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## Students with Autism Spectrum Disorders Who Participate in FIRST Robotics

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One of the challenges of educating adolescents with autism spectrum disorders is to find activities that are interesting and engaging. Researchers have shown that adolescents with autism often are attracted to technology. Using an exploratory research method, the experiences of three students with autism who participated in after school robotics clubs were analyzed. Common themes to emerge were the students with ASD were engaged and interested in FIRST robotics and technology. Specifically, they enjoyed coming up with ideas, inventions, and creating or solving missions. Their confidence increased and they learned to work better on teams. Additionally, they needed significant supports to participate in FIRST Robotics.

## **Keywords**

autism, robotics, technology, STEM

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Students with Autism Spectrum Disorders Who Participate in FIRST Robotics

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## Abstract

One of the challenges of educating adolescents with autism spectrum disorders is to find activities that are interesting and engaging. Researchers have shown that adolescents with autism often are attracted to technology. Using an exploratory research method, the experiences of three students with autism who participated in after school robotics clubs were analyzed. Common themes to emerge were the students with ASD were engaged and interested in FIRST robotics and technology. Specifically, they enjoyed coming up with ideas, inventions, and creating or solving missions. Their confidence increased and they learned to work better on teams. Additionally, they needed significant supports to participate in FIRST Robotics.

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## Students with Autism Spectrum Disorders Who Participate in FIRST Robotics

Autism spectrum disorder (ASD) is an increasingly common developmental disability that negatively impacts student performance. For example, students with ASD often fail to complete high school and obtain meaningful employment (Taylor & Selzer, 2011; Sanford, Newman, Wagner, Cameto, Knokey, & Shaver, 2011). Autism spectrum disorder is characterized by impairments in socialization, communication, and restricted or repetitive behaviors and interests (American Psychiatric Association, 2013).

Autism spectrum disorders now impact 1 out of every 59 children (Baio et al., 2018). Only 68% of students with ASD finish high school with a regular diploma (U.S. Department of Education, 2017). According to Taylor and Selzer (2011), between 89 and 94 percent of adults with ASD are unemployed or underemployed. In 2018, Wei and colleagues analyzed the National Longitudinal Transition Study-2 (NLTS2) from 2009 and found fewer than 30 percent of individuals with ASD from ages 21-25 were looking for a paid job and only 22 percent found a job on their own, the lowest rate among the disability groups.

A common perception is that students with ASD gravitate toward Science, Technology, Engineering, and Mathematics (STEM) fields as they mature (Wei, Yu, Shattuck, McCracken, & Blackorby, 2017). Baron-Cohen (2009) theorized that systematic thinkers (such as students with ASD) tend to construct rule-based systems to follow while empathetic thinkers analyze their world through social and emotional reactions to others. The systematic brain is necessary for success in STEM fields (Baron-Cohen, Wheelwright, Burtenshaw, & Hobson, 2007). This, coupled with the fact that the engineering field will add approximately 272 million new jobs by 2020 (U. S. Department of Labor, 2013), leads to the notion that students with ASD might realize significant employment benefits by experiencing activities in high school that promote

content and social skills necessary for successful STEM employment.

Although research shows nondisabled students who participate in STEM clubs tend to have better outcomes, many students with disabilities (SWD), including students with ASD are not involved in school related extracurricular activities compared to their nondisabled peers (Betz & Redcay, 2005). Specifically, SWD were reported to have a participation rate of 64 percent compared to their peers of 81 percent (Lipscomb, Haimson, Liu, Burghardt, Johnson, & Thurlow, 2017). Researchers have recognized the importance of informal learning environments on the reform of STEM education (Denson, Haily, Stallworth, & Householder, 2015). While much research has been conducted on the benefits of nondisabled students and club participation (e.g., Durlak, Weissberg, & Pacan, 2010; Eccles & Barber, 1999; Fredricks & Eccles, 2008; Mahoney, 2000; Mahoney & Cairnes, 1997), very little formal research has been conducted on the outcomes of SWD including students with ASD, and club participation (Coster et al., 2012).

