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Engaging Students With Robotics At The Harry Fultz Institute And Beyond

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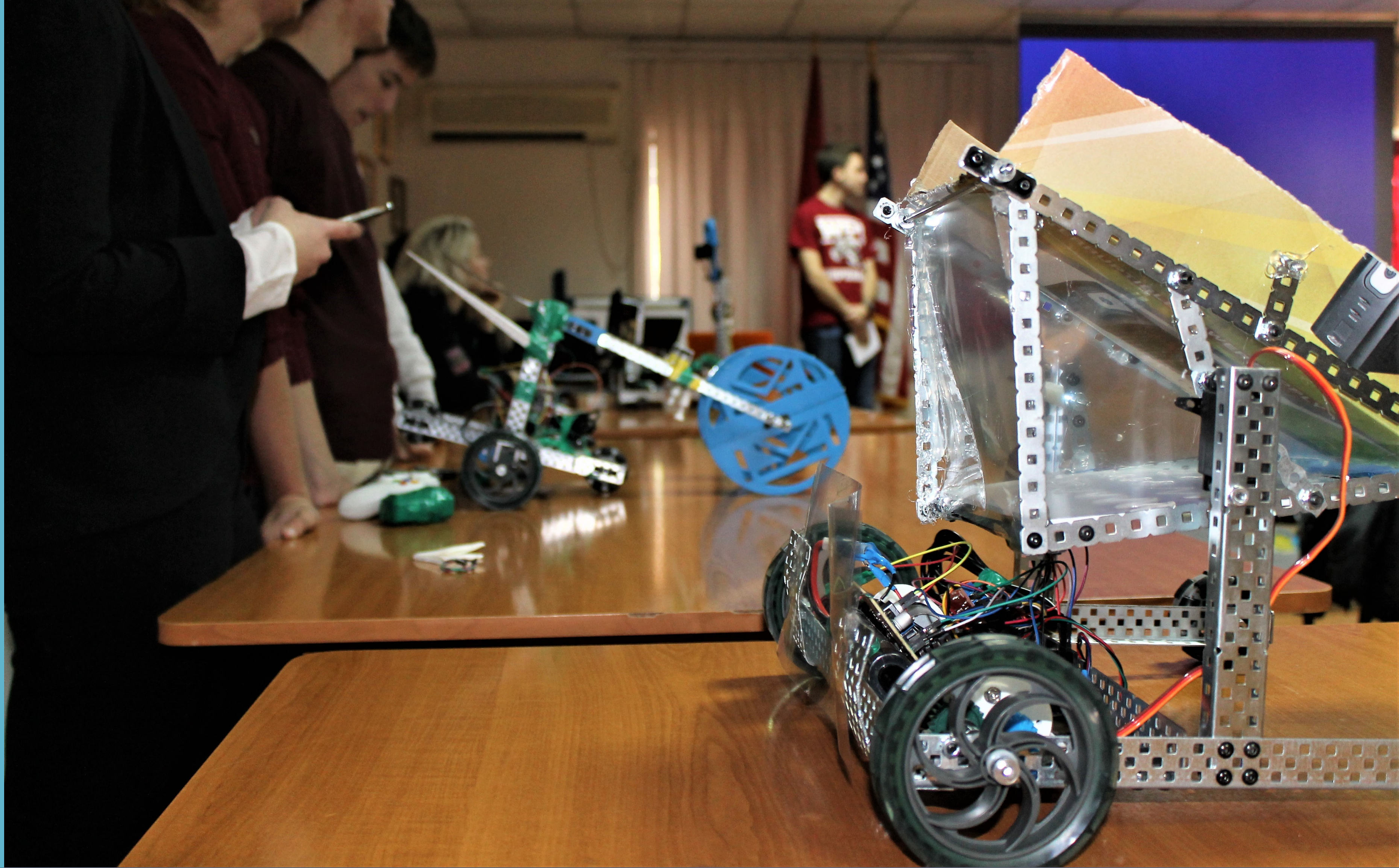


Engaging Students with Robotics
at the Harry Fultz Institute and Beyond

Rebecca Miles, Marek Travnikar, Benjamin Wagner, Jennifer Whelehan

Abstract

Robotics education places a premium on self-directed learning and teamwork. In the education system in Albania, however, these qualities have not been emphasized in the classroom. This project sought to engage students in robotics at the Harry Fultz Institute in Tirana and to assess the feasibility of expanding robotics in schools in the Tirana region. We mentored six student teams in the robotics club to design and build robots for a competition. This was accomplished by developing lectures on the fundamentals of robotics, helping the students apply these topics to their robots, and encouraging students to reflect on their progress with their teammates to recognize the skills they developed.

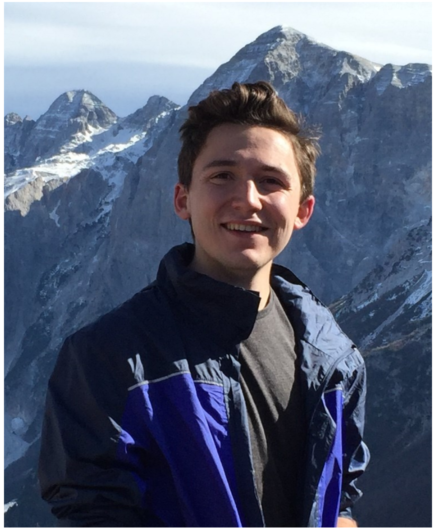
Acknowledgements

We would like to thank all of the people who made this project possible. This includes Professors Klarens Hoxha and Moisi Xhaferaj who were with us every step of the way, guiding the club, Professors Robert Hersh and Leslie Dodson for their invaluable advice over the course of this project, as well as Aida Hudhri, Besnik Zylka, and Meredith Hiemstra for providing information that helped us draw conclusions. Finally, we would like to thank Tony Bertucci of LASA Robotics and all of our generous donors who made the acquisition of VEX materials and, therefore, the success of our competition possible.

Meet the Team

Rebecca Miles

Rebecca is a robotics and electrical and computer engineering dual major. She is a member of WPI's VEXU robotics team and has a passion for breeding dairy goats which she raises at her home in upstate New York.



Marek Travnikar

Marek is a robotics engineering major originally from Austin, Texas. He is involved with Greek life, works as a Peer Learning Assistant in the Washburn Shops, and enjoys skiing in his free time.

Benjamin Wagner

Benjamin is a robotics and mechanical engineering dual major from Attleboro, Massachusetts. He is involved with Greek life and plays club water polo as a goalie.

Jennifer Whelehan

Jennifer is a biomedical engineering major from Cortlandt Manor, New York. She is involved with the Biomedical Engineering Society and Greek life. She spends her free time writing bulleted lists.

Authorship

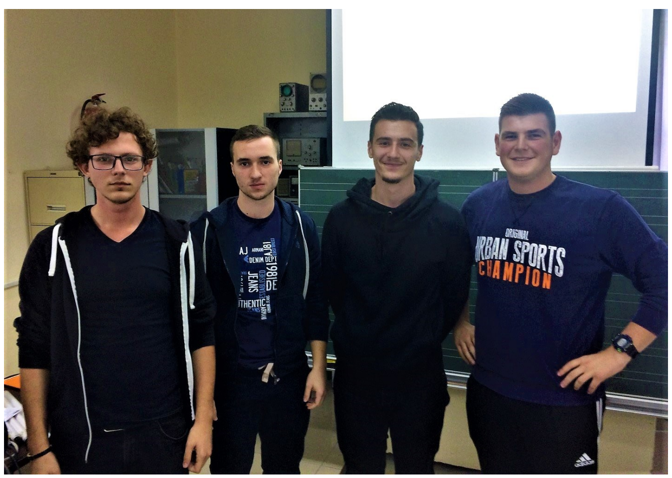
This report is the result of the hard work of each member of our team, and we are proud of what we have produced. For each section of our report, we, together, outlined the broad topics that we wanted to address. We would then divide up the sections and draft them to the best of our ability. Once a member had finished their section, we exchanged sections with another member for primary editing. This process would continue until each member of our team had read through and edited each section individually. From this point, we would each start from the beginning of the section and read through every part, editing and ensuring that all desired topics were addressed, that everything flowed, and that sections made sense from start to finish. Google Docs was utilized for the drafting of this report, as the suggesting mode kept all initial edits for later approval by secondary or tertiary editors. We believe that, through this process, this report incorporates the voices and writing styles of each member of our team.

Meet the Students

Knights

E-4

Caliber



Alpha

Edge Logic

Vortex

Disclaimer: Some students not pictured.

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Executive Summary

Goals

Our primary goal was to engage students in the robotics club at the Harry Fultz Institute in a robotics competition in order to promote creativity, communication, problem-solving skills, and teamwork throughout the six weeks of self-directed learning in which the students had to design, build, and program their robots.

Despite our initial limited experience as teachers and mentors, we intended to get to know the students and learn more about their perspectives, thoughts, and attitudes. By getting to know the students, we were able to adapt our lecture styles to more effectively connect to the students and help them get the most out of the learning experience. Our group also assessed the interest in, feasibility of, and resources available for furthering robotics education throughout Tirana.

Figure 1: Students working at their lab benches to finish their robots the day before the competition.

Objectives

Design an engaging and interactive educational experience through lectures and mentoring in preparation for a competition

Our teaching was based in part on the lesson plans and recommendations from the previous three WPI project groups involved with the robotics club. We presented short, introductory lectures at the start of each class. These lectures contained necessary information for the students to gain a better understanding of robotics each day, as we introduced more components. We kept lectures brief in order to maintain student attention while introducing topics and ideas to the students who could then ask further questions during the rest of the club time. This method of teaching was based on the findings of the 2014 Harry Fultz IQP group which concluded that the most effective way to teach the club students was to work as their mentors by helping them when difficulties arise, while allowing them enough room to research, fail, and problem-solve on their own.

The game we selected for this year's competition at the Harry Fultz Institute adapted the 2007 Savage Soccer game manual and utilized badminton birdies as well as a size-four soccer ball as game objects. Thus, the ten students that had been part of the club last year were unable to reuse the same mechanisms that they had developed to pick up the ping pong balls, allowing each team to begin on even ground.

Assess student teamwork and encourage reflection

We often prompted the students to reflect and identify how their interests changed or skills developed through their experience in the club. Through ongoing interaction with the students while teaching the lecture material, assisting students with problems, or performing other duties, we were able to observe student interactions and gauge the students' feelings about their team.. Further, by providing weekly surveys that prompted students to reflect on the lectures of the past week, we were able to determine how beneficial each lecture was for the teams, helping us to become better mentors.

In order to improve our abilities to teach, mentor, and communicate with people of a different culture, each member of our group kept a journal which highlighted the successes, failures, as well as personal and student motivations on a day to day basis. Furthermore, as small details tend to get lost over time, these journal entries helped us to note findings that could pertain and prove useful to other project objectives.

Explore feasibility of expansion of robotics education in Albania

One way to expand the benefits of a robotics competition is not only to take steps to ensure it continues in the years to come at the Harry Fultz Institute, but also to expand and encourage other schools in the greater Tirana region to participate in robotics education. We assessed the resources and opportunities available in Albania to facilitate the expansion of robotics through a series of interviews with various individuals and organizations.

Key Findings

The students were engaged in a fun and challenging way through the competition; however, the implementation of VEX parts this year reduced some challenge in order to maximize the time students had to embrace the engineering design process. By making it easier for the students to iterate through different designs and get creative, they built unique robots. While the competition was a critical milestone for this project, it's important to emphasize that it was only one part of this project. The five weeks of teaching robotics topics, mentoring students, and preparing them for the competition were the catalyst allowing us to study the larger questions of this project: namely the effects of mentoring, student engagement, and student teamwork.

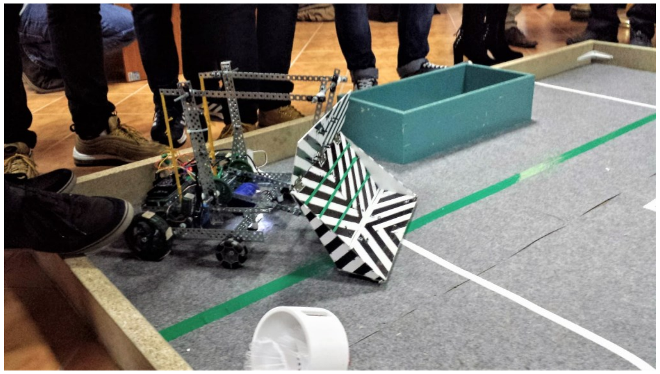


Figure 2: Team Alpha's robot; winner of the competition

Mentoring

Mentors must be ready to adapt to the changing ideas, plans, and directions with which the students wish to take their projects. One of our highest priorities throughout the course of this project was to better relate and understand the students in order to become better teachers and mentors for them. We found that it was initially difficult to maintain the students' attention during lectures, especially given that each student specialized in a particular field (electronics, programming, design). This meant that if we lectured about programming, the two thirds of the class that was not specialized in software would not pay attention. However, after we got to know them better, we began weaving humor into lectures and surveys. This lead to a significant increase in attentiveness from the students, including those who were not specialized in that day's topic.

Student Engagement, Teamwork, and Collaboration

We were concerned students were not communicating or getting a full robotics experience due to their unwillingness to move beyond their particular specializations and take on other aspects of robotics necessary for the competition. As the competition drew closer, and students became more familiar with the concept of robotics as a singular topic rather than three separate specializations, team members worked outside of their specializations more often.

Due to differences in students' schedules and obligations, some teammates were less involved than others. The smaller number of students that attended the extra hours of club time promoted inter-team collaboration as we observed students discussing their ideas and asking each other for help. Teams came to each other's aid in the weeks before the competition.

Feasibility of Education Expansion

Robotics is a complex subject with many contributing factors, and expanding robotics education is equally complex. We compared key components and relationships that support robotics education, teams, and competitions in the USA to the current state of robotics in Albania. In our experience, these key components include education, interest, facilitation, and goals. Robotics teams receive necessary education from coaches, teachers, or mentors- who may be alumni of the team or supplied by a sponsoring organization. Teams then stimulate interest through various outreach programs and activities which help recruit new members as well as generate funding. This funding - which can come from one time donors, companies, organizations, or even the government- along with the aid of the school administration, helps to provide the team with essential materials and space in which to work. Finally, teams and their constituent members typically have a goal for joining teams, which can come in the form of competitions, opportunities to enroll in institutions of higher education, or potential internships.

This current framework to support robotics teams in the United States relies on several key stakeholders, including, but not limited to, various levels of the government, school administrations, local technology-focused companies, and students. In addition to the United States federal tax code incentivizing companies and individuals to provide routine donations to organizations such as student teams, government organizations sometimes, in our experience, provide grants that assist with the acquisition of necessary parts and materials.

In our research, we identified several key missing components from the baseline structure that hinder robotics in the Tirana region. These missing components include a shortage of local technology-focused businesses, a lack of motivation for such businesses to support local programs, and limited higher education and career outlets for student interests as well as a high import tax on essential materials. Currently, a 20% tariff is imposed on imported electronic materials, which dissuade many from purchasing these components, and the Albanian tax code does not encourage charitable actions in the same fashion as its American counterpart.

Conclusions

Limitations

Our surveys were certainly flawed, as they failed to trigger more reflective responses among the students. We were frustrated throughout the course of the club by the limited time to explore the students' feelings about the opportunity or environment of the robotics club. Because the students had less than six weeks to design and finish their robots, much more club time was spent focusing on the physical products instead of the effects on the students' thoughts about the development of their skills or desires to continue their development. We wanted to maintain a more professional mentor-mentee relationship with the students, and we did not meet with the students outside of the classroom, which further lessened the time we had to connect with and understand the students. Admittedly, our own limitations in part are what kept us from meeting with the students outside the club, as the thought of maintaining two separate relationships- one that was professional and one that was friendly- made us nervous. We did not know how it would affect our classroom dynamic, and we did not want to risk it.

