

# *Using Informal Learning Environments to Encourage More Diverse Engineers*

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**Abstract**— Neurodiversity in engineering can be supported by encouraging all college capable students to consider engineering as a major. Many students who learn differently may not see themselves attending college and if they do see themselves in college they may not consider studying engineering. This past summer Aurora University in partnership with Landmark College held a summer residential program for students with Autism Spectrum Disorder to experience college including living away from home, academic work and afternoon activities both academic and recreational. Many of the afternoon activities explored engineering. These included robotics, code breaking, running a NASA mission to Mars and observing the night sky with telescopes at Yerkes observatory. The instructors and the parent evaluations can both attest to the growth of the students during the program. This paper will discuss the structure of the activities, the response of the students to these activities and the overall response of the parents to the program. It will conclude with a reflection on how as a community we might increase our diversity by including more learning styles in our programs.

**Keywords**—autism spectrum disorder, executive function, social pragmatics, informal learning

## I. INTRODUCTION

Engineering has long been a part of informal learning environments. Many students have been introduced to engineering through museums and out of school programs focused on areas ranging from city planning, to robotics to material science. In the summer of 2018, Aurora University and Landmark College partnered to create a summer residential program for high school students with Autism Spectrum Disorder (ASD). A primary goal of the summer experience was to provide the students with a college like setting and tools to manage college life so that the students and their parents might feel more comfortable with the idea of these students attending and succeeding at college. The name of the program, Summer Transitional Enrichment Program (STEP), was chosen to reinforce that the program is intended to be a STEP to success. One study of college pathways for students with ASD suggests that most college capable students with ASD attend community college after high school (81%). Students with ASD in community college are more likely to persist if they study STEM and the students who study STEM are twice as likely to transfer to a four year university than students in other areas.<sup>[1]</sup> A secondary goal of the summer program was to introduce these students to a range of STEM activities as part of the afternoon adventures. Although these

students are college capable, often they have not participated in mainstream enrichment activities through informal learning environments.

## II. OVERVIEW OF ASD, EXECUTIVE FUNCTION AND SOCIAL PRAGMATICS

According to the most recent data from the Center for Disease Control, the rate of individuals diagnosed with Autism has increased from 1 in every 150 individuals in 2000 to 1 in every 59 individuals in 2014<sup>[2]</sup>. At the current rate, nearly half of all public school classrooms will have at least one student with autism, on average. While many of these students receive special education services in the K-12 setting, often these supports are limited or nonexistent as these individuals transition to adulthood<sup>[3]</sup>. Compounding the lack of support, individuals with Autism struggle with executive functioning and social pragmatics, which are key components to success in education and employment settings. It is important to note that the diagnostic criteria for Autism does not include any component of intelligence level. Instead, individuals diagnosed with Autism Spectrum Disorder (ASD) exhibit persistent deficits in social communication and social interaction<sup>[4]</sup>. Despite the fact that Autism is not directly related to academic deficits, over time, the deficits that do exist in the social arenas often begin to impact academic participation and performance.

### A. Executive Function

Executive functioning refers to a set of mental processes that are used in a variety of situations including: situations that involve planning or decision making; situations that involve error correction or trouble shooting; situations where responses are not well-rehearsed or contain novel sequences of actions; dangerous or technically difficult situations; and situations that require overcoming strong habitual response or resisting temptations<sup>[5]</sup>. In neurotypical individuals, this set of mental processes develop naturally over school years and through the mid-twenties<sup>[6]</sup>. For those with ASD, some or all of these processes may not develop naturally. Individuals with ASD often exhibit a range of deficits in executive functioning which can impact school, employment, and social interactions to varying degrees. Once again, although academic ability is not directly connected to Autism, academic participation and

performance can be drastically impacted by deficits and dysfunction in executive functioning.

