEM careers.

CONCEPTUAL FRAMEWORK

There is a future need for scientists and engineers in the United States to stay competitive in the science and technology world. Other first world countries are ahead of the United States in science literacy (Gonzales et al., 2004). U.S. Students are falling behind in math and science (U.S. Department of Education, 1999). Within the next decade, "the number of individuals with science and engineering degrees reaching typical

retirement age is expected to triple" (National Science Foundation, 2002, p. 31). By the time U.S. students reach high school, achievement scores in math and science will drop below the international average (Lemke et al., 2004). Strengthening students' technical skills for the future will increase their success rate technologically and create competent adults ready to meet the challenges of the twenty-first century (Marghitu, Fuller, Brahim & Banu, 2009). One of the science educators' biggest challenges is to recruit and retain students in the STEM careers (Welch, 2010).

At a time when basic skills development, calls for academic excellence, and standardized testing are increasingly in the forefront of school reform, academic enrichment programs are increasing in number (O'Connor & McGuire, 1998). School-age children between the ages of 5 and 14 spend up to 80% of their time out of school. These hours represent an opportunity to help children grow and acquire important social, emotional, cognitive, and physical skills as well as lifelong interests. This time can also be used to provide support for the academic challenges faced by children each day in school (Coltin, 1999).

Classroom instruction focuses chiefly on logical/mathematical intelligences. In contrast, extracurricular activities appear to provide leadership and social skills development. These skills have been shown to lead to greater self-esteem and higher aspirations in both current academic situations and in the pursuit of long-term careers (Carns et al., 1995). Research has shown that after-school programs do not lead to extraordinarily large increases in reading achievement. However, we do not know whether after-school programs may be having more moderate, but nevertheless worthwhile, impacts on other academic performance measures (Kane, 2004).

Educational robotics can be used to enhance student learning. In British secondary schools, there was a substantial increase in math test scores compared to previous years in students who participated in project-based programs like robotics (Boaler, 1999). Additional research indicates that student learning through project-based programs can result in high test scores in math, science and writing (Honey & Henriquez, 1996). Introducing students to robotics programs is a proactive step in promoting science and technology literacy.

Robotics can be integrated into many subject areas and address state standards in STEM education (Papert, 1980; Rogers & Portsmore, 2004). Research suggests that robots tie into a variety of disciplines. A robot is made of component parts of motors, sensors and programs. Each of these parts depends on different fields of knowledge such as engineering, electronics, and computer science. This interdisciplinary nature of robots means that when students learn to engineer robots they will inevitably learn about the many other disciplines that robotics utilize (Papert, 1980; Rogers & Portsmore, 2004). In the same way, teaching students how to build robots teaches them how all the parts of a complex system interact and depend upon each other (Beer et al., 1999). This is an important lesson for computer scientists, biologists, doctors or anyone who will ultimately need to understand complex systems (Barker & Ansorge, 2007).

Robotics has been introduced to students across the United States in after school programs that promote learning by doing and teamwork (Barker & Ansorge, 2007). Using robotics to teach opens the door to many learning opportunities for students and improves teaching practices (Papert, 1993). FIRST LEGO League is one program that has addressed the need to increase STEM activities (Williams, Ma, Prejean & Ford,

2008). The increasing popularity of robotics had led to more after school programs. Dean Kamen, the founder of FIRST® (For Inspiration and Recognition of Science and Technology), is motivating students all over the country through project based robotic challenges. The FIRST Robotics program promotes STEM activities through a six-week challenge and results in influencing future careers (White Mountain Research Associates, 2001).

Students who participate in FIRST take on leadership roles, learn the importance of teamwork, develop research and technological skills, increase their knowledge of science and technology careers, and have many opportunities to practice their communication and presentation skills. Students learn to strategize, and solve problems in pressure situations (Melchoie, Cohen, Cutter & Leavitt, 2005). Robotics can be used to spark an interest and prepare students for future careers in STEM education (Barker & Ansorge, 2007).

Girls' attitudes towards science and technology improve when they are exposed to robotics programs and consider STEM careers options (Weinberg, Pettibone, Thomas, Stephen & Stein, 2007). NASA recognized the need for more women and minorities in the field of engineering. A steady rise in the number of female engineers has led to an increase of 20% but the percent of female engineers is still below the percent of men in engineering (Rogers, 2003). Girls exposed to robotics at a young age tend to develop a more positive attitude towards science education (Weinberg et al., 2007). Girls become more engaged with school and their self-confidence increases when they learn with robots. Robotics used in the classroom allows girls to problem solve, be creative, and engage in constructivist learning (Weinberg et al., 2007).

Robotics programs can strengthen skills in math and science. Robotics addresses science and math concepts through problem solving, trial and error testing and inquiry skills (Rogers & Portsmore, 2004). One of the biggest benefits is the increase in teamwork and cooperation among students working to solve a problem using robots (Nourbakhsh et al, 2005; Beer et al., 1999). Exposure to robotics and computers at an early age can help a student become a technically skilled adult (Marghitu, Fuller, Brahim & Banu, 2009). Students who participate in robotics programs show a greater interest in technology and have increased technology skills (Rogers, 2003). Robotics kits such as Lego Mindstorms can be used to increase computer engineering, problem solving and technology skills (Williams, 2003).

Robotics can also increase higher order thinking skills, creativity and communication skills (Rogers, 2003). In particular, engaging in robotics has been shown to strengthen communication skills among students with special needs (Marghitu et al., 2009). Project-based programs like robotics use real-life applications that engage students in hands on building, programming and communicating problem solving activities (Melchoie, Cohen, Cutter, & Leavitt, 2005). When students are actively engaged in learning and motivated to learn science their achievement scores drastically improve (Melchoie et al., 2005).

Although there is a growing demand for educational robots there are currently few robotics programs enacted in the formal education setting (Altin, Pedaste, & Aabloo, 2010). Robotics is not found in the formal education setting due in part to the lack of support from school boards (Altin et al., 2010). Teachers are also not confident with their own technical skills and are intimidated by the training. Some schools and teachers have

fears of failure (Altin et al., 2012). In addition, the expense of robotics programs has led to many schools not providing meaningful robotics opportunities for students.

One other major reason for the lack of robots in the classroom is the direction education is currently going. "The greatest problem of the tight focus on tested and standardized basics, though, is that the efforts and activity of teachers and schools concentrate overwhelmingly on these high stakes areas and neglect developing a curriculum or a pedagogy that will prepare students with the twenty-first century skills and capacities that are essential. Unstructured play is disappearing, reading for pleasure is actually in decline and the creativity that requires time, freedom and flexibility as well as exploration and conversation is in rapid retreat." (Hargreaves, 2009, p. 93). Innovation, creativity and exploration still need to be included in the classroom in order for students to do well on government required tests. When educational systems realize the toll high risk test taking is having, programs will once again emerge to allow students time for creativity or other project-based programs like robotics (Hargreaves, 2009).

