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Establishing a Robotics Competition in an Underserved Region: Initial Impacts on Interest in Technology and Engineering

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Establishing a Robotics Competition in an Underserved Region: Initial Impacts on Interest in Technology and Engineering

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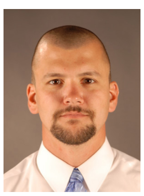

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ABSTRACT

This paper describes the processes undertaken to develop and sustain high school robotics teams in a technologically and economically underserved region and to support their participation in a qualifier competition. The project consisted of seeking and attaining funding, recruiting participating schools and mentors, recruiting students, training mentors, providing technical assistance, hosting a mock competition, and coordinating the actual robotics competition.

A brief survey was used to collect exploratory information on the influence of the robotics team/competition on students selecting a STEM discipline, college majors, and whether or not the participants plan to return next year. Of the 250 student participants, 68 responded and it was found that the younger students, 7-10th grade, had strong prior interests in engineering and technology. The 11th and 12th graders seemed to gain more of an interest through participation in the process. 43% of the participants reported that participation in the competition influenced their decision of a college major. The results suggest that the project did increase student awareness of the STEM fields, particularly engineering and technology. Students also responded that they gained experience and appreciation regarding important non-technical skills including teamwork, cooperation between schools, and project management.

INTRODUCTION

"In every sphere of life, the world is becoming increasingly complex. Citizens, managers, and individual contributors at work discover that they need to know more about science, technology, engineering, and mathematics to succeed in and evaluate a technologically dependent work and learning place." (Feller, 2011) The skills and technology required by today's workforce vary greatly from that of even a decade ago. Over 70% of the jobs in the U.S. require training beyond high school ("Locational Strengths and Weaknesses for WIRED Commerce Corridor of Southeast Missouri," 2009). Students need training in science, technology, engineering, and mathematics (STEM) disciplines to meet the requirements of the 21st century workforce. In 2003 and 2007 global assessments of the Organization for Economic Co-operation and Development (OECD) countries, 15-yr olds from the U.S. ranked 25th of 29 in math literacy, 24th of 29 in problem-solving, and 21st out of 30 in science. US rankings in these assessments have remained consistently low (Alliance for Excellent Education, 2008). In order to improve these statistics and provide a technically competent workforce, students need to be engaged in meaningful activities and curricula that improve their performance in the STEM areas and increase their interest in STEM fields.

The needs for STEM training and its positive effects on employment are especially pronounced in our region. Within our 18 county region, the persistent poverty rate is 44.4 % (compared to 12.3% nationwide) and the persistent child poverty rate is 66.7% (compared to 23.4% nationwide) ("USDA Economic Research Service - County Typology Codes," n.d.). Of these same regional counties, 50.0% have low education (compared to 19.8% nationwide) and 33.3% have low employment (compared to 14.6% nationwide). As technology educators in this region, we recognized this need for education and have established a goal to increase STEM experience and appreciation through the introduction of robotics competitions in our region.

Financial resources and the required technical knowledge are limited in the region. This meant that funds would be limited and must be strongly justified. While a significant number of robotics competitions take place each year, very little data exists that measures the effectiveness of these competitions on increasing students' knowledge of or in the STEM fields. Furthermore, there is not a large percentage of the population in this area that would be familiar with robotics and associated fields. In order for robotics competitions to be successful in this region the recurring costs would need to be low, the competitions would need to have a measureable effect on the participants, and sufficient support would need to be provided to ensure the long-term sustainability.

Benefits of Robotics Competitions

The various Robotics competitions have proven to be great motivators for students to not only excite them but also educate them about STEM fields and careers. Ruiz-del-Solar states, "Robotics is a highly motivating activity for children and young people" (2010, p. 38). Many contest that participation in robotics and robotic competitions increases STEM awareness as well as interest in STEM fields and careers (Oppliger, 2002; Ruiz-del-Solar, 2010; Tougaw & Will, 2005; Welch & Huffman, 2011). Welch and Huffman (2011) found that while most students participate for academic reasons, participation in programs such as the FIRST Robotics significantly improves students' attitudes toward science. One challenge when trying to determine if interests in the STEM fields has changed or increased is the fact that the students that participate are typically self-selected and thus may already have an interest in those fields.