### B. Social Pragmatics

As indicated by the diagnostic criteria, social deficits are a major component for individuals with ASD. Research has shown that young adults with ASD are more likely to experience social isolation <sup>[7]</sup> due to deficits and difficulties with social pragmatics. Taylor and Mailick (2014) <sup>[8]</sup> indicate that a lack of involvement in education, employment, and social interactions worsens in the ten years following high school. Due to the continuing social deficits and the decrease in support as individuals with ASD transition to adulthood, Senland and Higgins-D'Alessandro (2016) <sup>[9]</sup> conclude that support opportunities that continue to teach these individuals prosocial strategies is essential for success.

## III. ACADEMIC SUPPORT THROUGH STEP PROGRAM

Students participating in this program all had documented diagnosis of ASD; some also had secondary disabilities such as attention-deficit disorder, anxiety, learning disabilities, and obsessive-compulsive disorders. Among the various components of the residential summer enrichment program held at George Williams College and provided through a partnership between Aurora University and Landmark College were two academic classes for participants. These courses were required as part of the program and were both one hour and 45 minutes in length. Both classes were co-taught with two professors per course. The professors had collective, extensive experience teaching special education courses, students with Autism, and college courses. The first class focused on learning skills, specifically executive functioning strategies for college and the second focused on writing at the college level. Homework was assigned each day, with a culminating project due on the final day of classes. Each night students were required to attend an academic support hour in the college library. During this time, professors were available for support as needed although students were allowed to work independently if they chose to do so.

### A. Learning Skills

In the learning skills course, students learned and practiced planning, initiation, goal-setting, and organization of materials and time. In addition, students engaged in activities focused on identifying individual strengths and weaknesses. The culminating project in this class was a presentation in which students used the terminology covered in the course to share their own strengths and weaknesses and how these may impact them in college. In addition, students created an action plan with specific goals to improve upon for their upcoming school year.

### B. Writing

The writing class similarly focused on identifying students' strengths and needs as applied to writing at the college level. Students received writing prompts each day as well as instruction on essay and letter structure and strategies. Basic writing skills, such as grammar and punctuation, were addressed as needed. The culminating project in the writing course was a letter to future colleges explaining one's strengths, needs, and interests.

## IV. AFTERNOON ADVENTURES: ROBOTICS, CODE BREAKING, MISSION TO MARS AND YERKES OBSERVATORY

Every weekday afternoon students had the opportunity to choose a two hour long afternoon activity. These activities ranged from therapeutic riding to code breaking. The goals of these activities were twofold: continue to work on social skills and introduce the students to activities that they may choose to continue after the program. The bulk of the afternoon activities with an academic focus were tied to STEM. These included robotics and code breaking.

### A. Robotics

The students had several opportunities to learn about robotics. Three afternoon activities focused on robotics. The first day, students had the opportunity to build robotic arms using a kit from OWI. For all of the participants this was the first time that they saw the inner workings of a robotic arm. In addition to learning how to use simple tools, this exercise required teamwork since the arms were assembled in teams of two, and a discussion of gears. The second afternoon of robotics, the arms were used for a series of games. These included cooperative games such as using two arms to move a heavy cylinder from one location to another to how quickly can an individual arm be used to move small toys such as action figures from one location to another. In addition to robotic arms, the students were introduced to sensors and to programming for robotics on this day. Given the short amount of time to talk about programming we used an ozobot robot which could be programmed using color. The students were amazed that you could draw on the paper and the robot would follow the path and would turn or speed up depending on the pattern on the floor. These robots offer an opportunity to discuss both programming and sensors. The students also had an opportunity to use Cubelets which have a variety of sensors built into the blocks. The third afternoon adventure focusing on robotics used an underwater rover to explore the lake on the campus of George Williams College. This activity combined robotics with exploration with the great outdoors.

### B. Code Breaking

Two afternoons students had the opportunity to learn some basic code techniques and to use these to solve a fictitious murder mystery on the campus. Each day students learned new code techniques and solved a different mystery. The code

techniques included Caesar shifts, Pigpen, mirror writing, transposition ciphers, binary codes, ISBN codes, and frequency analysis. It should be noted that over the course of the two days several adults joined us for this activity and that one of the students was significantly better than any of the adults. Overall this activity was a huge hit with the students none of whom had previously been exposed to code breaking.