In summary, robotics programs are making a huge impact on student achievement and attitudes towards science, technology, engineering and math. Robotics programs like FIRST Lego League is preparing students for the future by developing skills in science, communication, technology, problem solving and teamwork. Due to the educational constraints and new demands on educators to teach to the test, most schools are not choosing to include robotics to enhance the curriculum but are adding it as an after school program. More research on the impacts of robotics in the regular classroom still needs to be completed (Petre & Price, 2004; Robinson, 2005). For example, the question of the extent to which LEGO Mindstorms for Schools formal curricular activities can improve

students' problem solving skills is indeed complex and will surely need to be examined in further studies.

METHODOLGY

My action research project was conducted over a four month period, from October 2011 through February 2012. The research methodology for this project received an exemption by Montana State University's Institutional Review Board and compliance for working with human subjects was maintained. The purpose of this study was to investigate the effectiveness of an after school robotics program. Secondary considerations included students' attitudes towards science, technology, engineering and math and teamwork.

This study was conducted at Target Range School in Missoula, Montana. Twenty-eight fifth grade students self-selected to participate in an after school competitive robotics program. The students were divided into three teams. Team One was composed of seven boys who were low achievers in math. Three of the boys had a history of misbehaving in the classroom and outside the classroom. Team Two was composed of a combination of five boys and seven girls. Two of the team members only participated in the practice and did not attend the state tournament and one of the team members joined the team a month before the state tournament. This team had two gifted and talented members, seven high ability members and three low achieving students. Team Three was composed of eight girls and two boys. Five of the students were high ability, two were average ability and three were low ability. The diversity of the teams

allowed the treatment's effectiveness to be analyzed for gender, academic ability, problem solving and teamwork.

The robotics teams practiced one night per week for two hours after school for fourteen weeks. During the first three weeks of practice the students built the LEGO mission structures used for the robotic game. FIRST Lego League core values were discussed during their snack time. During the last five minutes of practice the students reported on their progress and how they worked as a team. The teams were also asked to come up with a team name while they worked on building the LEGO mission structures.

After the third week of practice, the teams had the mission structures complete. They were asked to begin thinking about a topic to research. Team One chose to conduct an investigation on microbes and space food. Team Two chose to conduct a study on eggs and salmonella. Team Three chose to conduct research on cattle ranching and *E.coli*.

During the fourth week I began collecting initial baseline data. All students in the fifth grade completed the MAPs on basic math skills and problem solving test in October 2011. This test was administered on-line to each student. This test was taken again in January, March and May 2012. I used the MAPs results from January and May.

I administered the Test of Science Related Attitudes (TOSRA) in November 2011 (Appendix A). I revised the TOSRA for the post treatment so I could compare only relevant data (Appendix B). The revised TOSRA was administered in March 2012. Students responded by selecting *strongly agree, agree, disagree, or strongly disagree* or selecting the frequency with which they participated by selecting *never, once in a while, or several times.*

The next instrument was the NASA Engagement Survey (Appendix C). During the entire robotics season my students were also participating in NASA's Microgravity Experience. They were heavily involved in designing, creating and engineering an experiment to fly in microgravity. All three robotics team used NASA's Food for Thought activities to conduct their science investigations for robotics. I used a portion of this survey as an additional tool. I only included the portion on the survey related to STEM education. Students responded by selecting *strongly agree, agree, disagree, or strongly disagree to questions on STEM education and careers.* The next technique was the Robotics Competition Season Survey (Appendix D). Students responded by selecting *I know a lot, I know a little or I don't know anything about* the various robotics topics. Students were asked a set of questions related to their problem solving strategies, teamwork strategies and interest in science, math, technology and engineering. They were also asked three open-ended questions about how participating in robotics affected their lives.

The next data collection element used was a Pre & Post Robotics Team Interview (Appendix E). I conducted a video interview with two members of each team. They were each asked why they joined, what they learned and to share anything else they could think of related to their participation in robotics. I also kept a researcher journal to record my observations at the end of each week. Upon completion of the state robotics tournament in February, I collected the post treatment data using the same tools or revised tools.

During the entire robotics season I kept a researcher journal and made video recordings of the students during practices. Initially, I made observations on teamwork,

technology skills and how long the students would stick with building a robot before asking for help. About mid-season, I made observations on teamwork, mission strategies, natural roles the students took on the team and research progress. In the weeks prior to our state competition I made more video clips of the students working with their mission partners. I made observations on how they solved problems and how long they would stick with it before asking for help. The week before competition and during the competition I made visual observations of the students working and listened to them interact with each other.

Prior to the First Lego League Tournament, I simulated the role of competition judges to prepare the students for the state competition. The First Lego League information sheet I used included questions related to robot design, mission strategy, attachments, research project information, what experts they talked to, how they shared research information, teamwork information, how they solved problems and fun facts about the team or any funny stories to share with the judges (Appendix F). I listened to their mission strategies, research presentation and how they

The final instrument used was the teacher created parent email survey (Appendix G). This was sent to parents whose child participated in robotics. The parents made observations regarding their child throughout the season and also traveled to the state tournament. For some parents, this was their second or third trip to the state robotics tournament. The email was sent April 2012.

All the instruments were implemented to collect and analyze data to answer the focus questions as outlined in the Data Triangulation Matrix (Table 1). Table 1 below summarizes methods and treatment during this study.

Table 1
Data Triangulation Matrix

Focus Question: How effective is a school robotics program?	Test and Surveys	Journals	Interview
How does a robotics program affect students' attitude towards science?	TOSRA was administered in November of 2011 and a revised version in February 2012.	Reflections from Researcher Journal recorded October 2011- February 2012.	Student Interview conducted during November 2011.
How does a robotics program affect student attitude towards problem solving?	MAP Test was given October 2011and May 2012.	Reflections from Researcher Journal recorded October 2011- February 2012.	Student Interview conducted February 2012.
How does a robotics program affect students' attitude towards STEM education?	NASA Micro GX Pre-Long Engagement Student Survey was given December 2011 and March 2012.	Reflections from Researcher Journal taken October 2011- February 2012.	Student Video interviews conducted in March 2012.
How does a robotics program affect students?	Teacher made robotics survey was given in November 2011 and February 2012. Parent email survey May 2012.	Reflections from Researcher Journal taken March 2012.	FIRST LEGO LEAGUE Team Introduction Sheet recorded in January 2011.

DATA AND ANALYSIS

Students were interviewed at the beginning of the season regarding their reason for joining robotics. This resulted in fifty-four percent reporting that they chose to participate because it sounded like fun. Sixteen percent chose to participate because their friends were in robotics. Sixteen percent chose to participate because their parents

wanted them to join. Twelve percent chose another reason but didn't state why. Eight percent said it was something new and four percent said it was something they just wanted to try (Figure 1).