Robotics activities and competitions are set up in a way in which a student can learn and develop skills and abilities, express ideas related to design, and then test them out and see if their efforts have succeeded. This full circle nature of the design-build process naturally involves multiple disciplines. The multidisciplinary nature of robotics is another strong advantage of employing robotics and participating in robotics competitions. Students put math and science principles together when designing their robots (Oppliger, 2002). Robotics integrate technology, engineering, mechanics, computer science, programming, electronics, science, and many other disciplines. The competitions also include multidisciplinary components involving teamwork, communication, and presentation skills (Dodds, Greenwald, Howard, Tejada, & Weinberg, 2006; Ruiz-del-Solar, 2010; Tougaw & Will, 2005).

The missions of FIRST and similar robotics organizations are to inspire young people to be science and technology leaders and to encourage them to pursue careers in STEM related fields. Because students' interests and attitudes toward STEM fields are increased, they are more likely to pursue STEM related degrees. This provides a good avenue for Universities to recruit high school students that participate in robotics activities (Ruiz-del-Solar, 2010). The Universities also benefit from the industrial interaction with the robotics teams and the precollege interaction (Oppliger, 2002).

The benefits to the students, schools, universities and ultimately career fields are numerous. The students' increase their awareness of STEM activities, disciplines, and careers. They also have fun in the process. Schools benefit from having valuable in-class and extracurricular activities that educate their students and involve the community. Universities benefit from more students being educated in and about STEM disciplines. Industries and the STEM fields benefit from a trained and motivated future workforce. More research is needed to better understand the benefits and the effects of robotics competitions. This project examined the initial impact of a robotics competition in an underserved region of the country by investigating its influences on students' interests in STEM disciplines and college major selection.

The purposes of this paper were to:

1. communicate our procedure for establishing a robotics competition in one of the poorer regions of the country and to take an initial look at:
2. the influence of the robotics teams/competition on interest in STEM disciplines;
3. the influence of the robotics teams/competition on college majors selected by the students;
4. whether or not the participants plan to return next year in order to sustain the program.

The methods used to introduce the competition and recruit participants will be discussed. The steps taken to support the teams will also be laid out. Finally, data collected from the participants, lessons learned, and topics for future research will be presented.

PROJECT DESCRIPTION

The objective of the project was to stimulate interest in STEM disciplines through the promotion of high school robotics competitions. According to Nourbakhsh (2009), "Robotics has been an outstanding vehicle for helping draw young students to the magic of science and engineering". The project aimed to reach high school students with a low-cost, accessible opportunity to discover the excitement and rewards of science, technology, and engineering. Several contend that robotics competitions and involvement in robotics motivates students to pursue STEM related fields (Mosley, Liu, Hargrove, & Doswell, 2010; Ruiz-del-Solar, 2010). Through the implementation of this project, it was hoped that high school students would be more likely to enter technology-related fields. In order to accomplish this, the implementation was broken down into multiple phases: procuring funding for the project, recruitment, training and support, the competition, a pilot study of interest in STEM, and sustainability.

To meet the needs of this project, the robotics competitions sponsored by FIRST (For Inspiration and Recognition of Science and Technology) was chosen. The goal of this organization is to inspire young people to be science and technology leaders by engaging them in exciting, mentor-supported robot-building competitions. These competitions are designed to build science, engineering, and technology skills; inspire innovation; foster self-confidence, communication, and leadership; and to be fun. FIRST has two competitions designed for high school students, FTC (FIRST Tech Challenge for high school students) and FRC (FIRST Robotics Competition for high school students). This project focused on encouraging high schools within the Southeast Missouri region to participate in the lower-cost FTC competition.

Funding

A key factor in the success of this project was the funding that supported it. A federal Workforce Innovation in Regional Economic Development (WIRED) grant was received to support this project. Because of the unfamiliarity of robotics competitions in the region and the financial situation faced by local schools, it was decided early on that high schools would require extensive up-front support to encourage participation. Therefore, the kits for the teams and registration costs for the competition were both provided to the teams for the first year. The grant also provided funding for the support and training of the teams. It is very likely that none of the participating schools would have participated if these grant funds were not available.

While the grants funded a significant percentage of the costs incurred in the first year, teams were required to cover other costs, namely transportation and supplies. The teams were encouraged to hold fundraisers and/or solicit donations from the community to cover the additional costs. It was very important for teams to get this experience since the grant funding was only provided for the team's first year when costs are the highest and the teams are unfamiliar with the competition. It was hoped that once teams made it through the first year, they would become self-sufficient in the following years since there is increased familiarity and reduced costs.