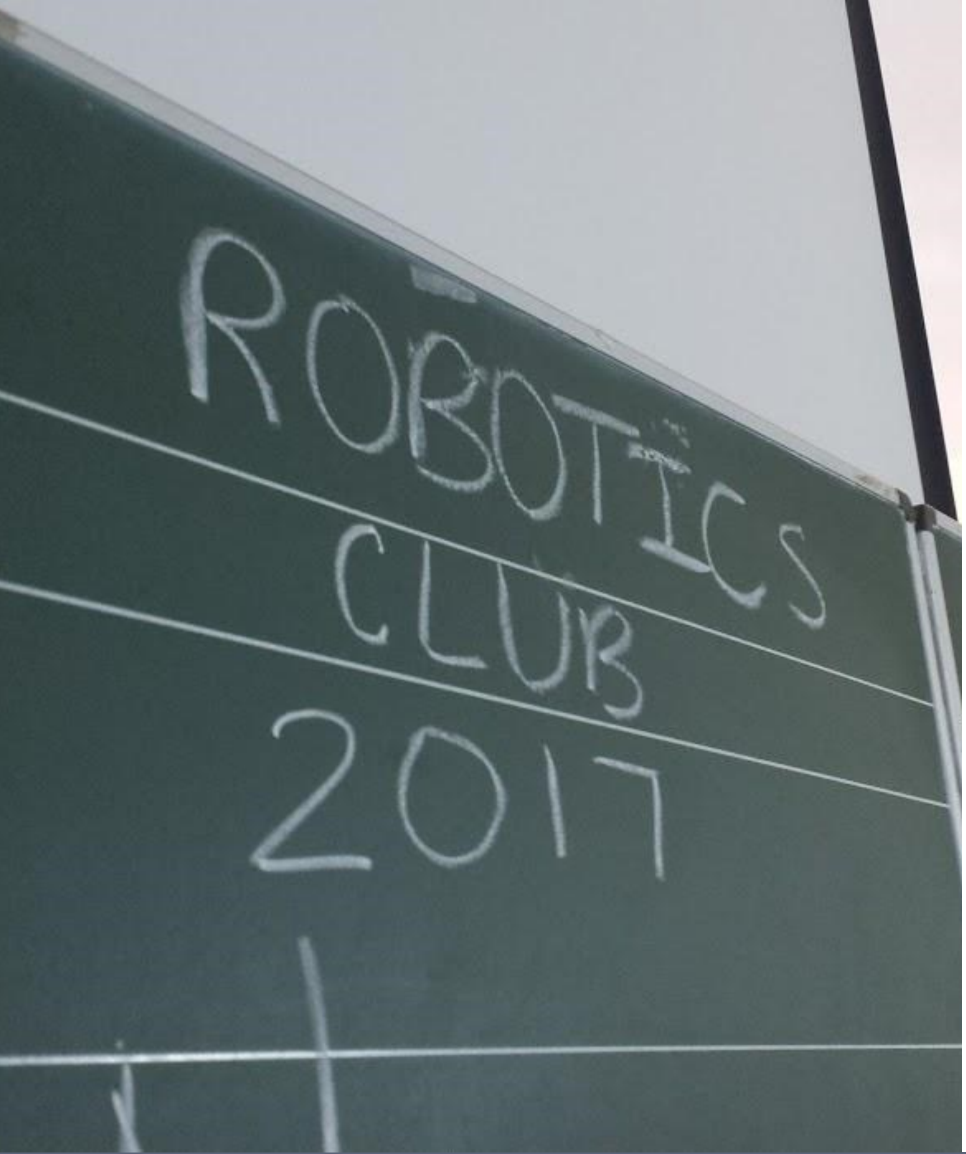
Figure 3: Students paying attention to a lecture.

Recommendations

We recommend that the Harry Fultz Institute establishes a VEX robotics competition team in the near future. With the metal kits and parts provided to the robotics club this year, as well as with the VEX robotics curriculum and lessons that are available online, the Harry Fultz Institute is well situated to begin the transition into starting a team and participating in VEX competitions. In order to set robotics education in motion in Tirana, we recommend reaching out to organizations outside of Albania, such as the U.S. Agency for International Development (USAID), the Peace Corps, or a similar European non-profit to sponsor events that may raise awareness and funding.

Ethics

The primary ethical concerns for this project involve providing an opportunity for students to engage in STEM in a country where such opportunities for students that want to pursue it are lacking beyond high school. We hoped to instill a passion for robotics, but we did not want our work to lead students at Harry Fultz Institute to feel frustrated by emphasizing a lack of local opportunity for them, and a world of opportunity for us. During our time here, we have noted for whom robotics education is accessible, and for the most part, it seems that it's available to students at private schools receiving specialized educations, such as at the Harry Fultz Institute or Tirana International School. Robotics education should be offered not only to those that have the resources to attend such schools. For these reasons, we hope our interviews created the beginnings of a conversation among students, schools, and organizations that will stimulate the growth of robotics education within Albania.



1.0 Introduction

"Robotics helps students by increasing their creativity, preparing them for the future and teaching children how to turn frustration into innovation."
-Professor Klarens Hoxha

Science, Technology, Engineering, and Math (STEM) related fields are becoming increasingly important as technologies advance worldwide. In order to facilitate the growing importance of technology, STEM and robotics (a multidisciplinary application of STEM) education have become increasingly prevalent in today's schools around the world (Higher Education in Science and Engineering, n.d.). This is due to the fact that STEM education, especially in conjunction with programs such as robotics competitions, can have a significant impact on students' perception of technology related fields (Yawson, 2016). The nature of robotics competitions provides students with hands-on experience in STEM education as well as experience working in a team to achieve a common goal. Robotics competitions also stimulate the long term and muscle memory, helping students to better retain the educational material taught (Kyere, 2017; Ingmire, Jann 2015) . In many countries, such as the United States, STEM education is often closely incorporated with projects and various other hands-on experiences such as robotics competitions. "There is evidence to suggest that consulting students about their perceptions of science and their school science education can enhance their motivation, contribute to the development of a wider range of teaching strategies and, thereby, help raise levels of student attainment in science" (Jenkins, 2006, p. 78). Robotics competitions, have been shown to increase student self-confidence, general education achievement, interest in STEM based education and careers, as well as career "soft-skills" such as communicating, public speaking, fundraising, and time-management ("Robotics Competitions: Building A Generation of Innovators", 2017; VEX Robotics: Inspiring and Preparing Students for STEM Careers, 2011; Rider, 2013)

The Albanian education system, however, is primarily focused on teaching through the use of formal lectures with less emphasis on student interaction or cooperation. A 2010 study of over 300 Albanian high schools found that a typical forty-five-minute lesson was dominated by teachers, who lectured for over 70% of the time, regardless of the subject matter with minimal student initiated interaction (Sahlberg, 2010). Due to the nature of lecture-style teaching, most students are rarely given the opportunity to apply the knowledge that they gain in the classroom to real world situations or multi-disciplinary exercises such as STEM and robotics activities. One of the objectives of the project outlined in this document was to explore the possibilities for expanding robotics education to a variety of schools and institu-

Figure 4: An electronics lab at the Harry Fultz Institute that has hosted the Robotics Club since 2014.

"Technology is kind of the future for every country. Either you produce this workforce, and you use the intellectual power to go on, or you end." -Professor Moisi Xhaferaj

tions throughout the greater Tirana area.

The technical high school at the Harry Fultz Institute in Tirana, Albania has already begun implementing robotics to better student learning in STEM education. Through the ongoing development of a robotics club, students at the Harry Fultz Institute are able to apply knowledge they learned in the classroom to build a functioning robot that can participate in a final culminating competition. The robotics club at the Harry Fultz Institute was founded in 2014 by Professor Enxhi Jaupi and supported by students from Worcester Polytechnic Institute (WPI). As part of their Interactive Qualifying Project (IQP), these and successive cohorts of WPI students helped Professor Jaupi by mentoring students and providing comprehensive lessons to complement the curriculum already present at the Harry Fultz Institute. In 2014, students used Lego Mindstorm NXT kits to understand the basics of robotics, such as programming and mechanical design (Hunt, McQuaid, Sussman, Tomko, 2014). The project has evolved over the years to permit students to use materials beyond the NXT kits in order to build robots ranging from a hexacopter drone to an autonomous rover (Jacobsohn, Landis, Pontbriant, & Schifilliti, 2015). By 2016, students in the robotics club were building robots to compete in a Savage Soccer style robotics competition. From introducing robotics topics to implementing a competition, the club's development is ongoing, and has made a lot of progress in the past three years.

The ultimate goal for the robotics club at the Harry Fultz Institute is to provide an engaging learning experience on the various aspects of robotics. This year, the club once again culminated in a competition which encouraged students to internalize the basic robotics knowledge they have learned and apply it as best they could while cooperating with and competing against other teams. Using a robotics competition as the basis of the club allowed students to learn from each other and gain confidence as well as professional skills that will be helpful later in their careers.

Figure 5: Harry Fultz Institute Classroom's Exterior

2.0 Background

"I think it's important to know the inner workings of the parts we're working with in the unlikely case we need to make unconventional implementations of them."
-Club Student

2.1 Hands-On Learning: Effects On Student Learning

Project based and hands-on learning has been shown in numerous studies to help students excel above those that follow traditional lecture-based curriculum (Ates and Eryilmaz, 2011). This is due to the fact that by allowing students to physically interact with the topic of a lecture, they utilize long-term muscle memory to retain information, while straight lecture based teaching utilizes short term memory, reinforcing certain topics repeatedly to ensure that it is retained (Kyere, 2017). This was further emphasized in a 2015 study in which students who participated in hands-on classes were shown to later have significant activity in the sensory and motor-related areas of the brain when they thought about the topics covered in class (Ingmire, Jann 2015). Additionally, hands-on activities provide a more enjoyable and engaging learning experience for students. This was emphasized in a study of a robotics competition at the Stevens Institute of Technology in Hoboken, New Jersey which stated that "the results from the first three offerings of the [robotics] course have been overwhelmingly positive. The students really enjoyed and preferred the hands-on labs and open-ended final project over a traditional lecture-only course" (Cappelleri, 2013). Hands-on activities have been proven to overall help students to better learn and engage in topics related to STEM and robotics.

Robotics competitions are a form of hands-on learning which has been embraced around the world to teach students engineering and technology (Robot Events, n.d.). These competitions are typically structured such that students are given a task to complete yet are not instructed on how to complete it. This forces students to band together in teams to overcome each challenge they face while problem solving their way to success. John Bugay, a mentor on a robotics competition in New Jersey with industry experience, utilized a robotics competition to provide students with guidance in project management, a skill not often taught in high school. According to Bugay, building a robot applies all the topics taught in project management school, making a robotics competition an excellent opportunity for students to learn about all the components and coordination that is necessary for the success of a project (Rider, 2013). As seen in figure 6, in order for students to get the most out of such a learning situation, they must be in an environment that promotes motivation. Students may perform tasks, but the amount of effort they put into the tasks depends on their motivation, which can be highly influenced by the presence of a competition. Students must be provided with general training that makes them feel qualified to build their robots, but they must also be in an environment where their final product will be shared with and compete against those of others. Participation in a robotics competition is a critical part of increasing student motivation to a point where they are likely to see the value in their experiences and learn the most (Bazylev, Margun, Zimenko, Kremlev, & Rukujzha, 2014).

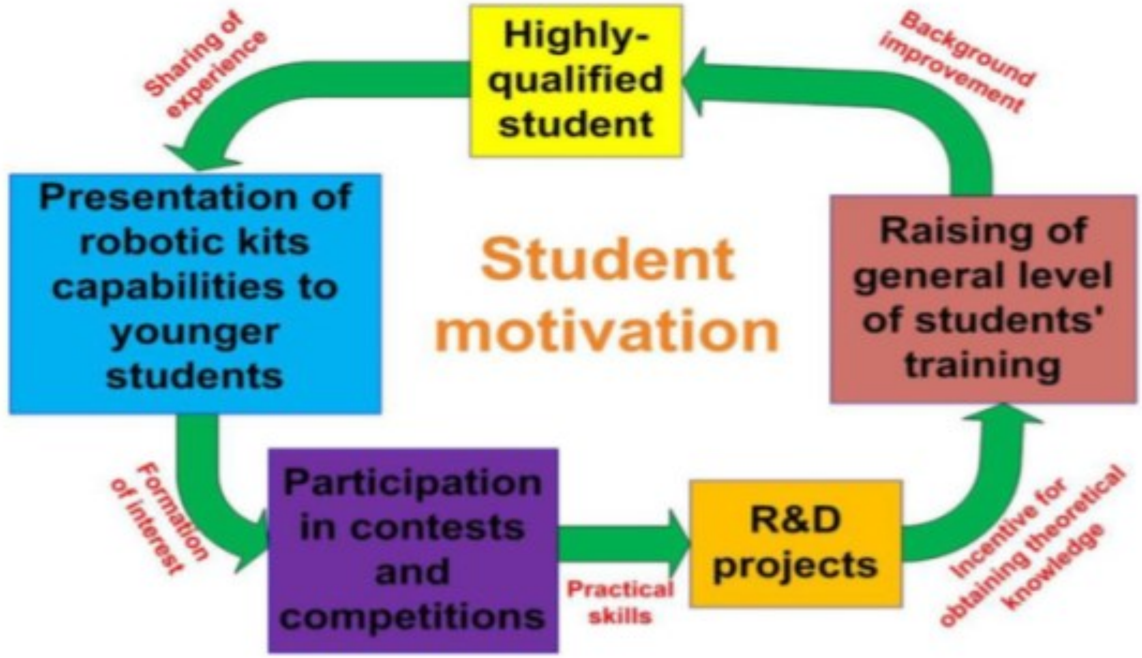


Figure 6 Implementation of competitions in education (Bazylev, Margun, Zimenko, Kremlev, & Rukujzha, 2014).

2.2 Evaluating the Structure of a Typical Albanian Classroom

Today's students are tomorrow's workforce. In the words of Ray Kelly, CEO of Certiport, "As technology has become pervasive in the classroom and the workplace, solid technology skills are essential for every student" (Caron, 2011). This statement was further emphasized in a 2014 analysis of the Albanian workforce in which over 35% of Albanian firms that acquired new technology cited the lack of an educated workforce as one of their major constraints in success (European Union, 2014), showing that the quality of a students education is primarily linked to their effect in the workforce. In Albania, students progress through primary and middle school for the first eight years of their educational careers before being faced with a choice: to enroll in a general education secondary school- called "regular" schooling by native Albanians- or in vocational schools. Regular schooling takes three years to complete, with the primary focus of enrolling in a university or other higher education institution after graduation. Vocational schools, on the other hand, may take anywhere from two to five years depending on the level of degree the student would like to achieve. Upon graduating from such a school, students can then enter directly into the workforce, if they wish, or continue onto a technical college for further education in their field ("Education System in Albania", 2012).

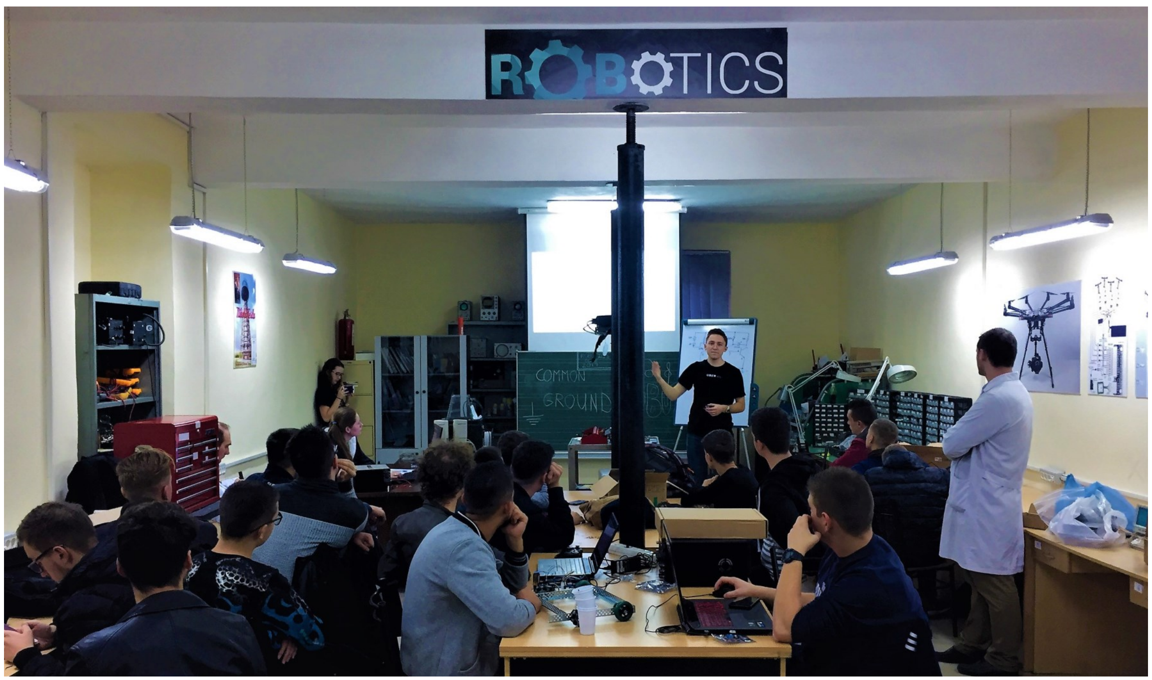


Figure 7: A WPI mentor lectures in front of the Robotics Club at the Harry Fultz Institute.