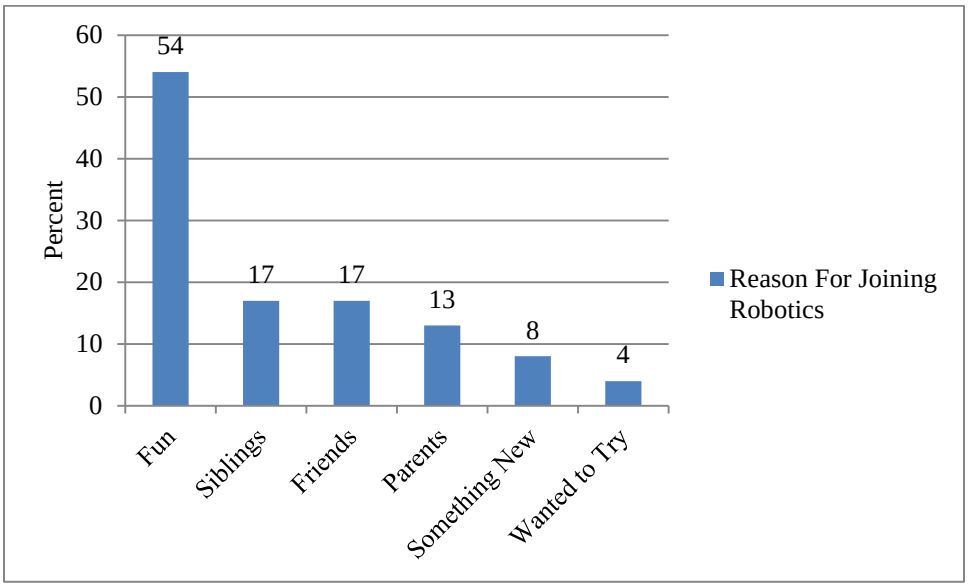

Figure 1. Reason for Joining Robotics, (*n*=24).

The results of the MAP tests for students who participated in robotics indicated that 84% of the students showed improvement and 15% scored lower (Figure 2).

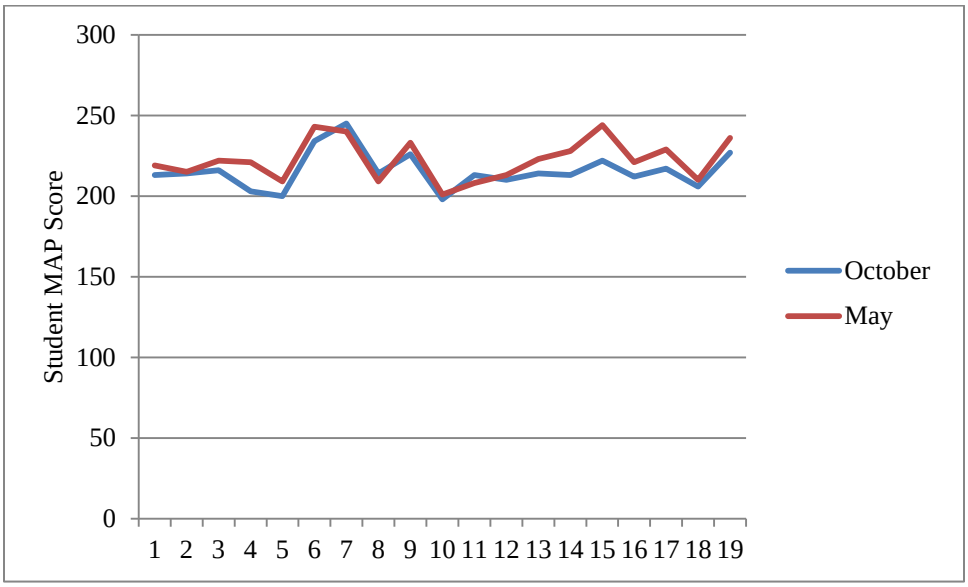

Figure 2. MAP Results, (*n*=19).

When asked how long they stick with a problem during the pre-robotics season, 40% of the students said they would stick with a problem until solved. Thirty-two percent answered they would ask for help only after two or three failures. Twenty–one percent answered they would quit right away if they didn't get the answer. In the post robotics season 79% percent of the robotics participants answered they would stick with a problem until solved. Eighteen percent would ask for help only after two or three failures. No students answered they would quit in the post season (Figure 3).

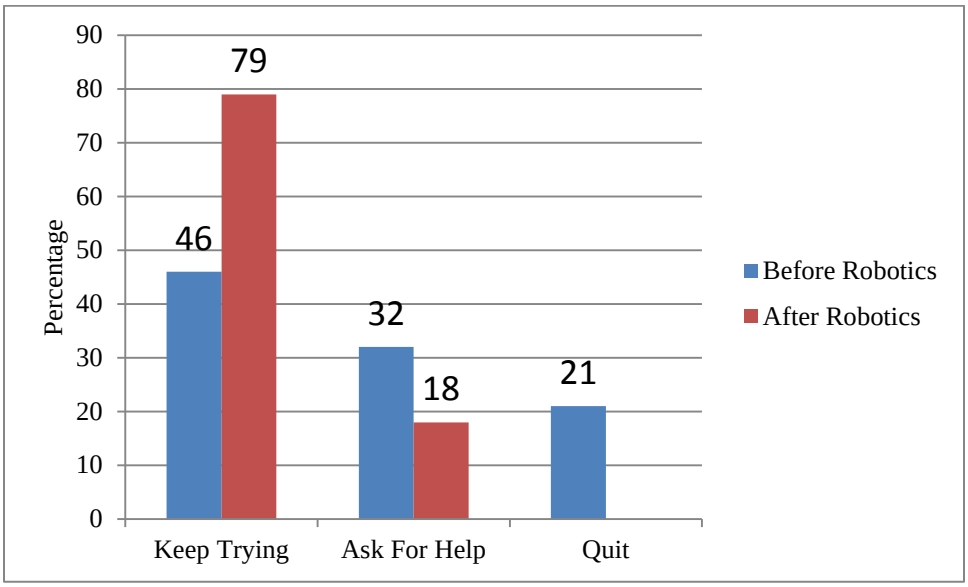

Figure 3. Problem Solving Strategy Results, (*N*=28).

The results of the pre TOSRA survey show that 85% of the robotics students had a strong interest in science compared to 81% of students in the post TOSRA survey. Seventy-three percent answered they were good at science on the pre-survey compared to ninety-two percent after the robotics season. Student consideration of a career in science remained at 65% from pre to post (Figure 4).