RECRUITMENT

Identification of School Districts. Since this project involved high schools, one of the initial tasks was to compile a list of the regional high schools that could participate. These schools were all contacted via phone and informed of the opportunities and benefits of participating. Coverage from local television stations, radio stations, and newspapers was very successful in helping to get the information out. While wanting to give every school a chance, the resources or experience needed to support all high schools in the region were not available. Once contact was made with the schools, additional information regarding the project, its requirement, and its benefits were provided to them through regional information sessions.

Regional Information Sessions. As part of our initial recruitment of high schools, information sessions at four different locations in the region were hosted to reach as many schools as possible. These information sessions were geared to get support from high school administrators, principles, and instructors. The support, both financial and technical, that would be supplied to help make the program successful was detailed. A demonstration robot was on hand at these information sessions and information on the programs provided. Representatives of current FTC programs and FIRST attended to speak at the information session participants and answer any questions they may have. The goal was to show that the FTC competition was a fun and cost-effective way to boost interest in science, technology, engineering, and mathematics at high schools as well as increase students' knowledge in those fields.

Recruitment of Individual Schools. Because of limited resources, it would be infeasible to have an unlimited number of schools participate in this project. Therefore, the level of interest and support that high schools could provide had to be gauged in order to narrow the list. To do this, the authors traveled to individual schools to help them in their decision and assess their interest levels. Similarly to the information sessions, demonstrations and details on the expectations and benefits of the program were provided. The authors met with more of the administration, identified instructors (or others) that could lead the FTC team at their location, spoke to students, and identified potential industrial representatives. The initial plan was to recruit until there was a maximum of 5 to 10 schools identified. Because of gracious funding on the part of the grant agency, the number of teams that could be funded was more than doubled to 22 schools and community groups.

TRAINING AND SUPPORT

Workshop for Coaches. Once the high schools had committed to the competition, our role shifted from recruitment to support. The first support activity was a workshop for coaches. The majorities were high school instructors but two of the teams were home school teams and coached by parents and members of the community. As part of the competition, teams were required to work with a standard kit of parts that includes items such as structural supports, motors, gears, encoders, sensors, joysticks, and programmable controllers. Since most of the high school instructors did not have significant experience with these types of devices, the function and application of each of the devices were explained. Considerable time was devoted to the programmable controllers and using the different programming languages that were available. Also, the session included how the controller could be connected to the sensors and other parts to perform simple operations.

Another important aspect of the training session was that it brought all of the coaches together into one room. To increase the sustainability of the program and to help the coaches in their first year, cooperation and mutual support between the coaches was encouraged. This was very successful and allowed many of the coaches meet each other and establish a valuable support network among the coaches and teams.

RECRUITMENT OF STUDENTS

For each school that took part in the FTC through this program the authors offered to travel to their location and assist with recruiting students to work on the robots. Demonstrations and information were provided for the schools that wanted additional assistance in recruiting. The goal was to show students how fun these projects can be and to encourage them to find industrial partners, industrial mentors, or parents to act as mentors. The demonstration robots made the students very excited about the competition and encouraged the students to ask a lot of questions about what went into building a robot.

ON- AND OFF-SITE PROJECT ASSISTANCE

The FTC is set up so that the rules and what the competition will entail are not sent out until September. Teams then have until December to design, construct, and program their robots to perform the tasks of the competition. The authors visited several of the schools to assist with issues the teams had with building and programming their robots. Coaching roles were not taken on, but instead the authors functioned as mentors and offered assistance in working out some of the more difficult problems. If a team had an issue they could contact the authors who would get back to them with an answer. The goal was to make one on-site visit to each team to ensure their projects were progressing and to assist with any problems the team may be having.

A mock competition/work day was hosted two weeks before the actual FTC competition. The purpose of this event was to ensure that all teams would have a working robot by the day of the actual competition. All of the teams were invited (and strongly encouraged) to meet at the University to work on their robots and to have ‘practice matches’ between robots. This allowed teams to get together, share resources, and get ideas from one another. It also demonstrated to the teams what would go on the day of the actual competition. This event was incredibly successful. It was surprising to find how eager teams were to help one another and the amount of progress that was made at the mock competition by several of the teams. Some teams who had early issues were able to complete their robots. Others used their experiences at this event to make substantial changes and improvements to their robots.