Numerous reports state that the current Albanian education system is primarily focused on theoretical knowledge which is rarely applied with hands-on problems during class time (Gjokutaj, M., Dr., 2013). For instance, Sahlberg (2010) found that a typical forty-five-minute lesson in Albanian high schools, regardless of the subject matter, was typically dominated by teachers lecturing with minimal student-to-student interaction or student-initiated discussions. This was further backed up by a 2013 report which stated that classes tend to be "conceptually overloaded and theoretic [in] character" (Gjokutaj, M., Dr., 2013), likely because, as found in a 2016 study by UNICEF, teachers in Albania often struggle to adapt their theoretical curriculum into real world scenarios (Asabella, 2016). Each of these reports show that students spend the majority of each school day listening to lectures rather than applying their knowledge to a physical system.

In 2008, the Albanian government began to put more focus on developing a plan for minimal learning objectives and school plans in order to give better education for students in Albania (Ministry of Youth, Sports, and Education, 2015). As of 2010, the Ministry of Education and Science has been working to identify knowledge gaps in the education of students in Albania, including STEM education, in order to better equip students to join the workforce (Country Profile 2010: Education In Albania, 2010). The lack of STEM focused education in Albania is recognized

"I think that this robotic class is the best part of the year at school... I don't have lots of knowledge at practice, but it's going fine, because my team is very helpful." - Club Student

by its students as very few of them enroll in undergraduate programs for STEM fields in Albanian colleges and universities. However, of the students who enroll in colleges and universities outside of Albania, 80% wish to pursue STEM based studies (Hudhri, A., personal communication, December 4, 2017). Furthermore, Besnik Zylka, a technology professor at the Tirana International School in Tirana, Albania asserts that the interest for robotics in Albania exists. When discussing the initialization of a robotics competition at the International School, he states that "it was an immediate hit and it's been growing since then along with our school population"(Zylka, B., personal communication 2017).

2.3 Effective Mentoring for Robotics

Prior to discussing what constitutes a good mentoring program, it is important to define three similar terms: "mentoring," "coaching," and "teaching." The Oxford dictionary states that a mentor is "an experienced person in a company or educational institution who trains and counsels new employees or students," while a teacher is, to be expected, "a person who teaches, especially in a school," and further, a coach is defined as "a private tutor who gives extra teaching" (Oxford University Press, 2017). These descriptions make it clear that the three terms can be confused as each encompasses some form of teaching. The main difference comes down to the approach taken and the time period over which these actions take place. Mentoring occurs over a longer period of time and incorporates not only information pertaining to the formal environment of the mentee, but advice regarding the mentee's personal life as well, such as when a medical student enrolls in a mentorship at a research hospital (Sanfey, Holands, & Gantt, 2013). In contrast to this, coaching occurs over a shorter period of time, and while it implements much of the same techniques, less of a relationship is developed (Brefi Group Ltd., 2015). Additionally, mentoring and teaching are distinguished from each other in the quality and way in which information is presented. Teachers are usually figures that possess a greater knowledge base and transfer such knowledge directly and formally, while mentors possess a greater perspective on learners' abilities and passion concerning subject matter (Cohen, 2015). "A coach has some great questions for your answers; a mentor has some great answers for your questions."-Brefi Group Ltd. 2015

Figure 8: A WPI Mentor, Rebecca Miles, discusses robot ideas with a Robotics Club team.

2.3.1 Capacity Building in Robotics through Mentorship

Mentorship programs provide students with one-on-one teaching, resulting in a more effective learning environment overall. This is particularly beneficial for STEM based subjects as it allows for students to ask specific questions and better understand challenging topics. However, the effectiveness of any mentorship program can be influenced by various factors. In a 2016 study of Ghanaian students' attitudes towards STEM education before and after outreach, it was determined that short term outreach activities (i.e. solitary classroom visits) were not nearly as effective towards getting students interested in STEM as long term exposure (e.g. classes, competitions, etc.) (Yawson, 2016).

Mentorship programs have been shown to be highly effective for inspiring enthusiasm towards STEM, as well as improving the effectiveness of the program as a whole (Beck & Morgan 2006). This fact was shown in a 2016 study of the establishment of mentorship programs in African countries. The study observed the positive effect that establishing mentorship programs had on student engagement and success. Students under the influences of mentors proceeded to go further in their respective competitions at the international level. Furthermore, the study noted a distinct improvement in the general attitudes of students towards STEM fields in the areas which the mentorship programs were implemented (Ilori, Watchorn, 2016).

"I spent a while with E-4 discussing their robot. They had some pretty neat ideas, but pretty complex. So I coached them to drop the really complex ideas for simpler." -Rebecca Miles

2.3.2 Mentoring in a Cross-Cultural Setting

While mentoring or teaching is difficult enough in a traditional classroom setting of students with similar cultural backgrounds, difficulties can be compounded when a culturally diverse classroom is presented to mentors and teachers.

In a 2009 study conducted in Australia, pre-service teachers- or college students guided into teaching by a particular mentor- were exposed to inner-city classrooms composed of an ethnically diverse student body for three-week periods. During these experiences, some pre-service teachers found it hard to connect with the students in their classrooms, dismissing it as due to the students' individual socio-ethnic upbringing (Santoro, 2009). In order to mentor effectively in such an environment, teachers and mentors needed to look beyond their assumptions to understand their mentees backgrounds and perspectives on potential topics. Because some of the pre-service teachers claimed to "lack ethnicity" due to their undiverse and "boring" heritage- a fact they attributed to being able to trace their ancestry back to the first settlers- it became challenging for the teachers to account for the different ethnic perspectives of the students. This caused issues with certain lecture topics, as the teachers would speak from one cultural perspective. For example, the Crusades were discussed from the Catholic perspective, which excluded certain other cultures from the discussion, such as the Muslim students present. This, in turn, made the teachers realize that their experiences and individual upbringings affected how they taught their outlook on certain topics (Santoro, 2009).

In her 2014 study on such mentorships, Crutcher identified the follow criteria for a successful cross -cultural mentor:

- Mentors must be adept at navigating cultural boundaries
- Mentors must be active listeners, honest non-judgmental, persistent, patient and posses an appreciation for diversity
- Mentors must see the mentee as an individual and as a part of a larger social context
- Mentors must avoid becoming too invested in their mentee's choices
- Mentors refrain from becoming friends with their mentees in the beginnings of the mentorship

Based on these criteria, cross cultural mentors should, in general, be aware of their mentee's cultural background and keep it in mind when giving advice or guidance.

2.3.3 Helping Mentees Achieve Higher-Level Thinking: The Role of Facilitation in a Mentorship

Facilitation is the process of providing learners with the opportunity to internalize information, processes, and abilities in order to promote higher level thinking. Forms of facilitation include modeling, coaching, and fading. Modeling is when a mentee directly mirrors the actions of their mentor while having the process explained to them. Coaching occurs when the mentor asks the mentee questions, provides hints, and gentle reminders in order to correct their actions, starting from base knowledge the mentees already possess. It is at this stage that mentees begin to develop their own problem solving strategies and decision making skills. Further, fading is when the mentor gradually pulls away from any directive or formal instruction involving the mentee, until the mentee is essentially self-sufficient in a given task. (Choi & Hannafin, 1995).

In the context of a robotics club or team mentorship, modeling would come in the form of hands-on instruction of such processes such as assembling a drivetrain or creating a Computer Aided Design (CAD) assembly. As time progresses, mentors of robotics clubs and teams transition into coaching practices, and begin to have students discuss out loud what they believe would be the best option to tackle certain challenges. After still more time, mentors slowly reduce their involvement in order to allow mentees to truly get the feel for designing a robot. Mentors in such situations would then only occasionally offer advice or help, preferring to have their mentees solve the problems of their own accord.

"I needed to slow down and speak more clearly. I think I lectured too fast and though I kept the students' attention, some information was lost in the process." -Ben Wagner

2.4 Robotics Competitions: Impact on Students Worldwide

Robotics competitions are an ideal outlet for encouraging student interest in STEM fields. By combining three core disciplines of engineering- computer science, mechanical engineering and electrical and computer engineering- students are exposed to a broad spectrum of STEM subjects. A study in 2011 compared the attitudes of 100 students before and after participating in the FIRST Robotics Competition (FRC), a competition in which teams build large robots to play a game. The participating students each completed the Test of Science Related Attitudes (TOSRA), which gauges students' attitudes towards the sciences, prior to the competition and again after the completion of the program. The study concluded that, after participation in the FIRST Robotics Competition, the students' opinions about STEM areas of study were significantly improved (Welch, Huffman, 2011).

By participating in robotics competitions, students may be encouraged to or dissuaded from following certain career paths, however, research suggests that, regardless of the participants' future plans, skills gained by participating in such a competition can contribute to success in any field. In a study conducted in 2017, it was found that team based competition increased students' communication and collaboration skills, enhancing their abilities to overcome a challenge as a group (Chen & Hwang, 2017). The application of robotics competitions can also lead to greater student self-confidence through peer interactions and success in the game (Brand, Collver, & Kasarda, 2008). In many competitions, some students may have very limited technical knowledge, but contribute more towards leadership, marketing, or other skills (Robotics Teaches Technology, Life Skills, and "Coopetition," 2017). These diverse contributions allow the team to connect and realize each individual's potential. In the words of one student on a robotics team in New Jersey, "everybody has to work as a team. If you don't work as a team, everything falls apart" (Rider, 2013).

Figure 9: An FRC Competition (FIRST Robotics Competition Game & Season Info., n.d.)

2.4.1 International Robotics Competitions

In order to expand the number of robotics clubs at schools in Albania, it is useful to take into account other programs which have successfully spread robotics and STEM education to countries that have limited financial and institutional resources. Some prominent organizations involved with this are FIRST (For the Inspiration and Recognition of Science and Technology), VEX Robotics REC (Robotics Education and Competition), Botball, and RoboCup. As an example, FIRST's competitions have seen the participation of over 460,000 students worldwide, with representation from over 160 different countries. These

"I was reading that STEM as a concept was starting to go around the International school realm and so I put in an order for 3 Lego kits" -Besnik Zylka

competitions have been shown to have a profound impact on the participating students worldwide. This was exemplified in a three-year study in which 636 FIRST participants were compared to 409 students who did not participate in FIRST. It was found that FIRST participants were 2.3 times to 3.7 times more likely to show gains on STEM-related measures, including involvement in STEM-related activities, STEM knowledge, and interest in STEM and related careers (Melchior et al, 2017). In addition to the reach of FIRST, VEX Robotics has also spread STEM through its own robotics competition and classroom material, which focuses on lower cost robotics education. While used in the VEX Robotics competition, VEX parts and kits are also frequently found in classrooms (Vandevelde, Saldien, Ciocci, & Vanderborght, 2013). With this, VEX Robotics has demonstrated potential keeping students engaged in science and math education. A two-year study of 1000 inner city Baltimore students found that students, after participating in a VEX robotics competition, had higher test scores as well as higher classroom attendance compared to students who did not participate in robotics (VEX Robotics: Inspiring and Preparing Students for STEM Careers, 2011). This shows that robotics competitions can be powerful tools for spreading robotics and STEM across a large range of students from many different backgrounds.

These competitions can also have inherently self sustaining aspects that can promote additional spread of STEM education. Though robotics education is still relatively young, and much of the long term effects and cycles have yet to be discovered, the student-turned-mentor aspect has already become apparent. For example, in a recent FIRST Global competition, one high school student, Michael Sergbeh, participated as member of the Liberian team. The success of his team in the competition inspired him to return home and begin teaching primary math and science to younger Liberian students, while he continued to further his STEM education (Ahmad, 2017). This shows how robotics competitions instill a sense of confidence in individuals while teaching teamwork as well as professional skills to be used later in their careers ("Robotics Competitions: Building A Generation of Innovators", 2017).

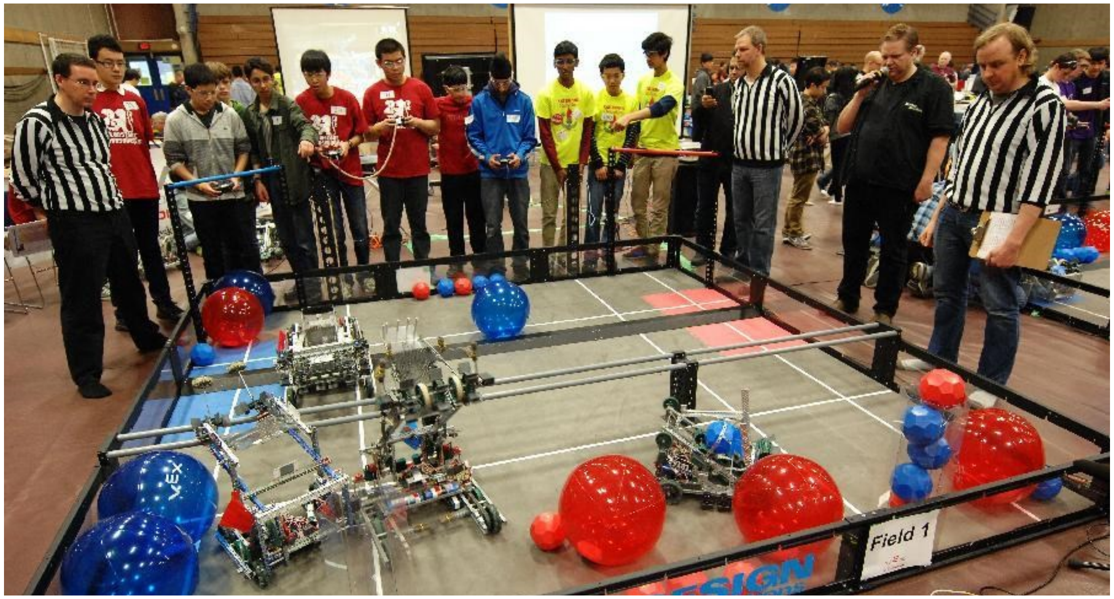


Figure 10: An FRC Competition (FIRST Robotics Competition Game & Season Info, n.d.)

2.4.2 International Competitions in Tirana: Tirana International School

While international robotics competition teams are rare in Albania, they are not altogether missing. The primary example of this is the Tirana International School (TIS). TIS was founded in 1991, and offers an American-style, K-12, college-preparatory education for students of the greater Tirana area. As a member of the Central and Eastern European School Association (CEESA), TIS is able to participate in extracurricular competitions with other CEESA member schools (Tirana International School, n.d). As such, TIS has maintained several FIRST Lego League (FLL) teams as well as a FIRST Tech Challenge (FTC) team which have participated in CEESA coordinated robotics competitions. While small, TIS has maintained a ro-

"A coach has some great questions for your answers; a mentor has some great answers for your questions." -Brefi Group Ltd. 2015

botics program for five years, making it one of the longest running robotics education programs in Albania.

2.5 Robotics at the Harry Fultz Institute

2.5.1 The Harry Fultz Institute

Figure 11: Professor Harry T. Fultz (Tomcini, 2014)

The Harry Fultz Institute is a private school consisting of a three-year general high school, four-year technical high school, and community college situated in the heart of Tirana, Albania that strives to supply its students with the skills to become high achieving professionals (Xhaferaj, M., Personal Communication, November, 17 2017). The school was founded in 1921 by the American Youth Red Cross under the name the American Technical School of Tirana. In that year, only 32 students enrolled in the school. By 1992, the school had grown to enroll over 800 students and had gone through several name changes, settling on its modern name to commemorate the professor of mechanical arts who left the University of Chicago to superintend the school until 1933 (Tomcini, 2014).