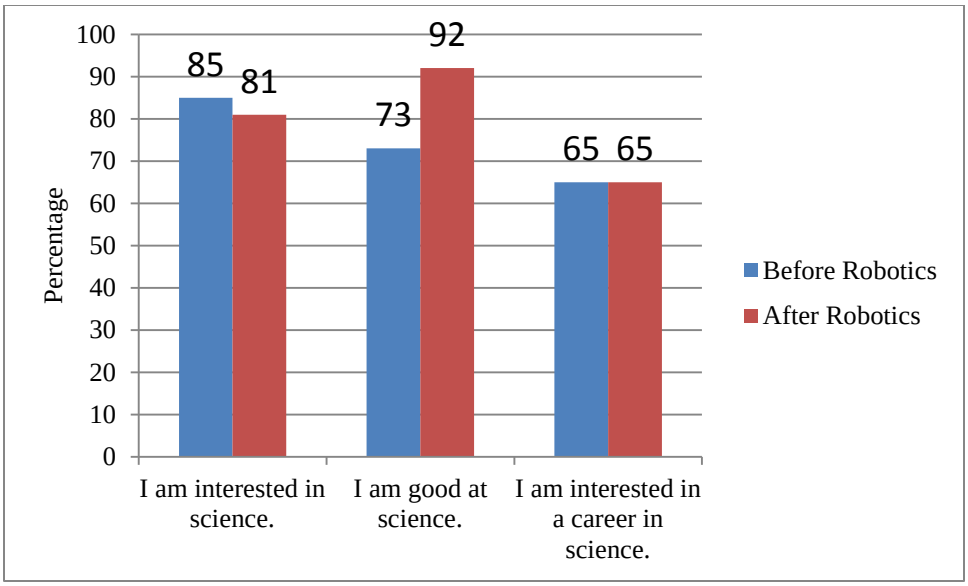

Figure 4. TOSRA: Attitudes Towards Science Results, (*N*=28).

The results of the NASA Micro GX Pre-Long Engagement Survey indicated that 65% had a strong interest in STEM subjects pre robotics. Sixty-nine percent answered they were good at STEM subjects and sixty-three percent had a strong interest in having a career in a STEM field. The results of the post NASA MicroGX Long Engagement Survey indicated that 73% percent had an interest in STEM subjects. Seventy-nine percent answered they were good at STEM subjects and eighty-eight percent answered they were strongly interested in a STEM career (Figure 5).

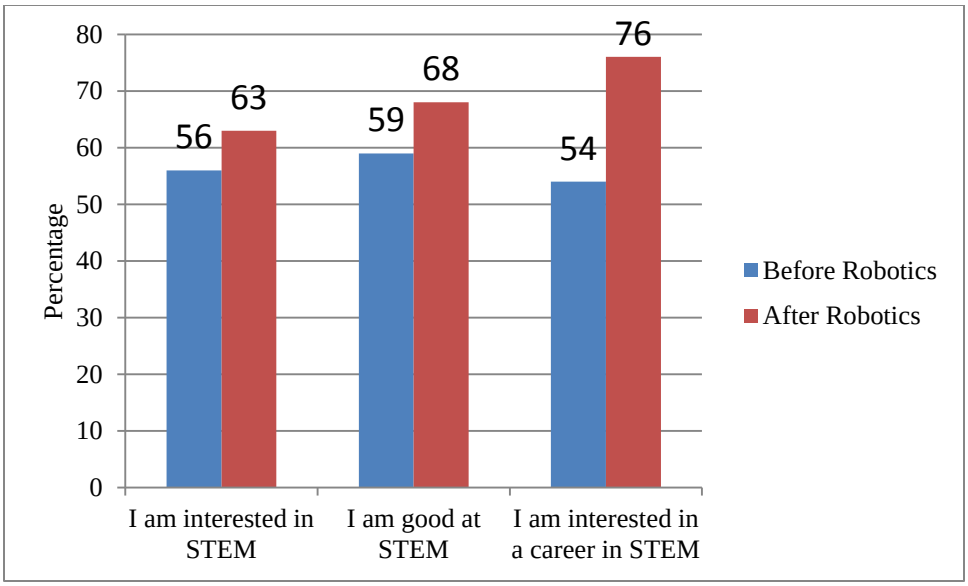

Figure 5. NASA MicroGX Pre-Long Engagement Survey Results, (*N*=28).

The results of the Ebelt Created Robotics Pre-Survey indicated that 29% did not know how to program a robot. One student said, "I know how to build things with LEGOS but I don't know how to build a robot." Seventeen percent did know how to build a robot. Forty-two percent knew how to conduct science research on a specific topic. Thirty-two percent knew how to work as a team. One student said, "I know how to build with LEGOS but I don't know how to build a robot." One student compared working on a team to playing nice with a brother or sister. She said, "To work on a team is kind of like playing with your brother or sister without fighting." Fourteen percent knew how to create a PowerPoint slide show.

After the robotics season ended, seventy-one percent of the students knew how to program a robot. One student said, "Now I can build a robot that could complete all the missions in one program. I can even use all the plugs and most of the sensors to make it work better." Fifty-seven percent could conduct science research on a topic. One student said, "We had to do a lot of research on microbes in space and work with an astronaut. We did some cool science experiments. We swiped yucky stuff and put it on a potato and

it grew microbes." Fifty-four percent knew how to build a robot. Sixty-eight percent knew how to work successfully as a team. One student said, "Our team won a trophy at the state competition because we had awesome teamwork, definitely." Eighty-six percent knew how to create a PowerPoint slide show. One student said, "I was the team's researcher and had to put the PowerPoint presentation together for the team. The judges asked me how I did it. I told them all the steps to put the information in your own words and how to insert pictures. Then you have to practice in front of people" (Figure 6).

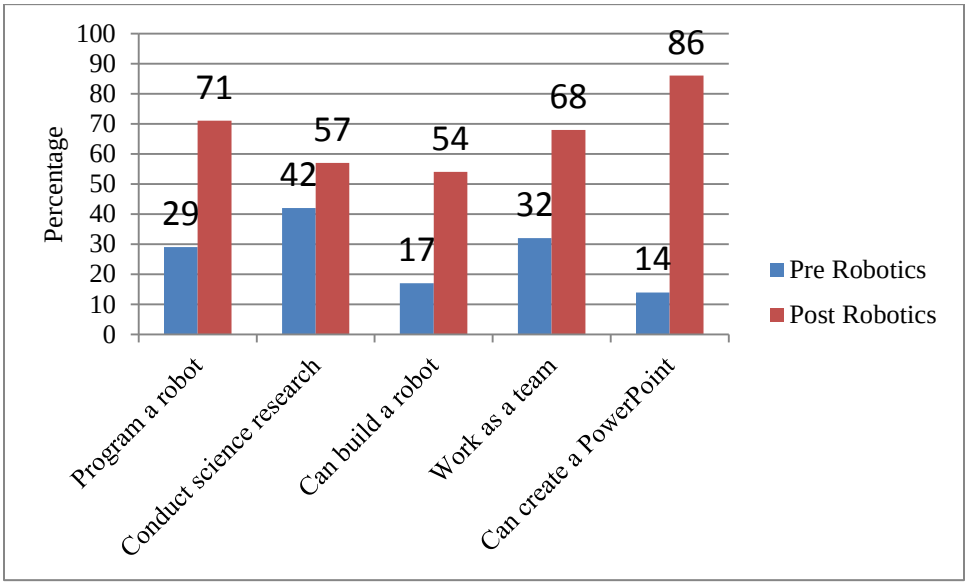

Figure 6. Ebelt Created Survey Results, (*N*=28).