COMPETITION

Many schools are using competitions as an affordable way to involve a large number of potential participants (Fiorini & Kragic, 2006). The initial plan was to recruit 10 teams and require that they attend an existing competition in a nearby metropolitan area. Since 22 teams ended up participating, the existing competition could not accommodate them. In working with *FIRST* it was decided that a separate regional qualifier should be hosted in that area. The authors took on the challenge, with a great deal of help and support from their department, the University, and *FIRST* volunteers, of organizing and hosting a competition. The new competition ended up with the 22 regional teams and an additional 10 teams from outside the region competing in the event. The competition is a crucial component of the project and a strong motivator for the students. The competition gives the students a chance to test their accomplishments and ideas, reinforces what was learned, and also promotes cooperation among the teams and other teams.

The competition is a very dynamic event with opening and closing ceremonies, music playing, announcers calling out play-by-play action, and students dressed in costumes with mascots. Each year the competition is different but utilizes the same basic materials or kit for the robot. Most of the regional or qualifying competitions accept anywhere from 20 to 35 teams. Teams can have from three to ten high school students. The teams will have at least one mentor and typically more. That is a total of over 350 students competing and hundreds of spectators at regional competitions which yields an incredibly exciting event with a lot of action and energy throughout the day.

There are many components of the competition besides just building a robot that completes a task. The competitions and activities are driven by *FIRST*’s underlying values such as respect, integrity, professionalism, and their motto of gracious professionalism. The teams are judged on several aspects of the processes that have lead up to the competition. Teams must document what they have done to develop their robot, fund their team, and create a team atmosphere in their engineering notebook. At the competition teams also attend judging sessions in which the team members have to articulate and demonstrate the many aspects of the experience they have been through during the development. Several awards are given based on the judging competitions.

Another unique aspect of the competition is that on the robot competition field, 4 teams compete at one time. Two teams work together against the other two teams. During qualifying rounds, the teams are selected and paired together as part of the bracketing process. During the final rounds the teams follow a process to select their own alliances or teams that will be a part of their larger team. This creates a very unique environment in which teams must cooperate, recruit other teams, and strategize how they will work together on the playing field.

SUSTAINABILITY

The grant was meant to support only the startup of FTC teams in the region. Fortunately, the first year is the most expensive year (in terms of both money and other resources) for FTC teams. Subsequent years are typically less expensive since the FTC kit, software, and development materials have already been purchased. Moreover, there is less of a time commitment from mentors and coaches since students, coaches, and mentors will have more experience with the program. Finally, there is less apprehension since teams are already familiar with the competition. That is not to say that there are not impediments to continuing the robotics teams. A financial commitment and technical assistance are both needed to keep the program going. The authors and additional faculty at the university have committed to continue providing technical assistance when possible. However, it is hoped that industrial sponsorships and partnerships will help with providing both financial and technical support. It is incredibly important to build these relationships in the first year of the program.

The robotics teams and competitions are an excellent extracurricular activity that should be on par with athletic programs in the eyes of administration. In fact, at some schools the FTC competition actually overshadows athletics in both administrator and community support. While the authors will do all that they can to encourage this support, student success and participation will be the most convincing persuasion.

SURVEY RESULTS

The participants in the FTC competition were each given a short, investigative survey during the event and asked to return them on a voluntary basis. The surveys asked the students to respond to the following statements regarding demographics and influence of participating in robotics.

A. Demographics:

1. Team number
2. Age
3. Year in school (grade level)
4. Gender

B. Influence of Robotics on interests and future education: (4-level Likert-type scale)

1. I plan to participate in an FTC program next year.
2. I had an interest in engineering and technology prior to participation in this competition.
3. This program changed or influenced my decision towards my selection of a major in college.
4. I have decided on a major in college.
5. I have decided on a college to attend after graduating high school.

C. Future Education Choices

1. Math
2. Science
3. Engineering
4. Technology

* Participants also had the option of selecting none of the majors or multiple majors.

D. Open-ended questions regarding competition and its influences:

1. In your opinion, what was the best or most challenging thing about the competition?
2. How do you feel that this competition has influenced you?

Of the approximate 250 student participants for the event, 68 valid survey responses were returned. Of those responses, 36 came from students within our region. The remaining responses came from schools in other areas that participated in the same competition. While a higher response rate was obviously preferred, the sample of responses was beneficial to examine. Figure 1shows the distribution of survey participation by grade level and gender.