Professor Harry Fultz and his staff maintained the outlook that the students of the institute would, in his own words, “try to make Albania a place worth living” (Tomcini, 2014). To that end, the Harry Fultz Institute provides a variety of technical and traditional courses in both the vocational and general high schools as well as the community college that all share the same campus. General high school students attend the institute for three years, just like most other Albanian high schools, while the technical high school students attend four years. Community college students attend classes for eight months to specialize in a technical discipline (Tomcini, 2014). In regards to the technical high school, students gain some experience in basic STEM courses including physics, chemistry, and mathematics and design, while specializing in one of three areas- electronics, business, or auto-mechanics- through elective courses. Now, there are about 230 to 280 incoming students in the technical high school each year (Hoxha, K., Personal Communication, November 19, 2017).

Outside of traditional schooling, the Harry Fultz Institute provides several additional services to their students. In keeping with the theme of preparing students for the job market, the institute routinely offers career counseling and university fairs. Students can also participate in extracurricular activities such as volleyball, basketball, a student newspaper, and, as of 2014, a robotics club mentored by WPI students.

2.5.2 Past WPI projects at the Harry Fultz Institute

The Harry Fultz Institute has hosted three groups of WPI students from 2014 to 2016 with each year’s group building on the progress of prior years. In 2014, WPI students worked with Professor Enxhi Jaupi to launch a robotics club at the Harry Fultz Institute and determine what teaching styles best complemented the existing curriculum. The Harry Fultz Institute students involved in this project desired shorter, more condensed lectures to increase the time to work on their robots, and enjoyed the self-directed learning style (Hunt et al., 2014). In 2014, the six, four student teams built small arduino based robots that ranged vastly in ability and purpose. For instance, some could be controlled through Bluetooth on android phones, follow lines drawn on the ground, seek a person out through sound or light, or balance on two wheels (Hunt et al., 2014). The following year, the six, five student teams were given a broad goal: to research robots and build something that interested them after basic robotics lessons on building, wiring, and programming with Lego Mindstorms EV3 kits. The 2015 group then created more advanced lesson plans focused on teaching the club students to program, 3D print, and apply their theoretical knowledge from their classes to practical challenges and problems. This resulted in an autonomous hexacopter drone, an autonomous rover, a balancing and jumping remote-controlled robot, a 3-axis CNC machine, a robotic hand, and a robotic arm (Jacobsohn et al., 2015). Then, in 2016, WPI students implemented a robotics competition to foster a competitive and collaborative environment among the twenty-four students. These WPI students mentored the club in building robots, as seen in figure 12, that competed in a Savage Soccer competition discussed below.

The club students have broad levels of understanding about a relatively large number of different technical disciplines. The 2015 group concluded that teaching would have been more beneficial to the students involved if the class sizes had been kept smaller and different skill sets (programming, electrical engineering, etc.) had been spread evenly throughout the teams (Jacobsohn et al., 2015). The following year, WPI students focused on helping students develop teamwork and collaboration skills while increasing the interest in applying skills learned in class by providing lessons that culminated in a robotics competition (Titus et al., 2016).

Each year, the successful completion of the robotics club has helped the club to grow and develop, although there have been difficulties each year. This included an ongoing issue of obtaining parts in time due to delivery delays. Such delays caused teams to complete the build of their robot in the last weeks of the competition, resulting in robots that the students felt did not quite represent the level of effort that went into them (Titus et al., 2016). In some cases, building had to continue after the WPI students had left Albania. Furthermore, due to a limited budget, several simpler parts were manufactured within the machine shops of the Harry Fultz Institute. While this saved money, it took more time, decreasing the time students had left to build. According to previous groups, the students respond well to self-directed learning and were motivated, ambitious, and excited to learn, work, and collaborate resulting in a unique environment the students could not get outside of the club (Jacobsohn et al., 2015).

2.5.3 Current State of the Harry Fultz Institute's Robotics Club

Over the last three years, the robotics club, and the accompanying projects, at the Harry Fultz Institute has been primarily led by Professor Enxhi Jaupi. This year, however, the club was led by Professor Klarens Hoxha alongside Professor Moisi Xhaferaj. As with previous years, each student applied to be part of the club and were selected based on criteria specified by the two professors. Similar to last year, the club was composed of six teams of four students each. Each team had a student that was good at electronics, one that was proficient in programming, and one with experience in mechanical design in addition to a team leader (Jaupi, E., Personal Communication, September 11, 2017). Ten of these students participated in the club and subsequent competition last year, of which six served as official team leaders this year. The remaining four were distributed among the teams as normal to provide leadership assistance when necessary.

The club, this year, followed the same structure as in 2016, that is, brief lectures were presented each class and were coupled with hands-on workshops and mentoring, culminating in a robotics competition at the end of the project. The role of WPI mentors in the classroom was to teach new topics, such as mechanical design and C programming basics as well as to encourage student interaction and teamwork.

The 2016 group implemented a Savage Soccer game. Savage Soccer is an introductory-level competition for groups to explore the basics of robotics, engineering and teamwork in a fun environment. The main goal of the game is to use a remote controlled robot to transport game pieces to scorable zones ("Welcome", 2017). Game pieces range from foam cubes to wooden eggs. The 2016 team utilized the Savage Soccer game manual from the 2014 game which used ping pong balls as game pieces on the field illustrated in figure 12. Students built their robots primarily from scratch, utilizing various provided parts as well as salvaging metal from sources such as computer cases (Titus et al., 2016).

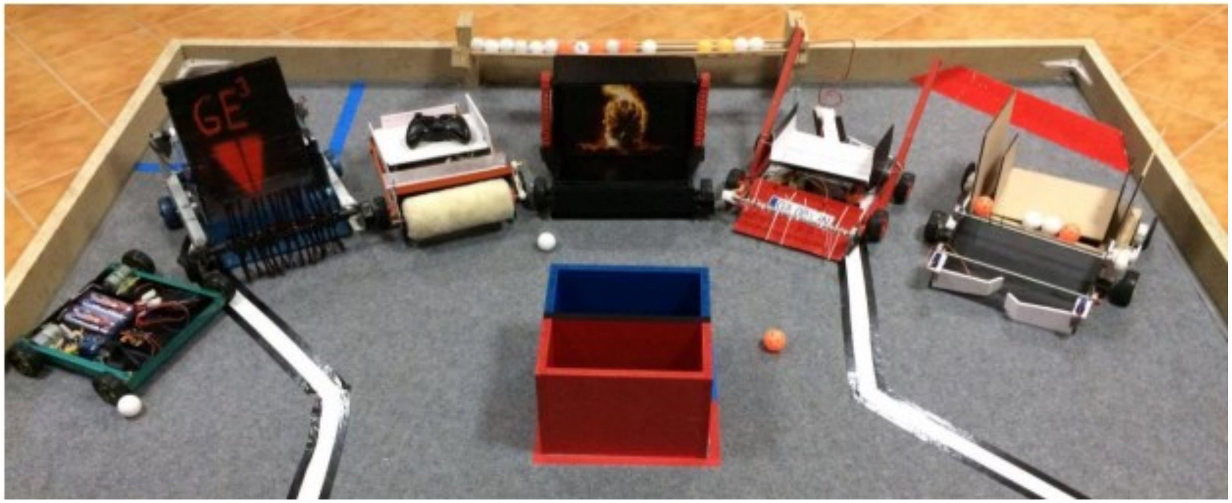


Figure 12: Completed Robots From 2016 Robotics Club Competition (Titus, et al., 2017)

"This year has been such an improvement from last year. I know I'm saying this over and over again. But seriously... I can't think of anything that needs to be changed. -Club Student

3.0 Process

"I learned how to think critically and acquired new knowledge on electronics and programming. I'm glad I was part of this project because it was a very new experience for me and it has prepared me for eventual problems that I will face in future projects in my life." -Club Student

The primary goal of the project was to engage students in the robotics club at the Harry Fultz Institute in a robotics competition in order to promote creativity, communication, problem-solving skills, and teamwork throughout the six weeks of self-directed learning in which the students had to design, build, and program their robots.

Despite our initial limited experience as teachers and mentors, we intended to get to know the students and learn more about their perspectives, thoughts, and attitudes. This was done such that implemented teaching styles could be adapted to more effectively connect with and ensure that students received the optimal combination of theoretical and applicable skills. Our group also assessed the interest in, feasibility of, and resources for furthering robotics education in Tirana. This goal was accomplished through the following objectives:

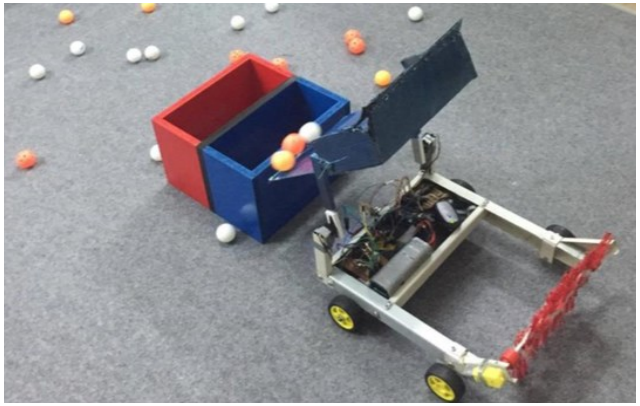


Figure 13 A Students Robot from 2016 deposits Ping Pong balls into the scoring Zone, (Titus, et al., 2017)

- Design an engaging and interactive educational experience through lectures and mentoring in preparation for a competition
- Assess student teamwork and encourage student reflection to heighten awareness of essential problem-solving skills and team dynamics
- Develop narratives to record thoughts and observations for further analysis
- Explore feasibility of expansion of robotics education in Albania

3.1 Mentoring Students for a Robotics Competition

3.1.1 The Robotics Competition

The game that was selected for the 2016 competition at the Harry Fultz Institute adapted the 2014 Savage Soccer game manual which utilized ping pong balls that were scored in colored bins as can be seen in figure 13. This year, in order to present the returning students with a different challenge than they had previously tackled, the 2007 Savage Soccer game manual was adapted. The corresponding game objects were badminton birdies as well as a size-four soccer ball. Thus, the ten returning students were unable to reuse the same mechanisms that they had developed to pick up the ping pong balls, allowing each team to begin on even ground. The fully adapted game manual for this year's competition can be found in appendix H.

3.1.2 Curriculum

Our teaching was based in part on the lesson plans and recommendations from the previous three WPI project groups involved with the robotics club. As a base, short, introductory lectures were presented at the start of each class. These lectures contained necessary information for the students to gain a better understanding of robotics each day, as more components were introduced. Checkpoint objectives were implemented in an attempt to keep student teams on track to complete their robots in time for the competition. Examples of such checkpoints can be seen in the table 1.

"As annoying as it might have been this lecture was the most important one for our team as it help us a lot to finalize our robot design and how our robot was going to work." -Club Student

Date	Checkpoint Name	Expected Product
October 31st	Initial Design	Drawing or CAD file of the rough design of each team's robot, including mechanisms, drivetrains, and any initial sensors
November 6th	Drive Trains	The base frame of the robot with wheels, transmissions, and motors attached
November 14th	Gameplay Mechanisms	Demo of mechanisms to be used in the competition, including physical structures running on programmed motors
November 17th	Desired Sensors	List of any and all sensors needed for autonomous operation of the robot
November 23rd	Sensor Based Autonomy	Demonstration of robot able to operate autonomously in the gameplay field
December 2nd	Final Competition	Compete head-to-head with other teams from the robotics club

Table 1: Robot Design and Build Checkpoints, and Associated Expected Results

A note on "Mentoring"

Aspects of the three instructional methods- mentoring, teaching, and coaching- played a role in the development of lecture material and student interaction over the course of this project. While this project did resemble a mentorship in the sense that students were guided into discovering the STEM education path, the short time span in which this occurred as well as the culminating competition implied coaching while the addition of lecture-based instruction contributed aspects of teaching. Therefore, this combination will be formally dubbed mentoring, but will differ from the traditional definition of the word as it combines aspects of all three disciplines together for the purpose of this project.

3.1.3 Mentoring

The 2014 IQP group concluded that the most effective way to teach the club students is to work as their mentors by helping them when difficulties arise, while allowing them enough room to research, fail, and problem-solve on their own. A 2013 study analyzed how teachers interpreted their students' problem solving abilities and related them to the student's native culture. Teacher's pedagogical reasoning as they reflected on their students' performance completing a task was organized into four categories: generativity, elaboration, justification, and explanation (Buxton, Salinas, Mahotiere, Lee, & Secada, 2013). Although this study analyzed how the teachers explained their students' problem solving procedures, this was adapted in order to analyze the club students throughout their design and building process. These categories provide a way to evaluate the students, and how they are rationalizing their decision making as they encounter options or issues. Although formal scores in these categories could have been assigned to individual teams or students while evaluating them, it was deemed most beneficial to keep the categories in mind to guide our feedback or when asking the students questions in class. In order to best assess the effectiveness of the planned teaching strategies, a multi-stage approach consisting of group- and student-initiated interactions was implemented as seen in figure 14.

" I think robots are mostly about programming. It was a nice lecture to hear ,even though I'm not responsible for the programming in my team." -Club Student

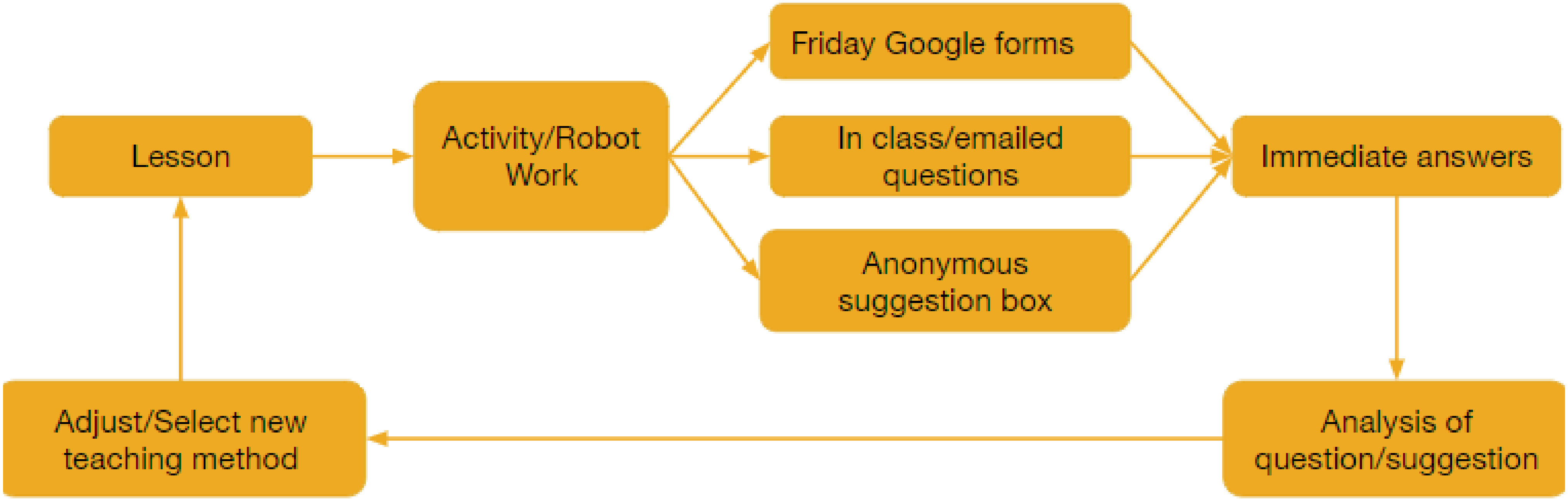


Figure 14: Feedback Flowchart for Evaluating the Effectiveness of Lectures

Each day, the topics students were having the most difficulty on were analyzed and subsequent lesson topics were adapted accordingly. Further feedback on lesson content and student issues was gathered via Google Forms at the end of each week.

There were two types of Google Forms: one which reviewed the previous week's lessons and activities and one that was constantly available for student feedback, dubbed the "Suggestion Box." Google Forms allow for the rapid collection of data from a controlled sample population, in this case the twenty-four students, and can combine qualitative and quantitative questions seamlessly. The weekly survey, an example of which is seen in appendix D, was structured such that each lesson of the corresponding week was given a numeric rating followed by a comment box where students could optionally explained the reasons for the rating. The survey responses were then put into word clouds in order to analyze prominent themes per lecture. Word clouds are an efficient tool to generate context-preserving visualization that depict the frequency of text content (Cui, Wu, Liu, Wei, Zhou, & Qu, 2010). Since the words or phrases that were used the most are considerably larger than other, it was simple to see if the students' collective attitude was altogether positive or negative regarding a particular lecture. By coding the survey responses for common themes, we were able to better serve each student better in future lectures, as well as analyze the impact of the hands-on workshops that were incorporated into several lectures.