Due to their strengths in logical, rule-based systematic thinking, students with ASD can excel in a highly specific field (Baron-Cohen, 2009). One way to potentially support students with ASD to use their systematic thinking and engage in engineering skills and technology while learning social skills is to consider after-school activities such as “For Inspiration and Recognition of Science and Technology (FIRST)” Robotics. The mission of FIRST Robotics is to “inspire young people to be science and technology leaders, by engaging them in exciting mentor-based programs that build science, engineering, and technology skills, that inspire innovation, and that foster well rounded life capabilities including self-confidence, communication and leadership” (USFIRST.org, 2019). For Inspiration and Recognition of Science and Technology is an international program and offers four different programs to K-12 students, involving more than 600,000 students (USFIRST.org, FIRST at a Glance, 2019).

Jackson (2013) stated FIRST Robotics made a significant contribution toward advancing STEM careers for students. Further, FIRST is more than building robots, it is about building self-esteem and self-confidence. Not only do students work as a team to design, build, program, and compete with robots, they also solve real world problems, build webpages, create and edit marketing type team promotional videos, create business plans, and perform community service (USFIRST.org, 2019). Additionally, Waters (2007) wrote, students learn about collaboration, project management, developing goals, and public speaking. In a 2017 study Menekse, Higashi, Schunn and Baehr found students taking part in First Lego League (FLL) were engaged in engineering tasks where collaboration and teamwork produced superior results in the competition.

It is not known how many students with ASD participate in FIRST robotics. The FIRST Robotics founder Dean Kamen has a goal of bringing video games to life to help students realize not only can they play games; they can learn the skills to make video games. Due to previous research by Baron-Cohen and colleagues (2007) on the systematic and logical thinking of people with autism, the rationale of this study is students with ASD will gravitate to programs like FIRST robotics if given the opportunity and support. While a longitudinal study (Melchior, Burack, Hoover, & Marcus, 2017) is underway on the impact of FIRST, no data has been collected on the impact of FIRST robotics on students with ASD.

FIRST robotics is designed to promote a culture called ‘gracious professionalism’, which is defined as, “a way of doing things that encourages high-quality work, emphasizes the value of others, and respects individuals in the community” (USFIRST.org, 2019). Additionally, FIRST encourages ‘coopertition’ which is “displaying unqualified kindness and respect in the face of fierce competition” (USFIRST.org, 2019). The inclusive culture encourages SWD to participate

in spite of their lack of social skills and inexperience with robotics. Given the need for a more diverse STEM workforce (Denson et al., 2015) and the success of students ASD in STEM like environments (Baron-Cohen, 2009) the current study examines the experience of students with ASD who participated in FIRST robotics. A scholarly investigation of students with ASD who participated in after school robotics may bring clarity to the importance of participation in FIRST after school clubs. The following research question was used to frame the discussion with students with ASD: What are the experiences of upper elementary and high school students with ASD who participate in FIRST Tech Challenge (FTC) and FIRST Lego League (FLL) robotics?

## Research Methods

### Setting

The researcher met with students in a classroom at the participants' school. The site for this study was a private school for students with disabilities. The school was comprised of approximately 45 students and 25 teachers and staff. All students were reported to have mild to severe disabilities and all students attending the school had an active Individualized Education Program (IEP). The school serves students from first through twelfth grade. The interview took place in one of the meeting rooms. Students and parents were interviewed on an individual basis.

**Robotics Teams.** FIRST Lego League (FLL) is a program for students' ages 9-14. Team members collaborate to create innovative solutions for current challenges in a research project. They also strategize, design, build, program, and test a robot that performs autonomous missions. FIRST Tech Challenge (FTC) is for high school students who want to compete. Team members collaborate to design, build, program, and compete with robots. The robots are programmed to compete autonomously and with remote controls to score points in a game created by FIRST.

## The Researcher's Role

Prior to this study, the researcher had coached FIRST robotics teams for three years in a public high school setting. The researcher who conducted the interviews was a coach of the students on the robotics team. The positionality of the researcher being the coach could impact how the students and parents interacted with the researcher. This factor is important because the information collected and how it is interpreted could be different because of the researcher's role with the students with ASD and their parents. The researcher's personal perspective might influence the findings.

## Participants

There were six participants in this study, three students and three parents. The parents were two fathers and one mother. All of the student participants were males between the ages of 10 and 16 and all had a primary diagnosis of ASD.