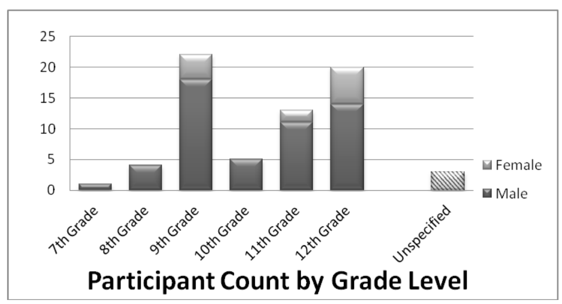

FIGURE 1- DISTRIBUTION OF SURVEY PARTICIPATION BY GRADE LEVEL AND GENDER

It was evident during casual observation of the competition that males outnumbered the females. Of the respondents, males (n=53) greatly outnumbered females (n=12) and the participants were primarily in high school (grades 9-12). An interesting result from this data is that 9th (n=22) and 12th (n=20) grades had considerably more participants than 10th (n=5) and 11th (n=13) grades. Data was not collected on why this might be but one speculation is that 9th and 12th grades may be more open to trying new things and that 12th grade participation increases because students are focusing more on future education options and exploring activities in STEM fields. It could also just be that they were more likely to complete the survey than the other grades.

Figure 2 displays the participant responses to the statement indicating previous interest in science and technology. This data shows that students between 7th and 10th grade had an overwhelming prior interest in engineering and technology. This likely led to their participation in the competition. Participants from 11th and 12th grade, however, were much more evenly distributed across the interest levels (with an average in the 'Agree' level). One possible interpretation of this result is that upper-level students are more likely to participate in a robotics competition even with a lack of interest in engineering and technology. This may mean that upper-level students are more likely to try out other 'career' types in preparation for college or they are more likely to participate in extra-curricular activities. Another interesting result from this question is the difference between regional and non-regional participants. Regional participants were 2.25 times more likely to not have an interest in engineering and technology. This could be due to the non-regional participants being primarily from a major metropolitan area where careers in engineering and technology are more common. Regional participants are less likely to be familiar with engineering and technology professionals.

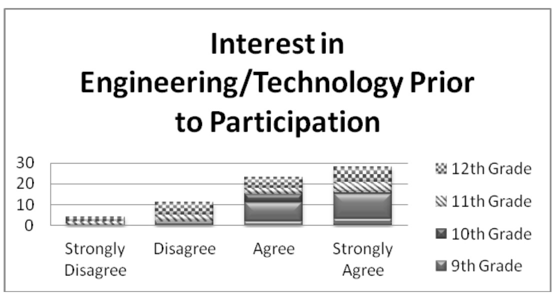

FIGURE 2- RESPONSE TO 'I HAD AN INTEREST IN ENGINEERING AND TECHNOLOGY PRIOR TO PARTICIPATION IN THIS COMPETITION.'

After participating in the competition, 68% of regional students and 75% of non-regional students report having decided on a college major. As for the majors they selected, 26% chose engineering, 15% technology, 12% science, 2% math, and 17% selected multiple majors. 43% of participants specified that the competition influenced their decision towards their selection of a major. Of the participants who did not report a major or reported multiple majors, 38% reported that the competition influenced their decision. Figure 3 shows which students have decided on a particular college. As expected, the 12th graders had the highest percentage of deciders. One interesting result is that regional students are more likely to be decided on a major. However if you look only at 12th graders, 100% of non-regional 12th graders report deciding on a college while only 38% of regional 12th graders have decided.

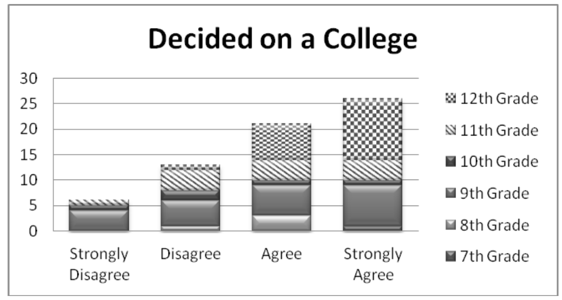

FIGURE 3- RESPONSE TO 'I HAVE DECIDED ON A COLLEGE TO ATTEND AFTER GRADUATING HIGH SCHOOL.'

The next question was designed to determine overall satisfaction for the participants and to determine how many participants would participate next year. Figure 4 shows the results of this question. The overwhelming result was that students would participate in the future. There were only a few students who did not plan on future participation. The results were approximately the same despite differences in region and gender. This tells us that participants do plan to attend next year but does not specify why they will. It could be because they thought it was fun or that they find value in learning and being exposed to the STEM concepts required. More data needs to be collected as to why they would return.