The second form, as seen in appendix D functioned as a digital suggestion box, which any student had access to at any time in order to ask a question or address some difficulty they were having, while maintaining their anonymity, if desired. The responses from this survey would explicitly point us to some area which the club was lacking, whether it be in an individual group or, if a certain topic came up repeatedly, the club as a whole. If the review indicated that there was a topic with which the class was struggling, short review lectures were prepared to address any material students needed more time with, or any other issues and concerns the students were having. Though it was not expected to have many submissions that asked for further clarifications on lecture material, as we were present at the club each day to answer questions in person, it was possible that students would express other difficulties, such as frustration with failure, outside of scheduled class time. In such a case, a lecture on the importance of failure and how to overcome it was deemed beneficial in order to let the students reflect on their process and see how each failure brought them closer to their desired outcome. The combination of these forms were intended to offer the students a way to communicate to us in their native language or submit a thought or concern anonymously if they felt the need to.

3.2 Assess Student Teamwork, Collaboration and Reflection

3.2.1 Encouraging Personal Student Reflection

As in previous years, students and their teams had the option of participating in semi-structured interviews in informal settings. Semi-structured interviews utilize a set of prepared questions that probe at the interviewee to follow a particular line of inquiry (Jamshed, 2014). Some examples of these questions can be found in appendix B. Some of the topics addressed in these interviews, include team dynamics, thoughts about the student's robot, potential interests in majors at university, or general interest in robotics as a whole. These questions intended to give students an opportunity to discuss their experience through guided questions, allowing them to reflect and identify how their interests have changed or skills have developed. These interviews took place during the robotics club regular meeting times for the convenience of the students, and were recorded for proper documentation. Since it was unlikely due to the school logistics that these interviews would include a complete population sample of the club, these interviews were primarily used for quote extraction on the relevant topics.

In order to better understand their motivations and viewpoints, a brainstorming prompt was asked of the students. This would enable them to respond with phrases, words, or sentences that they felt best fit the prompt, which was "What have you learned in the Robotics Club?" We chose this question in order to encourage students to think about what valuable knowledge they had gained since the start of the club and to brainstorm topics they wanted to know more about. A list of other brainstorming questions that were considered and a more in-depth procedure can be found in appendix C. The responses to these prompts were categorized through thematic analysis by patterns of conversation topics, which, when headed by a theme, represent a collective experience among informants (Aronson, 1995). For our organizational purposes, this allowed us to better identify what the students were most passionate about, and use that information to further adapt any interactions with each individual as well as the class as a whole.

3.2.2 Student Teamwork

Determining the collaborative-effects on the students was accomplished in two ways: recorded observations of the student interactions by us, the WPI mentors, and analysis of student usage of a Google Drive. Through constant interaction with the students while teaching the lecture material, assisting students with problems, or performing other duties, we were in an excellent position to observe student interactions and even gauge the students' feelings about their team as we were constantly in contact with them while they were working and could directly observe them in action.

In observing the students, we followed the model described in Stephanie G Adams' Team Effectiveness Model developed at the University of Nebraska-Lincoln which determined that an ideal, productive team exhibits seven characteristics as listed in table X: Adams also asserted that "these constructs have been defined as characteristics a team should encompass in order to be effective and will be the foundation for the behaviors identified in the development of the protocol to measure team behavior" (Adams, Zafft, Molano, & Rao, 2008). Table 2 also illustrates the various characteristics and how they were put towards the purposes of this project. Our analysis differs from Adams' suggestions, as we implemented a different ranking scale in each category in order to more effectively rate each team at a time instead of each individual.

As part of the observations of the students, each member of our group filled out a team success potential survey, as can be found in appendix D after each club meeting in order to score the individual team behavior. The survey quantified each student team's success using a number scale for each of the seven criteria laid out in the model above. There also was an option to add any addi-

"The opportunity to actually build something and experiment with it is priceless to me and that's what I like most about the robotics club." -Club Student

tional comments or issues observed with each team. Before the fourth week, each respective teams' scores in the seven criteria were averaged, and converted to a number grade. The comments attributed to each team were analyzed for common issues or problems, from which potential solutions were generated. These grades and comments were then compiled in a comprehensive sheet, an example of which is seen in figure 15.

In addition to the documented observations, we asked the students to fill out a Team Evaluation Survey. This survey, seen in appendix D, combined fun questions with requests to rate their team members contribution in order to keep the students from feeling too uneasy or pressured to talk about their team. By assuring them that their anonymity would be preserved, the students had the chance to answer more honestly. This survey was intended to provide confirmation of which students contribute more or less than others, while obtaining each student's insight on how their team was operating. From these survey responses, problematic team members were identified by the comments other team members left for them.

In the fourth week, we met with each team or problematic teammate met with a group member, to discuss the results of the observations and related surveys. The generated team success sheets were presented to the student teams such that each had the chance to reflect and make any necessary changes before the completion of the project. Each team met privately with a group member to discuss what was observed and any suggestions for improvement. Any exceptionally low scoring score, being less than a 75% in any particular section, required extra attention, explanation, and advice. Additionally, any teammate that was identified as a problem met one-on-one with a group

Team Characteristic	Meaning	Desired Behavior for High Score
Common Purpose	Each teammate is working towards the same collective goal	The entire team is in agreement of the design for the robot and working together to achieve that design.
Clearly Defined Goals	Each teammate is aware of the desired outcome and it does not change day to day.	Each team member is working towards the same design of the robot, with clearly stated direction and desires for the end product.
Psychological Safety	Teammates feel safe in their environment, feel comfortable to be themselves and to express their ideas and opinions to effectively contribute to the team.	Each student appears to be comfortable, happy, and often contribute to the work or conversation.
Role Clarity	Each teammate is aware of what they are expected to contribute to the final product.	All students are working an equal amount on the robot throughout the entire process.
Mature Communication	Teammates communicate their ideas concisely, are excited to listen to the conversation that follows, and encourage the development of the team's ideas as a whole.	Students are not being extremely loud or acting aggressively when discussing the project. Students are listening to each other and communicating in a mature fashion.
Productive Conflict Resolution	Conflicts are managed in a productive manner. A change is made instead of ignoring the issue.	Students make an effort to understand each other, and maybe change roles on the team, redefine their goals, remind teammates of a common purpose etc.
Accountable Interdependence	The team should not be able to succeed if a member were to not make contributions. Each teammate should be interdependent on the work and success of others.	The workload is spread well between members, students contribute to processes outside of their roles, and students have a high attendance rate.

Table 2: Adams outlined Effective Team Characteristics, their meaning, and how they relate specifically to this project.

	Overall TeamWork	Common Purpose	Psychological Safety	Role Clarity	Mature Communication	Conflict Resolution	Accountable Interdependence
Average:	6.60	3.40	4.24	2.05	3.05	3.90	2.20
Total Possible Average	10.00	5.00	5.00	4.00	5.00	5.00	4.00
Percentage	66.00	68.00	84.76	51.19	61.00	78.00	55.00

Meaning:

Overall Teamwork: How we think your team has been working together
Common Purpose: You are all working towards a common goal
Psychological Safety: You are comfortable around each other and share your ideas
Role Clarity: You each have a role, and everyone contributes to the project
Mature Communication: You communicate well and listen to each other's ideas
Conflict Resolution: You manage disagreements in a productive way
Accountable Interdependence: You understand that each teammate is valuable and the project should not be able to succeed without any one of you

Progress so far:

- We see some of you far more than others
- Share your knowledge about things so you guys aren't stuck if one person doesn't show up
- Everyone should be contributing all the time
- Try not to go around getting the other groups distracted

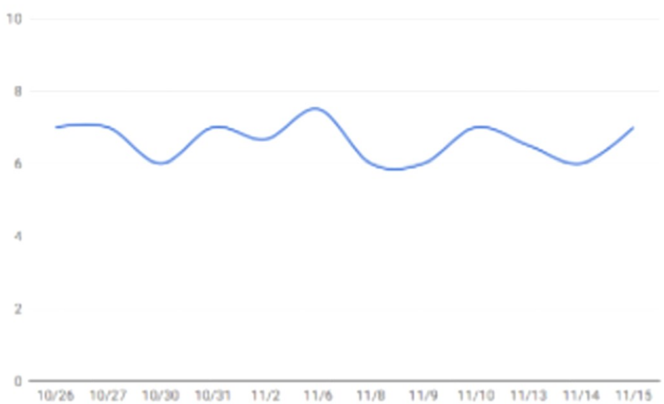


Figure 15: Example of Team Evaluation Sheet as provided to students

member in order to identify causes and brainstorm ways to improve their performance in the latter weeks.

In the final weeks leading up to the competition, each team was observed further to determine whether the discussion of their performance affected their team dynamic and performance. In a final survey at the culmination of the club, students were asked whether they found the meeting to be beneficial for their teams and if it affected the team dynamic at all.

3.2.3 Student Collaboration

While encouraging collaboration can positively affect the students as a whole, it is important to provide a collaborative medium through which they can communicate and document their interactions (Nag et al., 2013). Such mediums can take many forms, ranging from a class discussion board, to a Facebook group, to a wall dedicated to photos and questions on the matter. Instead of these, a Google Drive was set up so students had access to private folders in which they could upload their designs, thoughts, programming codes, and have access to any presented lectures, provided files, or feedback surveys. This provided a place for the members of the individual teams to store their work and collaborate on files, while also allowing us, the mentors, to view their progress and assist when they had problems. The Google Drive was chosen among other options as it was decidedly the best means of private documentation, since there was fear that collaboration and idea sharing too early on in the design process may result

"Our teamwork has been good overall, but it could have been better. Everybody has been busy with doing [academic studies]. So I can say that we didn't give our full potential." -Club Student

in a lack of creativity and individuality as occurred in previous years (Titus et al., 2017).

In their assigned team folders on the Google Drive, students could also fill out reflection documents, such as the one seen in figure 16, to make it easier for us to track their problem solving process and difficulties encountered. Using these, each student team could be assessed at the various stages leading up to the final competition. The various discussions, design changes, parts requests, or ideas that the students noted could be easily observed and discussed, which further influenced our interactions with individual student teams. Routinely, the teams were tasked with submitting documents, such as requests for particular motors or desired sensors. Through these documents, students were able to more clearly define their goals, in order to allow them to share their ideas with other groups more confidently once their ideas were flushed out and agreed upon.

3.3 Develop narratives to record thoughts and observations

One of the more important aspects of this project concerns the personal impact; our ability to teach, to mentor, and to communicate with people of a different culture in order to understand how to most effectively serve them and connect with them. To do this most effectively, each group member wrote a journal entry daily to highlight successes, failures, personal and student reactions, as well as the magnitude of both our and the students' motivation. Each group member used these

Team Name:
Team Leader:
Team Members:

This is your chance to write down what happens in your groups as a way to keep a record of your progress. Be sure to include any ideas you have for driving your robot, mechanisms for scoring, programming your robot, or anything else. If you have any discussions or debates with your teammates, write down the steps you took to resolve it all. Or, if you see something from another group you like, write that down (but give them credit)!

Questions to Consider

Design updates:
[Text]
Brainstorming:
[Text]
Have you had any frustrations?
[Text]
If so, how did you solve them, or how do you plan to solve them?
[Text]
Does your team work together well?
[Text]

Date:
[Text]

Figure 16: Team Reflection Template Provided on Google Drive

"Alpha had a question for me, but Edge Logic jumped in to help before I had the chance."
-Marek Travnikar

journal entries to note findings that could pertain and prove useful to other project objectives. Any questions or trouble the students had that particularly stood out were noted, to help influence lectures or activities, as discussed in Section 3.1.3 above. Furthermore, by keeping a journal, one can record thoughts and observations that might be lost in retrospect (Alaszewski, 2006).

Each entry was reviewed and analyzed by selecting key phrases or words from the text which would then be categorized based off of their content. The act of categorizing like this is called "coding," which is a judgement call on behalf of the researchers to identify key information (Saldaila, 2009). In this fashion, consistent trends or themes were identified and used to adapt our approaches and interactions with the students. Through the final analysis of these themes at the conclusion of our project, we were able to provide better advice to future mentors in similar situations.

3.4 Explore feasibility of expansion of robotics education in Albania

One way to expand the benefits of a robotics competition is not only to take steps to ensure it continues in the years to come at the Harry Fultz Institute, but also to expand and encourage other schools in the greater Tirana region to participate in robotics education. To do this, we conducted semi-structured interviews with representatives from schools, organizations, and companies that were considered as having an interest in discussing the possibility of implementing robotics curriculum in Tirana. Semi-structured interviews can be considered more appropriate for formal contacts, and were thus deemed more applicable than formal interviews. Since these interviews will become a source for those continuing the exploration of this topic, it was important to record them for later verbatim transcription (Jamshed, 2014).

In order to assess the possibility of expansion, key factors were explored, including:

- Robotics integration motivation
- Current State of STEM education in local schools
- Resources available
- Current state of the robotics industry and education
- Hopes for the robotics industry and education
- Possible connections
- Recommended next steps

Each interview had the interviewee reflect on how robotics could be integrated into the organization they are associated with, the current state of and future hopes for the robotics industry, and what resources may be available to give rise to widespread robotics education. These interviews concluded by asking if the respondent was aware of any other organizations, schools, businesses or individuals that were similarly invested in the expansion of robotics locally, domestically, or internationally, and by asking how to take the next steps with each interested party.

By gaining an understanding of the interest and available resources of other parties, we wanted to start a conversation that will hopefully blossom into an expansion of robotics education in Albania. It was intended to connect the people that have the ability and drive to make such an expansion happen, if possible, and who would feel responsible for keeping the conversation going in order to then turn that conversation into action.

3.4.1 Parties of Interest

The primary parties of interest that were contacted for interviews on this subject included Protik, the Tirana International School, the Ministry of Education and Science in Tirana, and EducationUSA.

Protik

Protik is a Tirana-based company dedicated to inspiring growth within the information and communications technology (ICT) industry within Albania. Already, they have exhibited some interest in robotics, seen in their Young Innovators Club, which has produced a remotely controlled robot (Protik.org, 2013).

Tirana International School

The Tirana International School, founded in 1991, is a private, not-for-profit school that follows the American style, K-12, college preparatory curriculum (Olson, 2017). In the past, the International School has sent a team of students to Washington D.C. to compete in a FIRST world competition. Besnik Zylka, a technology professor at the International School who helped to found this school's FIRST team, has been in contact with WPI's Professor Peter Christopher and expressed to him interest in expanding robotics education and competition in Albania.

Figure 17: CEESA Logo

(CEESA - Association for the Advancement of International Education, n.d.)

Albanian Ministry of Education and Science

Officially the Ministry of Education, Sport, and Youth (MESY), the Albanian Ministry of Education is in charge of drafting up and implementing nation-wide educational policies. Located in Tirana, MESY is in charge of the annual budget for schools and is responsible for following up on any new policies or teaching strategies that are presented to schools. Working with local governments, MESY constantly seeks to improve the overall educational value available to all citizens of Albania. (ACCE, 2017)

REPUBLIKA E SHQIPËRISË
MINISTRIA E ARSIMIT
SPORTIT DHE RINISË

Figure 18: Ministry of Education, Sports and Youth Logo

(Bes-ART. n.d.)

Further, MESY has demonstrated a significant interest in the advancement of robotics education, in addition to other essential fields. A 2015 article stated that the Ministry has been attempting to implement the ERASMUS+ program which encourages institutions of higher education to improve some aspect of their offered education. The program prioritized improvement of aspects of the current education system in four categories: subject areas, quality of education, management and operation, and higher education development. One of the subject areas of interest is the improvement of robotics education as a part of the general engineering discipline. For this reason, the Ministry is of particular interest to this team. (Ministry of youth, Sports, and Education, 2015).