### C. *Challenger Center Mission to Mars*

The Challenger Center of Science and Technology of Aurora University is part of the national network of Challenger centers which were created by the families of the Challenger astronauts to honor their legacy. The AU Challenger Center is located in Woodstock IL, a short drive away from the George Williams Campus. Saturday of the STEP program was dedicated to an activity at this center. The students participated in a mission to Mars simulation. This simulation required the students to break into two teams, one at mission control and one in the space station. Each person on the mission had a job to perform, such as storm tracking, in order for the mission to be successful. This activity provided a fun engaging way for the students to work on STEM, communication and teamwork.

### D. *Yerkes Observatory*

George Williams College is located adjacent to Yerkes Observatory in Williams Bay Wisconsin. On Sunday evening the students and staff had an opportunity to go to the observatory where we learned about the history of the site as well as had an opportunity to observe the sky through the 40inch refractor. This is the largest refractor in the world. Although it is no longer in use for scientific research it is an amazing educational facility and both the students and staff enjoyed the opportunity to use the telescope.

## V. FACULTY TRAINING

The faculty in the morning academic classes are all trained to work with students with ASD. One of the authors (Jonathan) along with Aurora University faculty and Landmark College faculty and staff provided several trainings throughout the spring semester. The program started on a Wednesday. The Sunday before there was training for the residential staff which were mostly Aurora University students. The Monday and Tuesday before the program was devoted to two full days of training for the all of the staff including instructors. A take away from this experience is that like all students, students with ASD are each unique. One has to create lessons which are engaging and which can be altered should the needs of the students require a change in plans.

## VI. PARENT AND STUDENT FEEDBACK

Using post-program surveys, the parents and students provided overwhelmingly positive feedback of the program. According to the surveys, 100% of the students reported that they strongly agreed or agreed that they gained valuable skills

in both the learning skills and writing classes. One student reported that he enjoyed the free writes because, "you can really see that you get an understanding of a college essay." Students reported value in active reading, note-taking, and self-awareness strategies provided in the learning skills class. Similarly, all of the parents reported that they strongly agreed or agreed that the academic portion of the program was valuable to their students.

Afternoon and weekend activities were rated highly positive by both student participants and their parents. 100 percent of parents reported that they strongly agreed these weekend and afternoon activities were valuable for their students. Students were split 50/50 percent between strongly agreeing and agreeing that these activities were enjoyable. Some students and parents reported that they wished the program, and specifically these activities, were longer so they could experience even more.

Along with the skills gained and practiced during these activities, students, parents, and staff noticed social opportunities and gains within the course of the program. Some students appeared to form strong bonds, to the point of choosing to participate in every activity together and eat every meal together. Others were able to express the strengths they saw in peers, and practiced perspective-taking and empathy in moments of struggle and celebration among peers. One particularly touching moment occurred on a student's birthday when his family had planned to come visit and take him out for a celebratory dinner. When the family called to confirm plans for the day, the student asked if he could instead stay with his peers and the staff at the program because he was having such an enjoyable time. On the final night of the program, students were given yearbooks which they signed for each other and exchanged emails and phone numbers. Students and parents reported that social experiences such as these were novel for them and provided significant social meaning for individuals who had not had many of these experiences in the past.

## VII. CONCLUSION

A partnership between Aurora University, a university with a grounding in the belief in the transformative nature of education, with Landmark College, an institution who works exclusively with students who learn differently, produced a summer program for students with the ASD diagnosis. This program met the goals of helping these students see themselves in college in the future, providing them with tools to be successful in college and exposing them to several aspects of STEM. For students with the ASD diagnosis there is clear evidence that pursuing STEM in college is positively correlated to persistence and completion of a four-year degree. Given this, we owe these students informal learning opportunities in addition to formal ones which introduce them to STEM and are supportive of their learning style. A surprising takeaway for one of the authors (Dahleh) is how

little exposure to STEM these students had prior to this program.

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