Students. Student one is a ten-year-old Caucasian student in the fourth grade. He has normal intelligence and is verbal, but his uncooperative behaviors have limited his ability to be successful with non-disabled peers. He has participated in extracurricular activities in the past including special needs soccer, karate and cub scouts. He has two older brothers and an older sister who attended public schools. He participated on the FLL robotics team.

Student two is an eleven-year-old Caucasian male in the fifth grade. He has normal intelligence and is somewhat verbal. He displays difficulty in communication with his peers. He is uncooperative and his behavior made it difficult for him to participate with his non-disabled peers in school. He has a younger brother who has spina bifida and is also a student at the school. Student two participated on the FLL team.

Student three is a 16-year-old student of color in the ninth grade. He was adopted and the rest of his family is Caucasian. He is of normal intelligence, but he has limited verbal skills. He has cooperative behavior but his needs for significant supports limited his ability to participate with non-disabled peers. He has two younger sisters. One also has a developmental delay and is a student at the private school. The other attends another private school for students without disabilities where her parents are employed. Student three participated on the FTC team.

Parents. Parent one is the father of student one. He is married and has a daughter and two stepsons. He is 48 years old and employed as a stockbroker. His wife is an educator.

Parent two is the mother of student two. She is married and has two sons with disabilities. Her husband works in the STEM field. She is a stay at home mom, a former educator, and involved in her children's education.

Parent three is the father of student three. He is married and has two daughters and a son. His son is adopted, and they have raised him since he was a baby. He is an educator at a private school and his wife is guidance counselor.

## Procedure

The research question for the study is What are the experiences of upper elementary and high school students with ASD who participate in FIRST Tech Challenge (FTC) and FIRST Lego League (FLL) robotics? In order to answer the research question data were collected from field notes and structured interviews with parents and students.

Field Notes. Observational field notes were taken during the robotics meetings and competitions to provide contextual evidence. Systematic note-taking was used from the beginning of the project as described by Miles and Huberman (1994). During the observations,

data gathered included the main issues or themes noticed by the researcher, questions that could be asked of the participants and activities, as well anything out of the ordinary or important.

Structured Interviews. Each interview lasted between 5 and 15 minutes. The interviews were recorded for accuracy and transcribed within two weeks. The participants were asked structured interview questions that were validated by a panel consisting of experts in special education and parents of students with ASD. The questions were sent to the experts along with the research question. The experts were asked if the structured questions were appropriate to answer the research questions. The experts on the panel were not involved with the study. Follow-up questions were asked to clarify anything that was unclear or if further information was needed to clearly understand the interviewee.

The structured interview questions for the three students with students with ASD were: 1) Have you ever participated in any type of robotics before? If so, what type? 2) What did you enjoy about FIRST robotics? 3) Was there anything you disliked about FIRST robotics? 4) Are you more interested in learning about STEM? 5) Did you make any new friends? If so, what was that like? 6) Do you want to participate again next year? Why or why not?

The structured interview questions for parents were: 1) Has your student ever participated in any type of robotics or STEM programs before? If so, what type? 2) Has your child participated in after school activities before? If so, what kind? If not, why not? 3) Do you think your child enjoyed FIRST? If so, what about it appealed to him or her? Does he or she want to participate again? 4) Was there anything your child disliked about FIRST? 5) Has your child talked more about STEM since joining the team? If so, what has he or she been talking about? In what context? 6) Do you feel FIRST has helped your student with his or her social skills? In what way?

## Data Collected

Field Notes. Field observations were conducted during meetings, builds, practices and competitions. Settings included the backroom of the school where the students attended, an empty retail store where students practiced with another team, and competitions which took place in empty cafeterias in various high schools. The students with ASD also participated in outreach events that included a large modeling and simulation convention and an event at the local science center. The settings for the outreach events and the competitions were crowded and noisy. The empty retail space and the back room of their school were quiet spaces with few students working on the robots or presentation materials.