EducationUSA

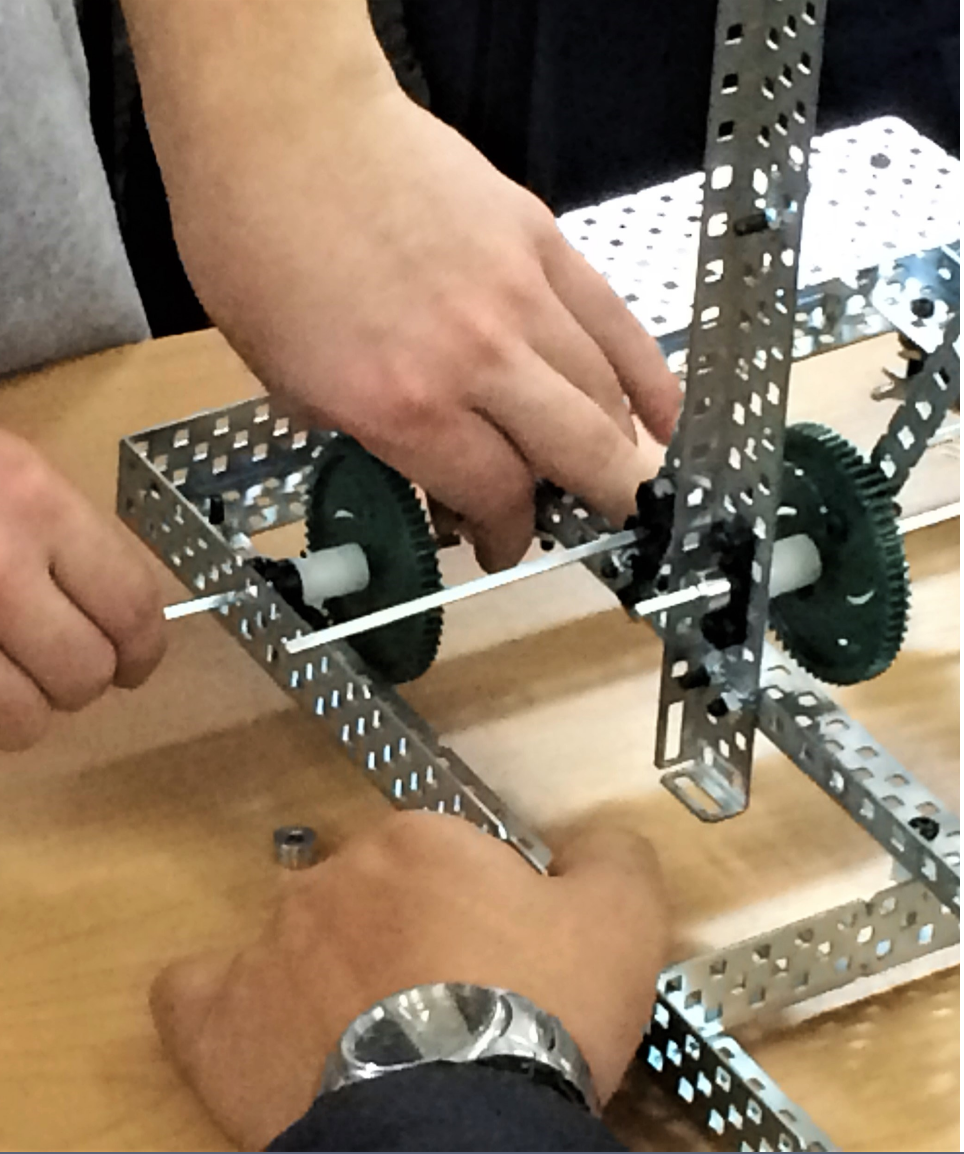
EducationUSA is an agency funded by the U.S. Department of State's Bureau of Educational and Cultural Affairs that is dedicated to helping students from countries around the world apply to institutions of higher education within the United States. EducationUSA has advising centers in over 170 countries worldwide, including one at the Marin Barleti University in Tirana, each of which is staffed by highly trained professionals, many of whom have first-hand experience studying in such institutions. At each advising center, students can find free information on various schools, universities, or colleges as well as the process for applying to higher education institutions. Additionally, advising centers frequently participate in outreach events such as fairs as well as reaching students websites and social media.

As more students look to the United States for both undergraduate and graduate degrees, the EducationUSA advising center in Tirana has become prepared to assist all students in achieving their goals. The center is open to the public and offers a multitude of sources on American institutions as well as administering the standardized tests needed to enter, such as the GRE or the SATs. (EducationUSA, 2017)

Figure 19: EducationUSA Logo

(Edusa Logo [Photograph found in US Department of State]. (n.d.)

"I think the studying abroad is something that can enrich you as a person... I think it's a life experience and if you can do it, why not?" -Club Student



4.0 Findings

"I like most the teamwork we have created. Each day we had new problems, and we solved that in a team. So that's the most important thing for me."

- Club Student

The robotics club students had about five and a half weeks to learn the basics of robotics, analyze the game, and then design, build, and program their robot. The competition was the tool used to engage the students in a fun and challenging way; however, the implementation of VEX parts this year reduced some challenge in order to maximize the time students had to embrace the engineering design process. Many of the parts that were used this year were purchased and brought from America to Albania. Thus, the students were able to utilize provided structural components rather than salvaging metal from sources such as old computer cases, as was the case in previous years. When asked about their experience in the club, the overwhelming majority, especially of students returning to the club, referred to the VEX parts as useful and stated that they made building the robots easier than in past years. One member from the winning team at the competition, Alpha, stated that: "you are giving us so much stuff. Last year I had to cut all of it myself and it was not fun. I am not cut out for that."

When asked what parts the students wished they could have had at the start of the club that they did not, most of the students referenced concepts such as knowledge or ideas rather than structural components as can be seen in the word cloud in figure 20. This indicates that the quantity and quality of the parts provided was adequate for the students to successfully construct their robots. However, it also indicates that there is interest for additional classes in robotics subjects prior to joining the club.

Figure 20: Word Cloud of Student Interview Responses, "What do you wish you had at the start of the robotics club that you did not?"

"Everything that we have discussed until now about design, building, mechanisms, etc. is about to become real." -Club Student

By the time of the competition, all six teams were able to score points in the competition with their completed robots as much of the manufacturing time was cut down. This marked improvement can be attributed to the provided VEX parts as they streamlined the building process and allowed for more trial and error in the designing process. In addition to this, by making it easier for the students to iterate through different designs and get creative, each robot was completely different from the others. In the very first lecture that we gave to the students, we gave examples of how two completely different robot designs could just as effectively complete the same tasks. Seeing how unique each team's design was and how excited the students were to describe their strategies for the game over the course of the club, as well as during the final competition, showed how much the students embraced the experience and made it fun and enjoyable for everyone involved. On the last day of the club, we asked the students to reflect over their experience in the club this year. We asked them to think about what they learned, how their team worked, and what we, as mentors, could have done differently. The word cloud illustrated in figure 21 highlights the students feelings of their club experience based off of the eleven responses that we received. This shows that the robotics club was an overall positive experience for the students, helping them to learn, think, and experience teamwork.

While the competition was a critical milestone for this project, it's important to emphasize that it was only one part of this project. The five weeks of teaching robotics topics, mentoring students, and preparing them for the competition were the catalyst allowing us to study the larger questions of this project: namely the effects of mentoring, student engagement, and student teamwork. The findings on these topics are each discussed in their respective sections as follows.

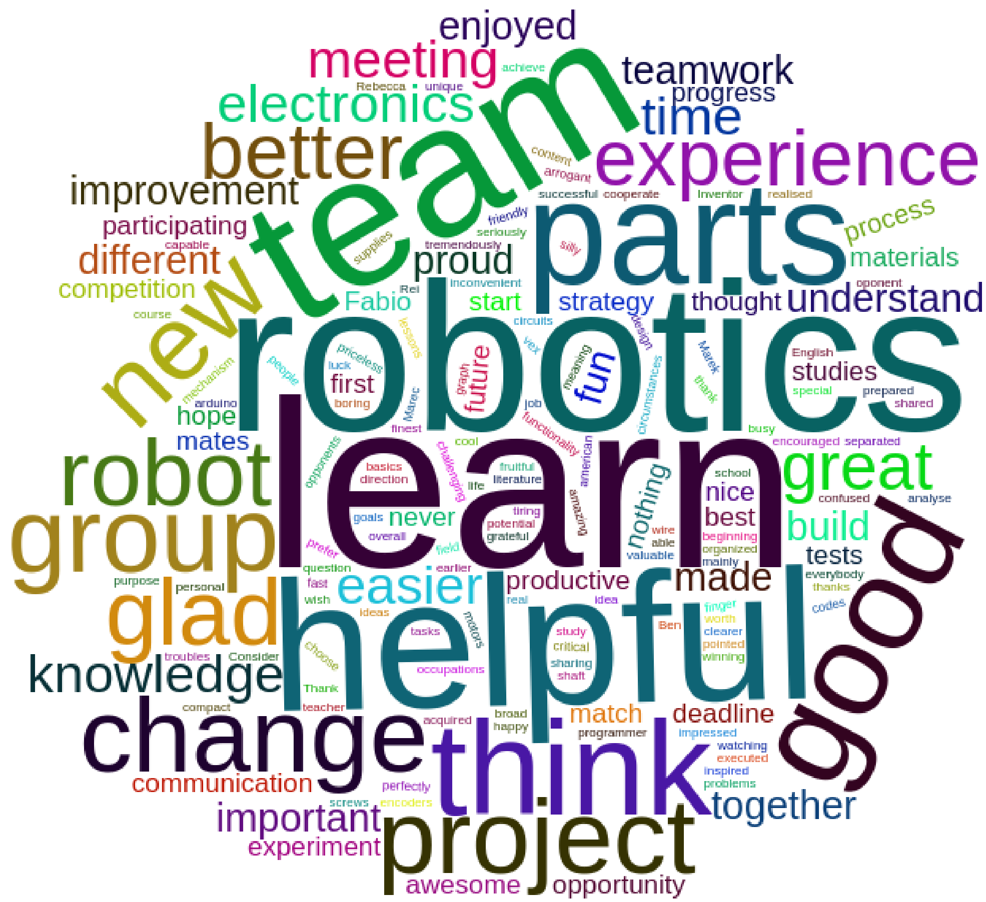


Figure 21: Word Cloud of Student Reflection Survey Responses

"I enjoyed [the club experience] very much since I never thought I would be able to build a robot not only at this age but at all, so it was a new cool experience" -Club Student

4.1 Mentoring

One of the most challenging aspects of this project was becoming good mentors to the students. Following Crutcher's guide to successful cross-cultural mentorship which states that "Mentors must avoid becoming too invested in their mentee's choices" (Crutcher, 2014), we needed to be able to adapt to the students' changing ideas, plans and directions for their robot designs and allow them to try, fail, and try again whenever they wanted to try a new mechanism or design idea. At times, students would have ideas that were completely unrealistic to successfully implement. In these instances, it was necessary for us to steer the team in a new direction in order to prevent them from wasting time on mechanisms or plans that could not ensure at least some limited success for their final robot. We did our best to guide the students towards designs that coincided with the team's own original, ideas while still being feasible given their resources, knowledge, and time constraints. That said, it was challenging for us to step back and not bias the students' unique designs in order for the students to learn through failure when their designs did not operate in practice as they had originally planned. This was partly due to a determination on our part to improve the club from previous years, as we felt pressure to achieve success as it was defined by the Harry Fultz Institute wherein every team must have a functioning robot by the day of the competition. It was expressed to us both by several students as well as the Professors that only having four functional robots at the competition last year caused significant disappointment for all who were involved. As a result of these pressures, we were occasionally more heavy handed with our advice and guidance than we had originally desired.

While failure is a highly effective way to learn (Starch, 1910), trial and error is a lengthy process which we wanted to limit in order for every team to be able to finish their robots on time. Some groups, in fact, seemed to learn best when copying designs until unique personal ideas emerged through attempted implementation. In the first week, one group, in particular, would simply copy whatever mechanism was covered in lecture on that particular day, resulting in their design and strategy to change daily. In order to encourage the students to commit to a design and try

Figure 22: WPI Mentor, Marek Travnikar, assisting a student with programming.

"I'm glad I was part of this project because it was a very new experience for me and it has prepared me for eventual problems that I will face in future projects in my life." -Club Student

to implement it rather than theorize and continually rework, checkpoint deadlines, as seen in section 3.1.2, were set up. At each of these check-ins, we expected the students to have completed some aspect of their robot. The students were not held to these checkpoints- considering that there were no repercussions or consequences of missed deadlines - yet they were routinely reiterated in order to remind the students of the approaching competition.

The students were extremely eager to begin building and testing their robots. Despite this, we made a point of stressing the engineering design process, as teaching it was one of the goals since the founding of the robotics club and one of the priorities for Professor Moisi Xhaferaj. To do such, we made a point not to give the students their kits until after they had finished a design for their robots. This served several purposes, including incentivizing the students to think about their design rather than just start building with no guidelines to follow. As they were required to think ahead of time and draw out their designs on paper, the students worked together and came to a consensus as a team as to what they wanted to do before actually doing it. Had a team failed to work together, their respective kit was withheld longer. Withholding the VEX parts served as leverage for us to assert our power as teachers of the club and organizers of the competition. We found asserting our power to be an important step for several reasons. Firstly, the Crutcher guide to successful cross-cultural mentorship states that "Mentors [must] refrain from becoming friends with their mentees in the beginnings of the mentorship"(2014). In the first few weeks of the club, we had desired to build a positive relationship with the students. This went against the guidance of Crutcher- and ultimately proved the validity of his claim- as no team submitted their designs by the initial checkpoint. It was important for us to gain the students' respect and instill a sense of urgency in them to fulfill our expectations and comply with our requests. When we began holding their parts as leverage, all of the students that day discussed in detail and submitted their designs to us. Asserting our power over the students also helped during lectures when students refused to quiet down. By "putting our foot down" we were able to gain command of the classroom and significantly improve student attentiveness and participation. This was expressed in one mentors reflections:

> ***"In a loud voice, I asked the students to quiet down and listen up, and I made it clear I was not going to take any disruptions. Amazingly they were near silent the entire time."***
> ***-Marek Travnikar***

We found that when we asserted our authority, the students respected our requests and instructions significantly more and without resentment. According to Crutcher, mentors must be able to see the mentee as an individual. Therefore, despite the need to maintain a sense of authority, it was important to us to relate to the students, make them comfortable, and to adapt our lectures to fit their individual personalities and needs. The students had a good sense of humor. This was not only recognized by us, the mentors, but also by Professor Moisi Xhaferaj who stated that when he lectures, he tries to crack jokes at the beginning of class so that the students can get their humor and laughs out of their system (personal communication, 2017). This "preemptive" fun, he argued, helps the students to focus better throughout the remainder of the class. Therefore, our lectures incorporated jokes, references to popular movies, and our surveys included fun questions such as "Which member of the Justice League is each of your teammates?". The hope was that if the surveys were fun, students would start talking about them and each person would want to complete it for themselves. Instead of having to remind students to take the survey once the last person finished, students made the first move to walk up to the computer, as they were intrigued by the conversations they overheard. As for humorous lecture material, we believe our "preemptive fun", as suggested by Professor Moisi Xhaferaj, released some energy in the classroom, allowing the students to focus on the material more. This was a successful tactic as multiple students directly referenced the fun details that were included in the surveys and lectures as positive improvements to the club in their feedback. As a member of team Vortex said: "It was the small stuff, at least for me, the small stuff for me personally the little cute friendly questions like 'which superhero would you be' or the little introductions you would do in the beginning or that you're joking some of the times or when you're

"If you want to go into STEM you have to be good in physics in mathematics and chemistry and mechanics and stuff that you have to know- the basics." -Professor Moisi Xhaferaj

interacting with other people on topics outside made us feel more like friends other than people who came from another land. And it was nice."

While it was important to relate to the students, make them feel comfortable and have fun with the club, we wanted to help them to learn as much as possible both about robotics as well as about their own interests in STEM and engineering. Therefore, in an effort to engage the students and give physical examples of systems to use on their robots, we structured as many lectures as possible around hands-on activities that were either directly applied to their robot or demonstrated examples of a concept. The breakdown of the 44 collected student responses to these hands-on activities and demonstrations can seen in figure 23.

While we implemented as many hands-on demonstrations as possible, once we gave the students their kits of parts, we began to limit lectures and class-wide demonstrations to allow the students as much time to work on their robots as possible. While multiple students were noticeably uninterested in lectures that did not utilize hands on activities, the activities had their own successes and failures. For instance, the students, despite their specializations, were highly engaged in the drive train demonstration which allowed them to see the effects of different gear ratios. However, in hands-on demonstrations that were solely design or programming oriented, such as the Inventor and Arduino lectures respectively, many students who did not specialize in the topic would simply get up and leave the room. Despite this, through analysis of the students weekly reflections, nearly 90% of the responses for lectures that included hands on components were positive. That is, they viewed the activities as fun, useful for their future, applicable to their robot, or stated that they learned something from the experience. Table 3 details each hands-on activity, its goal, and the result.