The results of the student video interview indicated that 44% joined robotics because they thought it would be fun. Thirty-three percent joined because it was something new and a brother or sister told them about it. Eleven percent joined because of a friend. One student said, "Robotics sounded interesting and I had a friend who said it was the best time of her life and I loved hearing her talk about it." Another student said, "I joined robotics because it sounded like fun and I didn't know a lot about it but wanted to give it a shot anyway." One student learned about robotics from her brothers

and had this to say, “I first saw robotics when my brothers were in it. I really liked watching what they got to do.”

Students were asked what they learned from being in robotics. One student said, “When I joined robotics I learned it wasn’t just about going to state and earning a medal. It was about working together as a team, researching a science topic and having the most fun possible.” Another student said, “Some of the skills I learned from robotics were to never give up on a problem when you can’t get it right the first time. I definitely want to have a job in mathematics because being in robotics made me a better problem solver.” One of the team members who were on the first place team had this to say, “I was always interested in robots. When I started the season all I really knew was how to build Legos. Our team got first place in science research. I think we did so good because we had so much fun working together as a team.”

The results of the parent email survey indicated that 100% of the students had a strong interest in science. Fifty percent said their child had strong problem solving skills. Seventy-five percent of the parents said their child had an interest in STEM education. One hundred percent of the parents said their child had improved technology skills and stuck with problems longer. Seventy-five percent said their child’s academic achievement improved. One hundred percent of the parents made comments about the life skills and confidence their children have as a result of the robotics program. One parent said,

> Your robotics program was a HUGE confidence builder for our son. THANK YOU SO VERY VERY MUCH!!!!!!!!!!! He truly loves Robotics. Thought you’d enjoy that last night during prayers as he gave thanks to God for all the

> things he's thankful for the first thing he said was 'thank you for letting me build robots, it's really cool!' I was so happy! He was telling my husband and I "yeah and we're building a robot w/ 3 engines and next year Ms. Ebelt said we get to use a sensor'… he was jacked! Personally, I don't even know what the sensor is – ha ha.

Another parent said, "Our son has become more focused while doing school work at home, reading, or doing research, knowing his work will produce a finished product. He has gained more confidence in himself. Working in a group or leading one, has allowed our child to grow as a leader." A parent of a gifted and talented student said, "Our son has been in the GT program and has enjoyed it but robotics in his words, 'Rocks!' This program has been the challenge him in many areas such as science and engineering. In addition to the STEM skills our son has gained we've also noticed his confidence in public speaking and presenting his research to college professors. We have simply been amazed and are so appreciative of your hard work." One parent thought her son might be affected by this later in life. She said, "I'm not sure of the affect now as I think it is too soon. That being said, his techno skills are incredible and I believe it is a direct result of his robotic skills. It's amazing to see him work on a project where he can try different things with the end result in it working." A former student's parent had this to say, "My son's early experience with problem solving in basic robotics laid the foundation for his current high school advanced science project in crane design and his future plans to study mechanical engineering" (Figure 7).

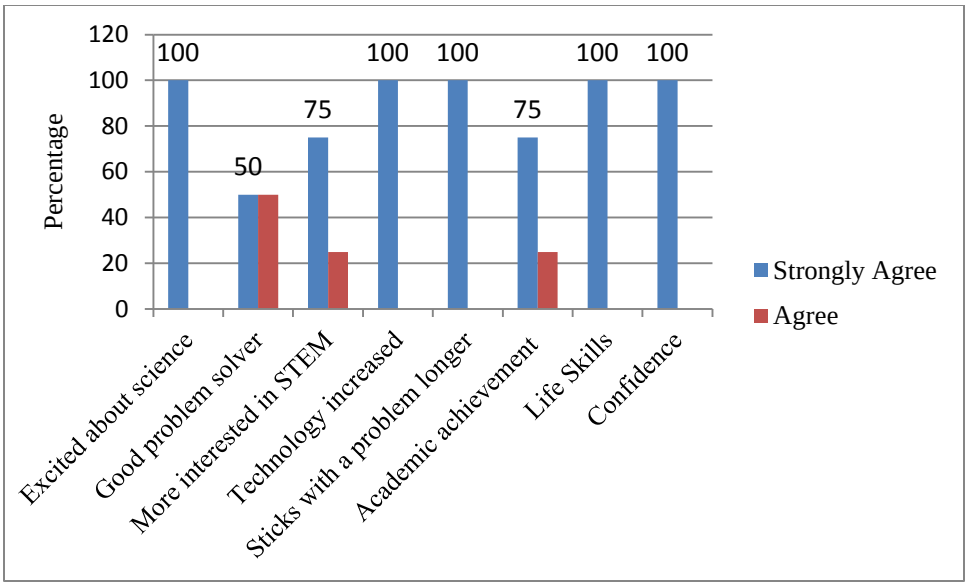

Figure 7. Parent Email Survey Results, (*n*=10).

INTERPRETATION AND CONCLUSION

The results of this action research provided evidence that students involved in an after school robotics program did show gains in several areas. The increased skills were predominantly in the areas of science research, engineering, technology and solving problems as a team. Specifically, students learned how to create a PowerPoint presentation, learned to conduct science investigations and research, build and program an NXT robot and learned how to get along with their teammates.

Students joined robotics for similar reasons. The biggest reasons for joining were to be with friends, it seemed like fun, a brother or sister had been in robotics before and recommended it or their parents wanted them to. A few just wanted to give it a try.

Most of the students had the idea that robotics was just about building a robot. Once they started practice they realize it involved so much more. Students were exposed to science research, science investigations, building and programming robots,

strategizing, problem solving and learning how to work as a team. Many students demonstrated these new skills as the weeks progressed.

The MAP test was included to show growth in problem solving skills. Although the results showed growth, I don't think the math problems on the MAP test can really be compared to the kind of math experienced in robotics. Their attitude towards solving math problems did significantly increase. In my observations, I noticed how students demonstrated time and time again how they would keep working on a robotics mission until they got it. Students would spend lunch recess and afternoon recess to work on a problem. I noticed they also carried this into the classroom and applied this attitude when solving a difficult math problem.

Students that tend to participate in robotics generally come in with a good attitude towards science. As a result, there was little change in their attitude towards science and having a career in science. But what did increase was their confidence in their science ability. When all STEM subjects were compared the students again showed an initial high interest in STEM with the biggest increase in STEM careers. I think the reason for this is that many students during their interviews told me they liked all subjects not just science.