Students with ASD were interested and engaged in the program. They were observed to be more interested in building rather than programming the robot. During practices and at competitions they enjoyed driving the robot as shown by their excitement which included smiles and full engagement in the activities. Even though the competitions were noisy, the students with ASD enjoyed them and would go outside for frequent breaks from the noise. They needed significant support from their mentors and parents more so than other teams observed. Supports included modeling and frequent step by step directions. When presenting to judges and creating a team video they needed written prompts on what to say. Students with ASD appeared to be proud of their accomplishments. Other teams of students without disabilities were accommodating and supportive to the team.

At team meetings and practices students were not as engaged as the competitions. This was shown through them being inattentive and mentors needed to prompt more for the students with ASD to stay on task and participate. At practices, student three was observed pacing around the room rather than participating in repairing the robot with his peers.

All of the students with ASD had difficulty communicating even though they were verbal. They rarely engaged in spontaneous conversations with their peers or other adults. During the structured interviews, none of the participants were eager to participate and often gave one-word answers. Parents were supportive of their students with ASD and provided transportation to the events and meetings.

**Structured Interviews.** All responses are the experiences of the participants (students and parents) in their own words and represent their participation in an after-school robotics club. Parents were asked to discuss whether their child had ever participated in any type of robotics or STEM program before FIRST robotics. All parents shared that their child had never participated in robotics or a STEM program prior to this year. Parents also were asked if their child had participated in after school activities before FIRST Robotics. The answers varied from “yes”, to “He participated in after school gymnastics,” to “He takes piano lessons and used to participate in soccer”. Parents noted none of these activities were school sponsored, and they took place on the children’s own time outside of school. Next, parents were asked if they thought their child enjoyed participating in FIRST Robotics. All said, “yes”. One dad specifically responded, “He [referring to his son] liked the activity, he gained confidence manipulating equipment and working with other kids. Going to the events and meeting students from other schools and feeling like part of something bigger was also a big plus.” A mother stated, “Yes, he definitely enjoyed participating in FIRST. Programming the robot, problem solving, and coming up with ideas for a rescue vehicle appealed to him the most.” All parents said their child wanted to participate again next year. When asked if there was anything their child disliked about FIRST Robotics one dad said, “The sensory environment of the competitions could be overwhelming.”

Another said her son's focus could be challenging. A same mother said her son had to adjust to working with others when his head was full of so many ideas of his own.

When asked if their children had been discussing STEM careers since participating in FIRST, one parent answered, "He has been talking about inventions that will rescue or otherwise help people. Almost every day he comes up with new rescue vehicles he wants to invent. He is very excited about STEM topics; coming up with new concepts." Another parent said, "He is interested in other mechanical gadgets – sirens, sprinkler systems, and sound engineering programs. These have been ongoing interests, but the robotics helped to boost that interest in technology." The last interview question was about FIRST Robotics and social skills. All parents felt their child's social skills increased. They all mentioned that teamwork and collaboration were new to their children. One mom said, "the robotics practices were at a time of real growth for him. He made some friends that he might not otherwise have made." Additionally, a dad said, "He is much more confident now in meeting new people and he is learning how to project his voice and provide the body language that is appropriate to the social environment." A mother said, "My son loves wearing his robotics t-shirts because of the attention he gains when people ask him about his shirt."

Overall, parents stated their students had never participated in a robotics or STEM program before and yet many had participated in other types of after school activities like sports or music. None of the activities were school sponsored. They all felt their students enjoyed their participation in FIRST robotics. They liked the technology part of the program. The biggest challenge was sensory overload at the competitions. Their students did seem to be talking more about STEM activities since their participation and are interested in participating again. All

parents felt their students increased their social skills due to the collaboration and team building aspects of the programs.

The students in this study are defined as students with ASD who participated in FIRST Tech Challenge (FTC) or FLL Robotics at their private school for students with disabilities. All three of the students were difficult to interview in that they were distracted and had difficulty talking about their experiences. Consequently, the interviews lasted between 5-15 minutes each. None of the students had ever participated in any type of robotics programs before FIRST Robotics. When asked about experiences, one said, “I enjoyed going to the competitions.” Another student gave more detail about exactly what he enjoyed about participating in the missions of the FLL team. He stated he enjoyed coming up with ideas on how to accomplish the missions. Additionally, he described how he would design and program the robot to accomplish certain tasks on the playing field. When the students were asked if there was anything they did not like, only one student gave more than a one-word answer. He said, “Although at first learning to work with others when I had so many ideas of my own was difficult, but I learned that we are a team.” When the students were asked if they were more interested to learn about STEM, the only student to give more than a one-word answer said, “I want to build my own robot to do missions.” When asked if they made any new friends, all said yes, especially kids from other schools. All three students stated they were interested in participating again next year.