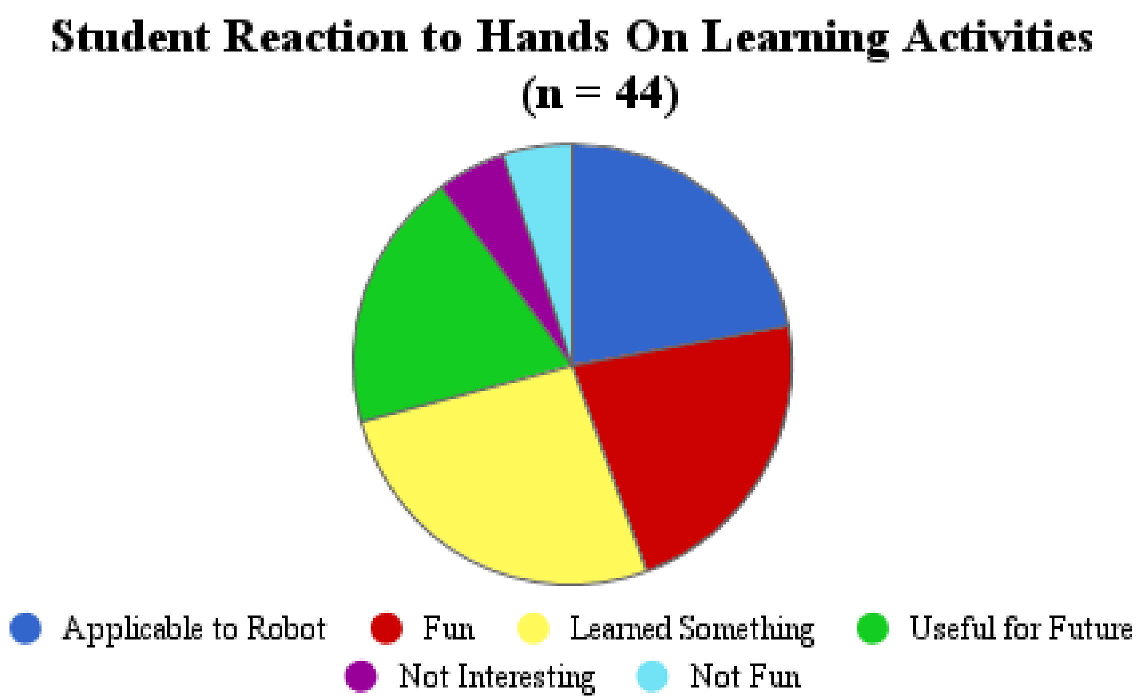


Figure 23: Pie Chart of Weekly Surveys Responses Relating to Hands-On Learning

"It's much easier to assist the students with a physical example to reference" -Rebecca Miles

Date	Lecture Topic	Hands-On Activity	Description	Goal	Result
10/24/2017	Introduction	Spaghetti Tower Challenge	Teams competed against each other to build the tallest structure out of spaghetti.	Team building	Well-received by the students: everyone seemed to have fun and each team seemed to work well together.
10/26/2017	VEX Parts	VEX Metal Car	Each team used VEX metal to build a car.	To get used to using VEX parts and experiment with how to put them together	Some teams worked better than others. A couple of teams spent the majority of the time arguing and did not even get to start building before the end of time. However, some teams exhibited good common purpose and teamwork and were able to fully complete the challenge.
10/27/2017	Drive Trains	Robot Race	Students experimented with robots that had different gear ratios. Students raced against each other or go into head to head pushing matches using the different robots.	To see first-hand how different gear ratios affected the driving ability of a robot	Students were, as a whole, highly engaged. They enjoyed getting to drive the robots, and a significant number of them swarmed us afterwards to ask questions and advice for designing their robots.
10/31/2017	Inventor	CAD Design	Using AutoCAD Inventor, students followed along with the instructions in the lecture in order to build a 3D CAD design of their proposed robot.	To become familiar with 3D design software and start thinking about the Physical construction of the final robot.	Several students exhibited frustration with having to learn Inventor rather than using AutoCAD, as they had already taken classes in it. Students who were not interested in design left the class. For those who stayed, many exhibited frustration when things didn't work on the first try but were exuberant when they managed to create the shape they desired.
11/7/2017	Arduino	Programming Practice	Students followed along with instructions in the lecture to run sample code on their Arduinos.	To become familiar with the Arduino IDE and ensure that all of the microcontrollers were in full working order.	There were difficulties getting Arduino installed on all of the computers initially. The teams' designated programmers exhibited the most interest. While some of the other students paid attention, the rest either occupied themselves or left.

Table 3: Hands-On Learning Activities Done During Club Meetings

4.2 Student Engagement

As previously discussed, we insisted on a quiet environment, wove humor into the lecture, or used some combination in order to gain the students' attention. Each student had a particular field in which they were primarily focused and, initially, few were willing to branch out and pay attention to lectures outside of their field of interest. There were a few factors that led to the students' specializations, such as the fundamental structure of the robotics club and education at the Harry Fultz Institute itself. When students enroll at the Harry Fultz Institute, they choose an area to specialize in- auto-mechanics, electronics, business- which dictates the classes that they take for the rest of their high school careers. Further, when they applied to the robotics club, the students were required to state which area they were interested in, and they were selected and placed into groups of four to ensure a rounded team skillset (Hoxha, K., 2017). As a result, the students were used to being specialized in one area of study and therefore less comfortable branching out.

From our experience in the United States, classes were usually silent during lecture. This has been true throughout high school as well as in college. In Albania, however, the classes are much different in environment, content, and style (Gjokutaj, M., Dr., 2013; Sahlberg, 2010). One theme that was maintained in our personal reflections throughout this project was the frustration concerning student attention and how there was always a handful of students who would revert to their phones or talk when we lectured. Across our 72 personal reflection entries, we explicitly noted lack of student engagement during lectures in 21 of them. After observing a lecture from Professor Hoxha where the students were, based on our experiences, loud and disrespectful, we began to realize that our frustration was attributed to a significant cultural difference in what is considered acceptable behavior in classrooms in Albania compared to our experiences in the United States. According to the testimonies of several students in the robotics club, students are often loud and disrespectful of the professors during class. In the words of one student:

> ***"If you don't want to listen you can't just go outside. You can just disturb the others, but everyone has to stay inside the class and so when they are not interested they start fooling around or chatting with the others that are not interested." -Club Student***

This helped us to realize that, compared to their behavior in their normal classes, the students were actually relatively attentive and respectful during our lectures, contrary to our original impression. There are several possibilities for what caused the discrepancy between our lectures and their normal classes. The first possibility is that the students had a greater level of respect for us as Americans, compared to their normal professors with whom they were more familiar and felt more comfortable being rowdy around. One student described this to us by theorizing that when students misbehaved during the lecture by Professor Hoxha, the students were thinking along the lines of: "Oh [the professor is] a cool guy he won't mind if we don't listen"

Although the students, as a whole, were indeed more attentive during our lectures than in their regular classes, there were still several students who would not pay attention during lecture. One factor that was pointed out to us by a student was that the language barrier likely played a large role. According to the student, the English language classes that are taught in school focus mainly on reading and writing, with less emphasis on speaking and listening. Due to this, students who were less fluent in English would tend to tune out and not pay attention to lecture. One group that lacked any fluent students, as we noted in our reflections, often paid the least attention during lectures, and eventually stopped showing up to class entirely. On two separate occasions, we met with Professor Hoxha to discuss repercussions and the possibility of withholding credit for completing the club for these students. Once Professor Hoxha addressed the issue by speaking to each team, students began to work together better and started showing up more often. For a while still, however, our reflections expressed significant frustration in this one team's apparent lack of effort in the club along with the absences of multiple other team members on a regular basis. However, once we realized that these students did not seem to be nearly as confident in their English-speaking abilities as other members of the club were, we under-

> *"I appreciate the ideas of the students, but… they tend to build things they already know how to build." -Professor Moisi Xhaferaj*

stood that we did not cater to them nearly enough. It is difficult to say for certain whether the two are connected, yet the most likely explanation for this teams lack of participation during club time is a feeling of intimidation of being faced with native English speakers, discomfort being approached, and self-consciousness when forced to explain themselves in an unfamiliar language. This team did almost all of their work outside of class time and had one of the first robots that could drive, but as they were never all together in the club, it was difficult for us to observe their teamwork. In order to remedy this discomfort that these students exhibited, it would have been beneficial had we enlisted the help Professors Moisi or Hoxha to repeat each of our lectures in Albanian.

Figure 24: Student playing a video game during a club meeting.

While the students openly admit to being rowdy during their regular classes, it is possible that they were especially so during the lecture by Professor Hoxha, as several students that day complained that the lecture was too long, taking up the entire two hour period, and had too much information such that they "could not absorb it all." As a result, many of the students simply shut down and stopped even pretending to pay attention to the lecture. Although none of our lectures ever lasted a comparable amount of time, we found that the students were significantly more attentive when the lectures were kept to between ten and twenty minutes in length. This lines up with numerous studies that state that student attention and retention of material decreases significantly after 15 minutes (Prince, 2004). We chose to limit the lecture length for several reasons: firstly, to avoid the information overload that the students complained of in Professor Hoxha's lecture, and secondly, to keep the club fun and different from their routine classes. By the time the students arrive at the club, they have spent all day sitting in lectures and no longer want to sit through any more. Oftentimes, when students were approached to discuss why they were not working, they would tell us that they were tired from their classes and did not want to work any more. It was important to us that the students not only learn as much as possible from the club but that they also enjoyed their experience. Therefore, we decided to keep the lectures as short and engaging as possible so that the students could get the information they needed and have more time to actually work on their robots.

In order to facilitate the students' understanding of the material presented, the lecture slides were routinely posted on the Google Drive, such that the students could review the material and have it translated into Albanian if needed. Several students cited the slideshow presentations that we prepared for each lecture as unique and useful elements to their learning. This came as a surprise to us as slide show presentations are standard practice in our American classes. One student stated:

"I think the slides play a big role. The moment you get visual information, it's much easier to memorize it. And also bringing examples. Our normal classes are more like authority. We write a lot we read a lot and it's always the same thing." -Club Student

"In general it's difficult to maintain the student attention when they work on projects because they only see the work side of it but not also fun of it." -Professor Klarens Hoxha

In addition to the lecture slides, the Google Drive also provided a space for the students to record their ideas and process over the course of the project. To our surprise, only two teams utilized their team folders on the drive. When asked why this was, several students expressed that they simply are not used to recording their thoughts, or using the Google suite in general. While in the United States, we, as students, tend to use Google Drive for the majority of our studies. In contrast, the robotics club students at the Harry Fultz Institute do not. While a handful of students expressed that they found being able to look at lectures on the drive as helpful for them, many did not see the point in recording their designs on it. In the words of one student:

"The fact that we meet every day during school and after school we don't fancy using the Google Drive. Physical contact with each other is much better."
-Club Student

Despite the fact that the Google Drive also contained the weekly lecture review surveys, it was difficult at first to get any responses. However, this lack of student initiative was supplemented by putting the survey on a computer in the classroom and asking students to fill it out during club time. In doing this, the responses increased significantly. Many teams chose to fill out the weekly surveys together and, as a result, the actual number of student participants increased from 4 individuals to every team having responded. One survey, however, never received any responses despite our best efforts. The suggestion box, where students could point out ways in which the class could be improved remained empty for the duration of the club. When asked why suggestions or feedback were never submitted, nearly all of the students stated that they simply did not have anything to suggest. One student stated that he did not know that the survey existed despite us bringing it up in several lectures. This particular student was absent for a large portion of lectures, which could explain why he did not know about it, yet perhaps a better attempt could have been made of advertising its existence.

"Above all we had fun and learned very much, that's very important at the end of the day."
-Club Student

4.3 Teamwork and Collaboration

The students' teamwork and collaboration were analyzed through the following surveys: Team Success Potential, Team Evaluation, Student Reflection, as well as through our personal reflections as mentors. As discussed in the process section, the Team Success Potential survey was filled out each day by mentors and was influenced by Adams' seven constructs for successful team behavior (Adams, Zafft, Molano, & Rao, 2008). We ranked a team with a low score in a construct if they did not fulfill its expectations and a high score if they did. A limitation with this method of scoring teams is that even though we predefined what each level of scoring meant, as mentors, we may have filled out the survey differently depending on what we experienced with that team or how we understood the ranking system. The teams did not know that these constructs that we were ranking them in existed until the fourth week. We met with each team and gave the teams overall scores for each construct, and we explained the observed progress in their teamwork and work ethic. In these meetings, we also showed the students a graph, as seen in figure 15 that illustrated their progress over time, and explained why certain days had lower scores than others. The lower dips were often due to a student not showing up, so a team would be clueless of what to do, only one person would actually be working, or they wouldn't be listening to each other. One student said, "I was very impressed with the graph [the WPI students] had made us and that helped us understand how important each every one of us in this group [is]." An example of the feedback provided to the students can be seen in "3.2.2: Student teamwork" section of the process chapter.

The student body president, a member of team Alpha, who has previously held a team leadership position on the a school newspaper said, "I love to cooperate and I adapt very much to my teammates, and I want to make them think the way I think. This is very important to me. I have studied for that, and I read a lot about that." These thoughts strongly identify with few of Adams' constructs, namely common purpose, psychological safety, mature communication, and productive conflict resolution. Furthering the support for these constructs, team Alpha was consistently ranked among the highest two teams in the Team Success Potential, as shown in figure 25. Their exemplary teamwork and work ethic was what allowed them to build the robot which ultimately won the competition. Using the constructs was a simple way to understand what teams seemed to be functioning better than others; however, the teams with the highest scores do not perfectly correlate to the teams which ended up in the final rounds of the competition.

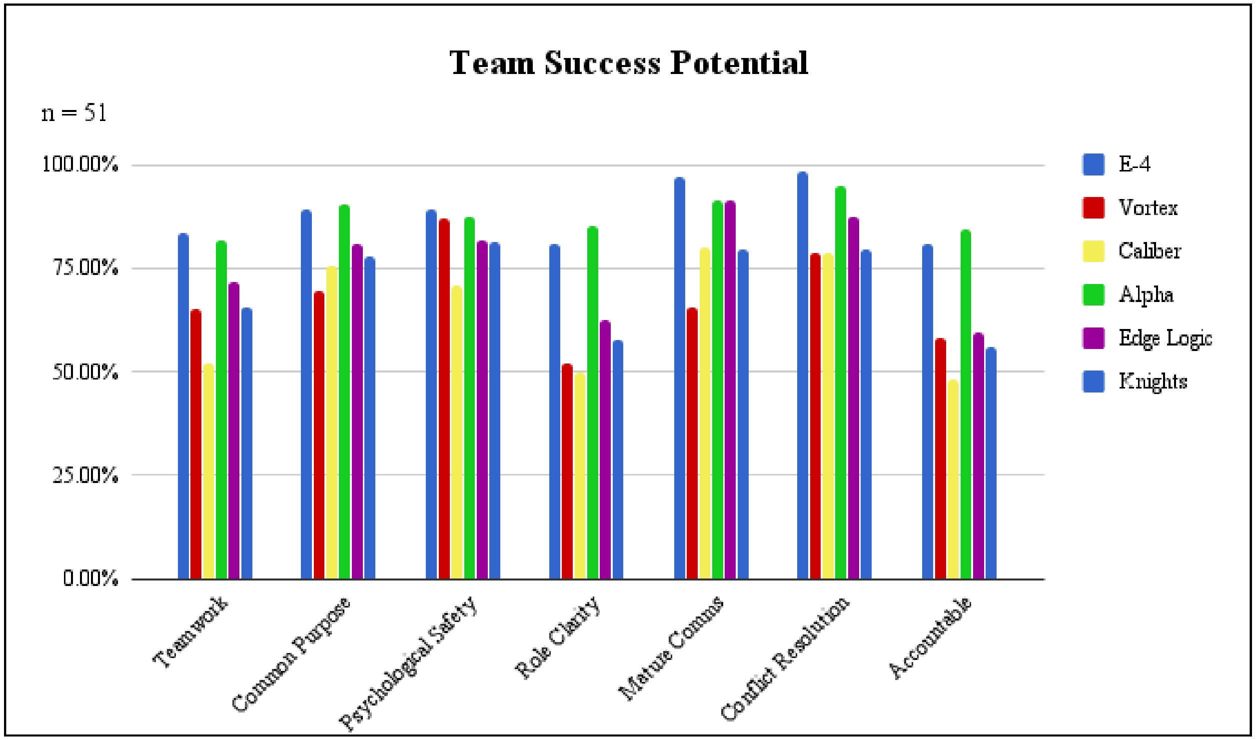


Figure 25: Averages of Each Team in Each Construct from the Team Success Potential Survey Completed Daily by WPI Mentors

"I think robotics is a necessity of nowadays for the students to understand the technology and to find answers for everything." -Professor Klarens Hoxha

Teams Alpha and E-4 had the highest scores throughout, and we had predicted in our reflections that one of them were going to win. From our study, its difficult to determine if a team that scores well in these constructs will be successful, as Edge Logic made it to the final round of the competition. It is likely this method of analysis did not predict which teams will be most successful in winning the game due to the unpredictability of robotics competitions. Examples of the technical difficulties that ensued during the competition include boost converters blowing, failed USB/Bluetooth connections, and accidentally cutting wires due to poor placement. This was even supported by the previous year's WPI team, who suggested that in robotics, the success of the final product is not a good indicator of the amount of work put in (Titus et al., 2016). Figure 25 does provide a good understanding of which teams had a better club experience, as Vortex usually consisted of two working members, and Caliber consisted of only one on a typical day. Through the feedback we gave to each team, our hope was to raise awareness of the students' teamwork skills in order to prepare them better for future teamwork experiences. Most of our data comes from the teams that were doing well, as they were the most open to spending time giving responses. The teams that were lacking members were usually the most busy, so they did not contribute a lot of time to answering surveys. This means that it was hard for us to gauge if the students benefited from reflecting upon their experience through speaking with us and through surveys, as not every student participated in every survey and those that did did not give particularly detailed answers.