The skills these students demonstrated at the end of the season were recorded on video during their state competition and in a post interview. In my own observations, I noticed how these skills have carried over into the classroom. The three skills I've noticed the most are their ability to conduct science research with a team and present this information creatively through a variety multimedia applications. I've also noticed how poised there are at giving presentations to large groups of students of all ages. In every

single interview I conduced, the students mentioned the importance of teamwork. In their opinion, this was the most important lesson they learned.

VALUE

The experience of conducting an action research-based classroom project has resulted in an increased awareness of how my teaching and programs are affecting students. Throughout this process I was setting out to find how robotics was increasing student achievement. But what I found was the students took away so much more. When conducting my interviews after the robotics season ended, all of the students made a comment on how important working with a team was to them. When I asked them to explain one student told me, “When you work together as a team you get to hear so many ideas. At first you don’t want to hear all of them but then you learn that one of those ideas just might be the one that works the best.” Another student said, “Working as a team takes the pressure off your shoulders. When you have your friends to help it’s just more fun to solve hard problems. It’s even better when everyone listens to each other’s ideas. I learn a lot more by hearing their ideas too.”

After reading the parent email survey responses I discovered some skills I hadn’t considered. It was evident to several parents the level of confidence their child had in themselves because of their participation in robotics. Most parents agreed that their child already had a strong interest in STEM but public speaking and working together as a team were life skills that carried over into their home. Another skill mentioned several times by the parents was leadership skill. In years past, I’ve noticed the teams with strong

leaders are usually more successful in practice and during the competition. It's a skill I didn't really address in this project but should have found a way to include.

There are some things I would have done differently with the project. I had my student teacher conduct most of my pre-treatment interviews. What I didn't realize is that all the interviews were in her handwriting with no way of identifying the students. It made comparing the post interview with the pre-interview for individual students impossible. Most of the students didn't remember what they had said at the beginning.

I would have spent more time on the survey tools. I don't feel all of the questions addressed my focus question and sub questions. I used the entire TOSRA survey for the pre survey but did revise it for the post survey. I might have been somewhat overly ambitious to have seven different data collecting tools. I spent many long hours recording it and analyzing data it and ended up only using two or three tools.

I also wonder how my participation in the NASA's MicroGX and reduced gravity experience affected the students' responses to the survey. The robotics season began the same week as our notification and acceptance into the NASA program. The students worked on both projects simultaneously. Fortunately, we were able to use NASA's Food For Thought educational curriculum for our robotics Food Factor research. Still, I can't be sure if changes in students' attitudes towards STEM were entirely because of robotics or also due to their involvement with NASA project.

Personally, this has been one of the most rewarding experiences I've had in my entire teaching career. I now feel confident in my ability to review literature, collect data, analyze data in order to improve my own teaching practices and increase student learning.

Reviewing literature was fascinating. This was the first time I have ever reviewed the work of other educators and researchers. I have always relied on the administration to keep me informed of the latest in educational practices and have gone along with the changes. Now I feel as if I could be someone who creates positive changes in education and in my own district.

During the past six months, I have learned so much about collecting data. Creating a survey tool that would not only collect the data necessary but also answer the focus question was difficult. I found myself changing the questions as I went along only to realize the survey tool looked very different in the post treatment. I wish I would have spent more time developing a better survey tool. I would also be interested in conducting an action research project over a longer time period. It would be interesting to find the long term effects of a robotics program.

Now that I've completed an action research project, my school district is looking at implementing a robotics program during the school day. The administration would like me to offer robotics to all fifth and sixth grade students. They share the vision that this program does inspire and motivate students to pursue a career in science, technology, engineering or math. I am especially impressed with the teamwork accolades as, clearly, these talents play well for life.

This entire process has given me more confidence in my ability to teach and credibility in my district. I have given numerous presentations to the school board, administration and staff on many aspects of this action research process. I have provided new techniques to give formative assessments that teachers have used. I look forward to sharing the actual results of my action research project.

Seven years ago when I completed my first master's degree, I felt relieved that it was over. I did have a sense of accomplishment but nothing life changing. This master's degree had made me a better teacher for my students, a more confident educator in science, and given me a renewed passion for teaching. Having gone through this process makes me think that I could even pursue a doctorate.

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APPENDICES

APPENDIX A

TOSRA

Test of Science Related Attitudes (TOSRA)
(Fraser, 1981)

Your participation is voluntary.

Directions:

1. This test contains a number of statements about science. You will be asked what you think about these statements. There are no "right" or "wrong" answers. Your opinion is what is wanted.
2. For each statement, draw a circle around the specific numeric value corresponding to how you feel about each statement. **Please circle only ONE value per statement.**

5 = Strongly Agree (SA)
4 = Agree (A)
3 = Uncertain (U)
2 = Disagree (D)
1 = Strongly Disagree (SD)

Statement	**SA**	**A**	**U**	**D**	**SD**
1. Money spent on science is well worth spending.	5	4	3	2	1
2. Scientists usually like to go to their laboratories when they have a day off.	5	4	3	2	1
3. I would prefer to find out why something happens by doing an experiment than be being told.	5	4	3	2	1
4. I enjoy reading about things that disagree with my previous ideas.	5	4	3	2	1
5. Science lessons are fun.	5	4	3	2	1
6. I would like to belong to a science club.	5	4	3	2	1
7. I would dislike being a scientist after I leave school.	5	4	3	2	1
8. Science is man's worst enemy.	5	4	3	2	1
9. Scientists are about as fit and healthy as other people.	5	4	3	2	1
10. Doing experiments is not as good as finding out information from teachers.	5	4	3	2	1
11. I dislike repeating experiments to check that I get the same results.	5	4	3	2	1
12. I dislike science lessons.	5	4	3	2	1
13. I get bored when watching science programs on TV at home.	5	4	3	2	1

14. When I leave school, I would like to work with people who make discoveries in science.	5	4	3	2	1
15. Public money spent on science in the last few years has been used widely.	5	4	3	2	1
16. Scientists do not have enough time to spend with their families.	5	4	3	2	1
17. I would prefer to do experiments rather than to read about them.	5	4	3	2	1
18. I am curious about the world in which we live.	5	4	3	2	1
19. School should have more science lessons each week.	5	4	3	2	1
20. I would like to be given a science book or a piece of science equipment as a present.	5	4	3	2	1
21. I would dislike a job in a science laboratory after I leave school.	5	4	3	2	1
22. Scientific discoveries are doing more harm than good.	5	4	3	2	1
23. Scientists like sports as much as other people do.	5	4	3	2	1
24. I would rather agree with other people than do an experiment to find out for myself.	5	4	3	2	1
25. Finding out about new things is unimportant.	5	4	3	2	1
26. Science lessons bore me.	5	4	3	2	1
27. I dislike reading books about science during my holidays.	5	4	3	2	1
28. Working in a science laboratory would be an interesting way to earn a living.	5	4	3	2	1
29. The government should spend more money on scientific research.	5	4	3	2	1
30. Scientists are less friendly than other people.	5	4	3	2	1
31. I would prefer to do my own experiments than to find out information from a teacher.	5	4	3	2	1
32. I like to listen to people whose opinions are different from mine.	5	4	3	2	1
33. Science is one of the most interesting school subjects.	5	4	3	2	1
34. I would like to do science experiments at home.	5	4	3	2	1
35. A career in science would be dull and boring.	5	4	3	2	1
36. Too many laboratories are being built at the expense of the rest of education.	5	4	3	2	1
37. Scientists can have a normal family life.	5	4	3	2	1