### Credibility

Prolonged engagement and persistent observation. Cresswell (2013) noted that prolonged engagement and persistent observation helps to build trust with participants, learn the culture, and check for misinformation. The researcher in this study spent many hours with the

participants, two in particular. She built trust with the participants by being open and honest about the robotics team and her study. She checked for misinformation because she was there, at the students' school, all of their competitions, and outreach events.

Triangulation of sources. The consistency of different data sources (field notes, student and parent interviews) were examined. All students said they enjoyed participating in after school robotics. When compared to observation and parent comments, the information is consistent; the students did enjoy the robotics clubs as observed in their facial expression and their desire to continue. One student proclaimed he had difficulty working as a team in the beginning but learned teamwork during the course of the season. The researcher observed this student disengaged more from the team earlier in the season. He handled his frustration better as time went on and he had more experience working with a team on a single project. The student's parent also said that she noticed how he was more engaged and willing to accept others ideas as he gained experience working with others. One student said he didn't like robotics because he broke his tooth. The researcher was present when the student ran, slipped, and fell breaking his tooth, leaving him with a bloody lip. The parent told the researcher about the trips to the dentist to have the tooth repaired. Overall, the comments from the students corroborated with the comments from the parents and from the observation field notes.

### Analysis and Results

Data from the field notes and structured interviews were analyzed and coded to determine themes. Codes that emerged from the field notes included engagement, interest, support, and technology. For the structured interviews codes that emerged were confidence, technology, inventions, teamwork, ideas, and missions. Themes that emerged from the codes were students with ASD were engaged and interested in FIRST robotics and technology. Specifically, they

enjoyed coming up with ideas, inventions, and creating or solving missions. Their confidence increased and they learned to work better on teams. However, they needed significant supports from mentors and coaches to participate in FIRST Robotics.

The information gathered from the students about FIRST Robotics shows that these students with ASD were interested in technology and willing to participate in social activities when it involved technology, specifically robots. Programs like FIRST Robotics could give students with ASD experience in working socially with peers in more real-world situations (Kulman, 2013).

### Discussion

The purpose of this study was to describe the experiences of students with ASD who participated in FIRST Robotics. Students with ASD lack social skills and have restricted interests (4<sup>th</sup> ed., text rev.: DSM-IV-TR; American Psychiatric Association, 2013). Because many students with ASD withdraw into technology like video games, interventions need to be developed to assist with socialization and friendships (Simpson, 2004). The interventions to be developed should focus on students' restricted areas of interests like technology.

FIRST Robotics was developed to encourage young people to be STEM leaders (USFIRST.org, 2019). The results of this study show the three participants with ASD did enjoy participating in FIRST robotics. Based on parent and student report and field observations, they made new friends and learned about teamwork. These findings add to the body of literature on students with ASD and their attraction to technology (Kulman, 2013). Additionally, using technology programs like FIRST Robotics can potentially help increase social and teamwork skills in students with ASD. Studies (e.g., Menekse, Higashi, Schunn & Beahr, 2017; Kandlhofer & Steinbauer, 2015) show students without disabilities have better teamwork, collaboration and

social skills after participating in robotics competitions. The current study is the first to explore the experiences of students with autism who participate in FIRST robotics. The results of this study can be used to further research other areas of interest of students with ASD and engagement. The researcher posits the more students with ASD are exposed to different types of technology tools, environments, and clubs, the more likely they will become engaged in the technology. That engagement can be used to increase social and teamwork skills as well as increase post secondary opportunities to students with ASD.

Students with disabilities can and should participate in activities like FIRST robotics. With FIRST's culture of 'gracious professionalism and coopertition', students are encouraged to work with and help each other. All students will benefit as they learn that when given the right opportunities, everyone has strengths to share. Programs like FIRST robotics will help any student have positive post secondary outcomes due to its propensity to engage students in educational activities as a part of a team.

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