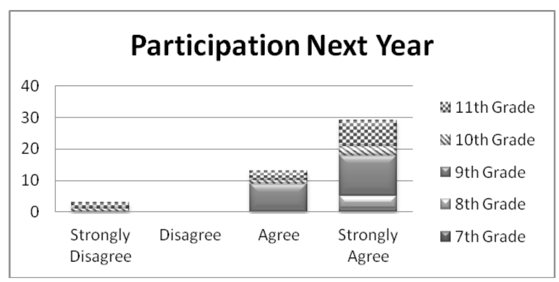

FIGURE 4- RESPONSE TO 'I PLAN TO PARTICIPATE IN AN FTC PROGRAM NEXT YEAR.'

Finally, there were two open-ended questions on the survey. The first open-ended question asked what was the best or most challenging aspect of the competition. The most common responses referred to the actual work of getting the robot put together and working. Specifically, 22% of respondents referred to troubleshooting ('fixing glitches', 'keep the robot working', 'getting it to run'), 19% to building ('building the robot', 'building the basket', 'how to construct a robot'), and 18% to programming ('getting the programming to work', 'programming'). Another major response was from 13% of the students that referred to interacting with others ('learning to get along with people', 'interacting and learning from other teams', 'teamwork') as one of the best or most challenging aspects. Computer issues were a challenging aspect for 9% of respondents ('bluetooth!', 'connecting the bluetooth', 'technical difficulties').

The second open-ended question asked the participants how the competition influenced them. The most common was the 18% of responses that indicated the competition taught them about technology and engineering fields ('greatly changing my ideas about engineering', 'helped me realize how complicated engineering is', 'opened my eyes to a new way of looking at engineering and technology'). Not all responses were positive towards engineering and technology, however. One response was that 'it reassured my decision not to go into engineering'. 16% of respondents indicated that they increased their technical knowledge in some way ('better understanding of the programming', 'hands-on experience with engineering'). 17% of participants referred to improving their teamwork, work ethic, and project management skills ('made me work better with groups', 'taught me to keep working on it, even though it was difficult', 'taught me how I can work under stress'). While 12% of respondents said the competition did not influence them, 9% said it increased their desire to enter engineering or technology fields or participate in future robotics competitions.

CONCLUSIONS AND RECOMMENDATIONS

The purpose of this article was to communicate our procedure for establishing a robotics competition in one of the poorer regions of the country and to explore the influence of the robotics team/competition on interest of the STEM disciplines and selection of college majors, and whether or not the participants plan to return next year. This project was very successful in recruiting and getting teams to participate in robotics and the qualifier competition. Having 22 teams participate far exceeded the goal of approximately 10. The initial data collected on the participants provided interesting insight into some potential influences the project had on the students and the data also presented many questions and opportunities for further research. Data suggests that the students will return, the project will be sustained, and they did benefit from participating. Particularly, they reported having increased appreciation in engineering and technology. 43% reported that participation influenced their decision towards their selection of a college major.

Interestingly, the students also mentioned interaction with others as a challenging and beneficial part of the process. Being able to work cooperatively and with teams is a skillset that many employers consider critical. It is often difficult to teach and assess these skills and abilities in classroom settings. Participation in robotics may be an additional way to teach and reinforce these concepts.

The authors' assumptions and recommendations are presented through a postpositivist worldview (Creswell, 2008). It is the opinion of the authors' that specific factors are contributing to the need for students trained in science, technology, engineering, and mathematics (STEM) disciplines in the Southeast Missouri region. These factors are influencing and perpetuating the lack of students available to enter STEM related fields upon graduation. It is the belief of the authors' that additional examination of the following will give way to information necessary to combating this dilemma:

1. Is there a correlation between student exposure to programs that increase excitement and disposition towards STEM in middle school and their career choice upon graduation? How does this relate to the career choice of high school students that are exposed to programs that increase excitement and disposition towards STEM?
2. To what extent and in what ways does a school district's financial resources impact STEM programs in high school? Furthermore, what impact does a school district's financial resources have on the availability of programs designed to increase student excitement and disposition towards STEM?
3. Are middle schools and high schools utilizing recruitment strategies that encourage student participation in STEM programs and, if so, what is the effectiveness of those strategies when compared to middle schools and high schools that have no recruitment strategy?

There are three purposes for the recommended studies:

1. To determine what factors positively influence middle and high school student readiness and disposition towards STEM careers.
2. To determine if the lack of individuals available to populate technical positions is impacted by a districts financial resources.
3. To develop enhanced STEM recruitment strategies based on identified factors, develop performance measures for middle and high school teachers, and increase teacher accountability for student enrollment.

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