38. I would rather find out things by asking an expert than by doing an experiment.	5	4	3	2	1
39. I find it boring to hear about new ideas.	5	4	3	2	1
40. Science lessons are a waste of time.	5	4	3	2	1
41. Talking to my friends about science after school would be boring.	5	4	3	2	1
42. I would like to teach science when I leave school.	5	4	3	2	1
43. Science helps to make life better.	5	4	3	2	1
44. Scientists do not care about their working conditions.	5	4	3	2	1
45. I would rather solve a problem by doing an experiment than be told the answer.	5	4	3	2	1
46. In science experiments, I like to use new methods which I have not used before.	5	4	3	2	1
47. I really enjoy going to science lessons.	5	4	3	2	1
48. I would enjoy having a job in a science laboratory during my school holidays.	5	4	3	2	1
49. A job as a scientist would be boring.	5	4	3	2	1
50. This country is spending too much money on science.	5	4	3	2	1
51. Scientists are just as interested in art and music as other people are.	5	4	3	2	1
52. It is better to ask a teacher the answer than to find it out by doing experiments.	5	4	3	2	1
53. I am unwilling to change my ideas when evidence shows that the ideas are poor.	5	4	3	2	1
54. The material covered in science lessons is uninteresting.	5	4	3	2	1
55. Listening to talk about science on the radio would be boring.	5	4	3	2	1
56. A job as a scientist would be interesting.	5	4	3	2	1
57. Science can help to make the world a better place in the future.	5	4	3	2	1
58. Few scientists are happily married.	5	4	3	2	1
59. I would prefer to do an experiment on a topic than to read about it in science magazines.	5	4	3	2	1
60. In science experiments, I report unexpected results as well as expected ones.	5	4	3	2	1

61. I look forward to science lessons.	5	4	3	2	1
62. I would enjoy visiting a science museum on the weekend.	5	4	3	2	1
63. I would dislike becoming a scientist because it needs too much education.	5	4	3	2	1
64. Money used on scientific projects is wasted.	5	4	3	2	1
65. If you met a scientist, he/she would probably look like anyone else you might meet.	5	4	3	2	1
66. It is better to be told scientific facts than to find them out from experiments.	5	4	3	2	1
67. I dislike other peoples' opinions.	5	4	3	2	1
68. I would enjoy school more if there were no science lessons.	5	4	3	2	1
69. I dislike reading newspaper articles about science.	5	4	3	2	1
70. I would like to be a scientist when I leave school.	5	4	3	2	1

APPENDIX B

TEACHER REVISED TOSRA

Teacher Revised TOSRA

#_____

5 =strongly agree (SA)
4= Agree (A)
3= Uncertain (U)
2=disagree (D)
1 Strongly Disagree (SD)

	SA	A	U	D	SD
1. I would prefer to find out why something happens by doing an experiment than by being told.	5	4	3	2	1
2. Science lessons are fun.	5	4	3	2	1
3. I would like to belong to a science club.	5	4	3	2	1
4. When I leave school, I would like to work with people who make discoveries in science.	5	4	3	2	1
5. Science is one of the most interesting school subjects.	5	4	3	2	1
6. Talking to my friends about science after school would be fun.	5	4	3	2	1
7. I would like to teach science when I leave school.	5	4	3	2	1
8. Science helps to make life better.	5	4	3	2	1
9. I would rather solve a problem by doing an experiment than be told the answer.	5	4	3	2	1
10. A job as a scientist would be interesting.	5	4	3	2	1
11. I would enjoy visiting a science museum on the weekends.	5	4	3	2	1

APPENDIX C

NASA'S MICRO GX PRE-LONG ENGAGMENT SURVEY

NASA'S MICRO GX PRE-LONG ENGAGMENT SURVEY

What is your gender? Male Female

Circle only one response for Questions 1 – 14.

SA = strongly agree A = agree N = neutral D = disagree SD = strongly disagree

1. I am interested in Science.	SA	A	N	D	SD
2. I am interested in Technology.	SA	A	N	D	SD
3. I am interested in Engineering.	SA	A	N	D	SD
4. I am interested in Mathematics.	SA	A	N	D	SD
5. I am good at Science.	SA	A	N	D	SD
6. I am good at Technology.	SA	A	N	D	SD
7. I am good at Engineering.	SA	A	N	D	SD
8. I am good at Mathematics.	SA	A	N	D	SD
9. I am interested in careers in Science.	SA	A	N	D	SD
10. I am interested in careers in Technology	SA	A	N	D	SD
11. I am interested in careers in Engineering.	SA	A	N	D	SD
12. I am interested in careers in Mathematics.	SA	A	N	D	SD
13. My family is interested in my science, technology, or mathematics coursework.	SA	A	N	D	SD
14. I participate in an after school robotics club?	SA	A	N	D	SD

APPENDIX D

PRE AND POST ROBOTICS TEAM SURVEY QUESTIONS

Pre and Post Robotics Team Survey Questions

#_____

1. Were you involved in robotics? Yes No

2. If you answered yes, circle the answer that best describe you.

a. It sounded like fun.
b. My brother / sister participated in it and said it was fun.
c. My friends were in robotics.
d. My parents wanted me to be in it.
e. Other reason:

3. If you answer no, circle the answer that best describe you.

a. I didn't want to.
b. I was in too many other activities.
c. I wasn't allowed to.
d. My friends weren't in robotics.
e. Other reason:

4. When working on a problem, how long do you stay focused on it?

a. If I don't get it right away, I quit.
b. I keep working, but after 2 or 3 failures, I quit.
c. I keep working on it until I get the answer.
d. Other:

5. What do you know about using robots to learn about science?

a. I know a lot about how to use robots to learn science?
b. I know a little about how to use robots to learn about science.

c. I don’t know anything about how to use robots to learn about science.

6. What do you know about programming a robot using the computer?

a. I know a lot about how to program a robot.
b. I know a little about how to program a robot.
c. I don’t know anything about how to program a robot.

7. What do you know about using robotics computer software?

a. I know how to use robotics software.
b. I know a little about how to use robotics software.
c. I don’t know anything about how to use robotics software.

8. What do you know about building an NXT robot?

a. I know a lot about how to build an NXT robot.
b. I know a little about how to build an NXT robot.
c. I don’t know anything about building an NXT robot.

9. How do you feel about learning science?

a. I am excited to learn science.
b. Science is alright but not my favorite subject.
c. I don’t like science that much.

10. What do you know about researching a science topic?

a. I know a lot about how to research a science topic.
b. I know a little about how to research a science topic.
c. I don’t know anything about how to research a science topic.

11. What do you know about the way hunters and gathers in 12,000 B.C stored food?

a. I know a lot about how hunters and gathers stored food.
b. I know a little about how hunters and gathers stored food.
c. I don't know anything about hunters and gathers.

12. What do you know about the days of ancient Romans and how they protected their food?

a. I know a lot about how ancient Romans protected their food.
b. I know a little about how ancient Romans protected their food.
c. I don't know anything about ancient Romans.

13. What do you know about the way people in medieval Europe made their food last from harvest to harvest.

a. I know a lot about how people in medieval Europe made their food last.
b. I know a little about the way people in medieval Europe made their food last.
c. I don't know anything about the way people in medieval Europe made their food last.

14. What do you know about how the pioneers of North American might have kept their food safe to eat?

a. I know a lot about how the pioneers of North America kept their food safe.
b. I know a little about how the pioneers of North America kept their food safe.
c. I don't know anything about the pioneers of North American made their food safe.

15. Do you know how your food stays fresh?

a. I know a lot about how my food stays fresh.
b. I know a little about how my food stays fresh.
c. I don't know anything about how my food stays fresh.

16. Do you know how your food is protected from microscopic attacks?

a. I know a lot about how my food is protected from microscopic attacks.
b. I know a little about how my food is protected from microscopic attacks.
c. I don't know anything about how my food is protected from microscopic attacks.

17. Do you know where your food comes from?

a. I know a lot about where my food comes from.
b. I know a little about where my food comes from.
c. I don't know anything about where my food comes from.

18. Do you know how your food stays safe to eat?

a. I know a lot about how my food stays safe to eat.
b. I know a little about how my food stays safe to eat.
c. I don't know anything about how my food stays safe to eat.

19. Do you know how your food is prevented from spoiling and contamination?

a. I know a lot about how my food gets spoiled and contaminated.
b. I know a little about how my food gets spoiled and contaminated.
c. I don't know anything about how my food gets spoiled and contaminated.

20. Do you know the threats your food faces and who helps protect it?

a. I know a lot about the threats to my food and who protects it.
b. I know a little about the threats to my food and who protects it.
c. I don't know anything about the threats to my food and who protects it.

21. Do you know how to work together on a team to solve a problem?

a. I know a lot about working on a team to solve a problem.
b. I know a little about working on a team to solve a problem.
c. I don't know anything about working on a team to solve a problem.

22. How could your team protect or preserve your food?

a. I know a lot about how my team could protect or preserve food.
b. I know a little about how my team could protect or preserve food.
c. I don't know anything about how my team cold protect or preserve food.

23. What do you know about using PowerPoint?

a. I know how to create a PowerPoint presentation and add pictures.
b. I know how to create a PowerPoint presentation but need help.
c. I don't know how to create a PowerPoint presentation.

24. What do you know about trial and error testing?

a. I know a lot about trial and error testing.
b. I know a little about trial and error testing.
c. I don't know anything about trial and error testing.

25. What do you know about working together to solve problems on a team?

a. Every time I work on a team someone always bosses someone around.
b. I know that if you listen to your teammates' ideas you will solve a problem together.
c. I have never worked on a team to solve a problem.

26. What makes you excited to participate on a robotics competition team?

a. I like to build things.
b. I like to learn about science.
c. I like to be with my friends.
d. I like to solve problems.

27. What it the most exciting part of being on a robotics team?
a. I like competition.
b. I like to build things.
c. I like to math solve problems.
d. I like to learn about science.

28. What is your least favorite part of being on a robotics team?

a. I don't like competition.
b. I don't like to build things.
c. I don't like to solve math problems.
d. I don't like to learn about science.

29. How many years have you participated in robotics?

a. This is my first year.
b. I have participated 1-2 years
c. I have participated 3-4 years.

30. Will you participate next year?

a. Yes
b. No

31. Do you think you would like a job working with robots someday?

a. Yes
b. No

32. Do you think you will like a job building things someday?

a. Yes
b. No

33. Do you think you will like a job that involves science someday?

a. Yes
b. No

34. Do you think you will like a job that involves math someday?

a. Yes
b. No

35. Do you think you will like a job that involves working with computers someday?

a. Yes
b. No

APPENDIX E

PRE AND POST STUDENT INTERVEIW QUESTIONS

Pre Student Interview Questions

#_____

1. Why did you choose to participate in robotics?

2. What is the best or was the best part about being in robotics?

3. What do you think you will learn or have learned from your participation in robotics?

4. What do you know about teamwork?

5. What do you know about where food comes from/

6. Is there anything else you would like to tell me?

Post Robotics Interview

#_____

Please record the following after each practice.

1. What would you tell someone about being in robotics who has never been in it?

2. What are some things you learned about being in robotics?

3. What did you learn the most about being in robotics?

4. What did you enjoy the most about being in robotics?

5. Is there anything else you want to share about being in robotics?

APPENDIX F

PARENT EMAIL SURVEY

Parent Email Survey

1. My student is more excited about learning science.

   Strongly Agree Agree Disagree

2. My student is a good problem solver.

   Strongly Agree Agree Disagree

3. My student is now more interested in STEM careers.

   Strongly Agree Agree Disagree

4. My student's technology skills have increased.

   Strongly Agree Agree Disagree

5. My student sticks with a problem longer.

   Strongly Agree Agree Disagree

6. How has your students participation in robotics affected his/her academic achievement?

7. How has your students participation in robotics affected his/her life?

8. Is there anything else you would like to comment on?

APPENDIX G

FIRST LEGO LEAGUE INTRODUCTION PAGE

FLL Team Information Sheet

FLL Team Number:

Team Name:

School/Affiliation/Location:

Team Members:

Coach/ Mentors:

Robot's Name:

Robot Design Information

Tell the judges information you want them to know about your robot's design. You might tell them something about your game strategy you think is cool, or some interesting attachment you designed, or some other facts about your robot that you think are cool.

Research Project Information

Tell the judges information you want them to know about your research project. Examples include something special you learned, who you shared your research with, what experts you talked to, and what you learned about your community

Teamwork Information

Tell the judges what you learned about Teamwork this season. Let them know about problems you solved, what you've learned about FLL Core Values, and other things you know about how important teamwork is.

Fun Facts About Our Team

Tell the judges anything fun about your team that you want. It could be a funny story, your team motto,