According to figure 25, the constructs that the teams, as a whole, scored lowest in in were overall teamwork, role clarity, and accountable interdependence. All of which can be based off of each other. When students were not showing up to fulfill their role on the team, others had to sit around without accomplishing anything while trying to contact that teammate or step up and fill their role. Upon reflection, this is why we scored teams lower in those categories.

At the end of each day, we would each individually reflect on our experience in the classroom, addressing things that particularly stuck out to us about the student teams or how we felt about any situations that were worked through. The codes that were used to analyze our reflections are shown in table 4. These codes can be related to the constructs in the Team Success Potential Survey, especially to those that the teams scored lowest in: overall teamwork, role clarity, and accountable interdependence. As our reflections allowed us to record events while they were still fresh in our minds, we were able to keep track of the students teamwork over the course of the club. By coding these reflections for the quality of student teamwork, it was found that we observed good teamwork almost twice as much as bad teamwork, as this was what we saw a lot of and was most notable to us, but also what we expanded upon the most. We wrote about teams ignoring their problems just as much as teams fixing their problems, and more often noted when students were engaged compared to when they were not. We also took note of when we saw students working outside of their specialties and when we saw students slacking, which can be compared to the amount of times we addressed everything else.

FIgure 26: Team Alpha making an initial design plan for their chassis.

"You should work a lot, but not too much, so you have to work exactly how much time you have."
-Club Student

The Team Evaluation and Student Reflection surveys were filled out by the students towards the end of the project. According to the chart in figure 27, when reviewing their teammates, a very small number of students addressed issues with their teammates or gave suggestions for improvement. These issues included communication, role clarity, and engagement between teammates. A vast majority of the students gave positive feedback for every team member. Upon reading through the comments, while some students did take the opportunity to address their teammates' strengths and some of those comments may have been deserved, it's more likely due to how many students ranked their teammates high and submitted simple answers as to why they did so, such as "Because he's good." instead of taking the time to dig deeper. We believe the numbers of substantial criticisms are low not just because of time constraints, but because the students do not have experience reflecting on their experiences. According to Professor Moisi Xhaferaj, the students have never even kept lab notebooks in their classes. Also, the students are not normally exposed to many teamwork opportunities. One club member who is also the president of the physics club explained that the only teams he worked on before were through physics or robotics. Because of the lack of teamwork experience, we assume it was difficult for the students to both form expectations for how their team should operate and reflect upon what issues they were having as a team simultaneously. On top of this, even though the students were told they could fill out the surveys in Albanian, very few ever did. One student in particular, from team Caliber, always enlisted the help of a member of team Edge Logic to complete the surveys in English. These inferred reasons also explain the lack of constructive criticism or feedback that we received about our lectures or how the club was run.

Reflection Codes	Description
Good Teamwork	All team members are working equally and communicating in a civil manner
Bad Teamwork	One or more members of the team are not working, one member is dominating and not letting others work
Team Takes Mentor Advice	Problem is pointed out to the team, team reconsiders design
Team Does Not Take Mentor Advice	Problem is pointed out to the team, team proceeds with the design regardless
Students Slacking Off	Students refused to work, made excuses or were overall unproductive
Students Branching Out	Students tackled problems outside of their specializations (programming, mechanics, electronics)

Table 4: Codes Chosen from Analysis of Our Daily Reflections Explained

Students had the opportunity to submit any additional comments in the Team Evaluation Survey to discuss what they thought of their time, and most of the surveys lacked a response. Students would submit short, simple phrases such as, "My team will win." and, "We [are the] best." instead of truly reflecting or suggesting that there was room for improvement in the two weeks before the competition. A couple of thoughtful responses that still did not dig very deep included, "All in all, I'm lucky to be in a team that gets along as individuals and function smoothly to make the best robot we can." and, "At the end of the day we are proud for our group and the robot we are building, so for me this is the most important thing."

The Student Reflection Survey had eleven responses providing slightly more in depth than the Team Evaluation Survey. The graph in figure 28 shows how many students addressed teamwork and what their general feelings about their experiences were. As one student stated, "Our team had a pretty good work progress. [A WPI mentor] actually pointed out that we were a little separated in work groups but I think that's a good thing. I had really good communication with our programmer and that helped us a lot." A member of the same team explained, "Our group consist in four members, which we work in pairs by two, keeping two works at the same time. If one of two pairs finish the work, try to help the other pair to keep things in the way, and mostly to save more time." The majority of the time the responses were pretty general and did not involve significant reflection or analysis. An example of this is "The team wasn't so productive", coming from a student that built majority of the robot himself.

When asked what the students had learned so far at the halfway point through the brainstorm-

"Teamwork can be hard to achieve, but once you get to that point, everything gets easier and work flows seamlessly." -Club Student

ing activity, 65% addressed teamwork. This was a relatively knew experience for the students, so teamwork stuck out as something new that they had to learn. When asked what they had learned in the robotics club, the majority of students responded that they learned how to work in teams as can be seen in the word cloud in figure 29.

As stresses increased, and as the competition drew closer, more team members were found working outside of their specializations than in first weeks of the club. A student that started the club more interested in electronics said in the Student Reflection Survey:

"I learned how to use the Arduino and program it to do different tasks and by doing so I learned that I am capable of programming if I broaden my horizon on this field." -Club Student

This may be attributed to certain team members not contributing to the project and the increased working hours that were necessary to finish the robots on time. Due to their obligations of classes, jobs, and homework, some students spent more hours working than others on things that may have been accomplished by a teammate. A member of team Alpha addressed in the Student Reflection Survey, "We had one problem in our team last week about the absences of the group leader. We found a solution and it is not going to happen again. Hope to work harder and longer this week." However, some teams were not able to address and find solutions to the difficulties they were having. One student took on a lot of extra work, as a teammate of his became so frustrated with the programming, that he had to give up on it. This student expressed through an anonymous survey, "I had to do the rest by myself...if it wasn't for me the robot would not move at all."

Though it is likely that expanding beyond students' specializations was due to team issues, it

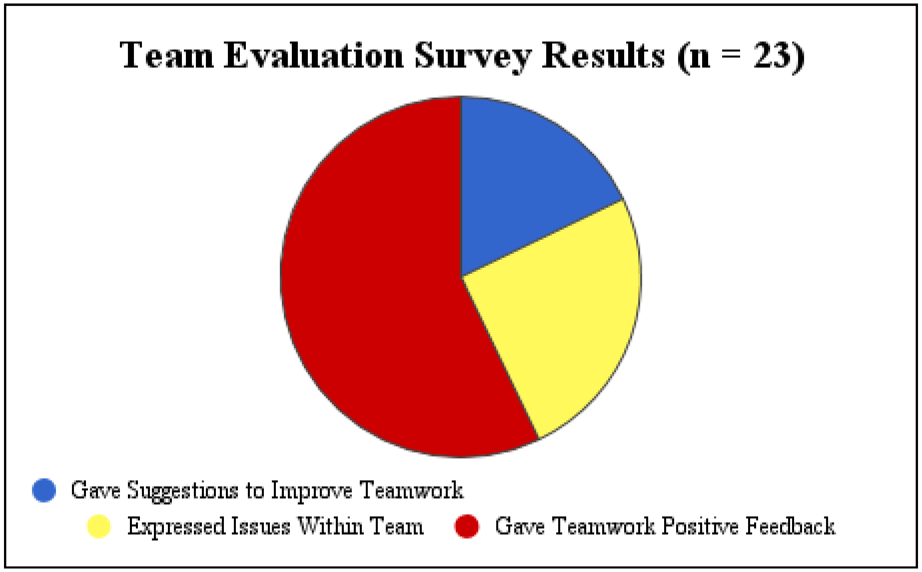


Figure 27: Team Evaluation Responses Addressing the Students' Teamwork

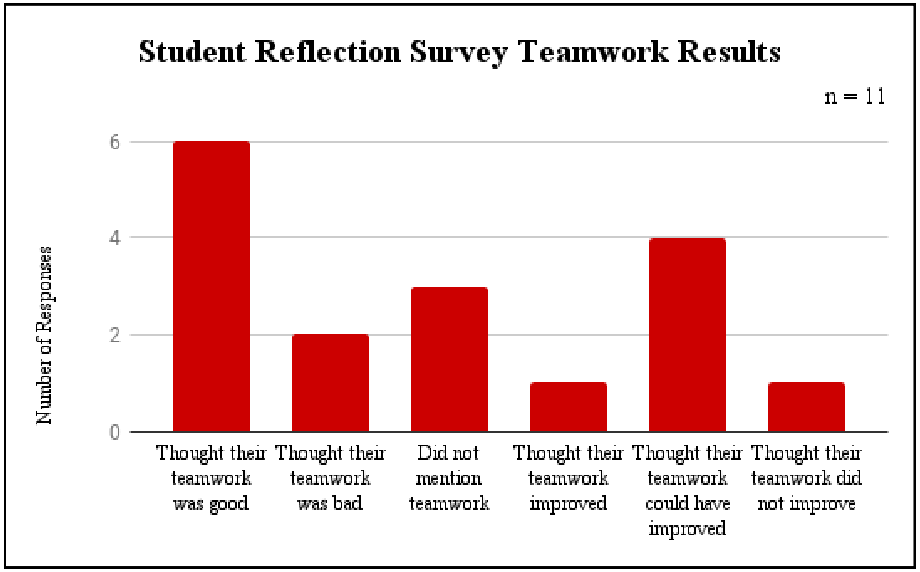


Figure 28: Student Reflection Survey Frequency Analysis of Codes Addressing Teamwork

""In the robotics club I learned that only one person can't do anything, but if we are in group, the project will be done in a short period of time and it will be successful." -Club Student

allowed students the opportunity to realize new interests or confirm original ones. When asked what he learned in his time at the club, a student said, “Me personally, I learned much more about programming. As a senior year for me, robotics also helped me decide better for my studies. I saw where I was better.” A quote from another student- “Maybe I will go for electronics and electrical engineering, then I’m going to go for mechatronics, or robotics. If I don’t fit that very well, I will try artificial intelligence“- confirmed what we were emphasizing to the students over the course of the project: as high school students, they may not know exactly what they want to do, what they perform well doing, or what they most enjoy. We wanted to give the students the opportunity through the competition to realize their interests through practice. A student said that the thing he liked most about the club was, “that we have the opportunity to just try everything out and just experiment with everything.” When a student was asked about his experiences with the club, he said, “I want to study, later, electronics or electrical engineering, so this is going to help me very much. Also, the teamwork, is very important, in all your life, and this is a good example of how you can do it.”

We arrived at the classroom two hours prior to the official start of the club each day in order to be more available to the students and provide assistance in overcoming challenges. Due to the smaller number of students that attended these early hours, we observed students discussing their ideas and asking each other for help, contributing to inter-team collaboration. Teams came to each others aid in the weeks before the concluding event of the project, where they would be competing against each other.

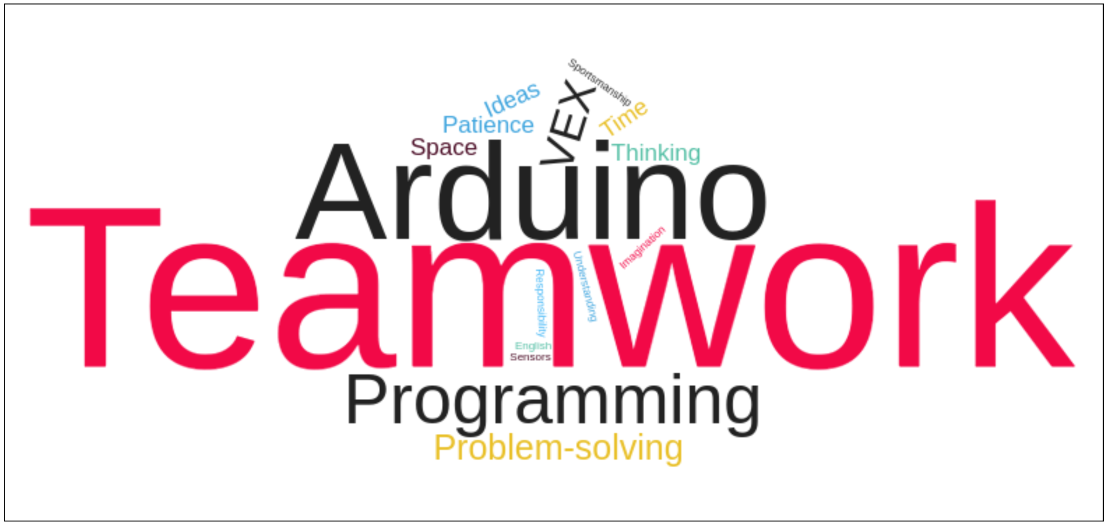


Figure 29: Word Cloud of Students; Brainstorming Responses

“I learnt a lot this year, starting from my teammates, I learnt how well we can co-operate if we put our thoughts together by sharing ideas, even with other groups, we got so well with each other, even with the other groups, which we were supposed to be opponents with each other, we were friendly instead, but not for long, when the competition is about to start, we will have to choose [to be opponents], in order that the competition would not be boring,” - a robotics student regarding completing their robot the day before the competition.

The quote is quite nuanced. The student notes that she can count on others beyond her teammates for help, but understands that while collaboration would lead to a more successful project, she would be competing against them in the end. Based on an analysis of our reflections, we found that the vast majority of times that teams collaborated with each other, it was to help each other and to share ideas. There was rarely any conflict between the teams despite the competitive atmosphere.

"Each of us has decided to make a design... to combine them together in order to have a final design that all of us can agree." -Club Student

4.4 Feasibility of Robotics Education Expansion

Robotics is a complex subject with many contributing factors, and expanding robotics education is equally complex. The point of the section is to map out the key components and relationships that support robotics education in the USA , and to compare the American example (figure 30) with the current state of robotics in Albania (figure 31). The following discussion, is based solely on our collective experience as American robotics students.

In figure 30, the three cycles shown need a catalyzing moment or action in order to set each cycle in motion. They can be initialized and self-sustained with just three things: interest, a mentor, and a competition. These cycles include club alumni returning as mentors, team-generated interest encouraging new members to join, and competitions fueling the formation and continuation of robotics teams. Take, for example, that through the introduction of WPI robotics mentors in 2014, and the additional introduction of a competition in 2016, the Harry Fultz Institute was able to create and sustain a robotics club of its own, albeit with the assistance of mentors from WPI. Through the informal outreach of the students and professors involved in the club, more students applied each year, ensuring the continuation of the club. Further, after the initial year, students returning to the club served as peer mentors to the more novice members. In our personal experience, these cycles, once initiated, continue to operate with minimal issues year after year.

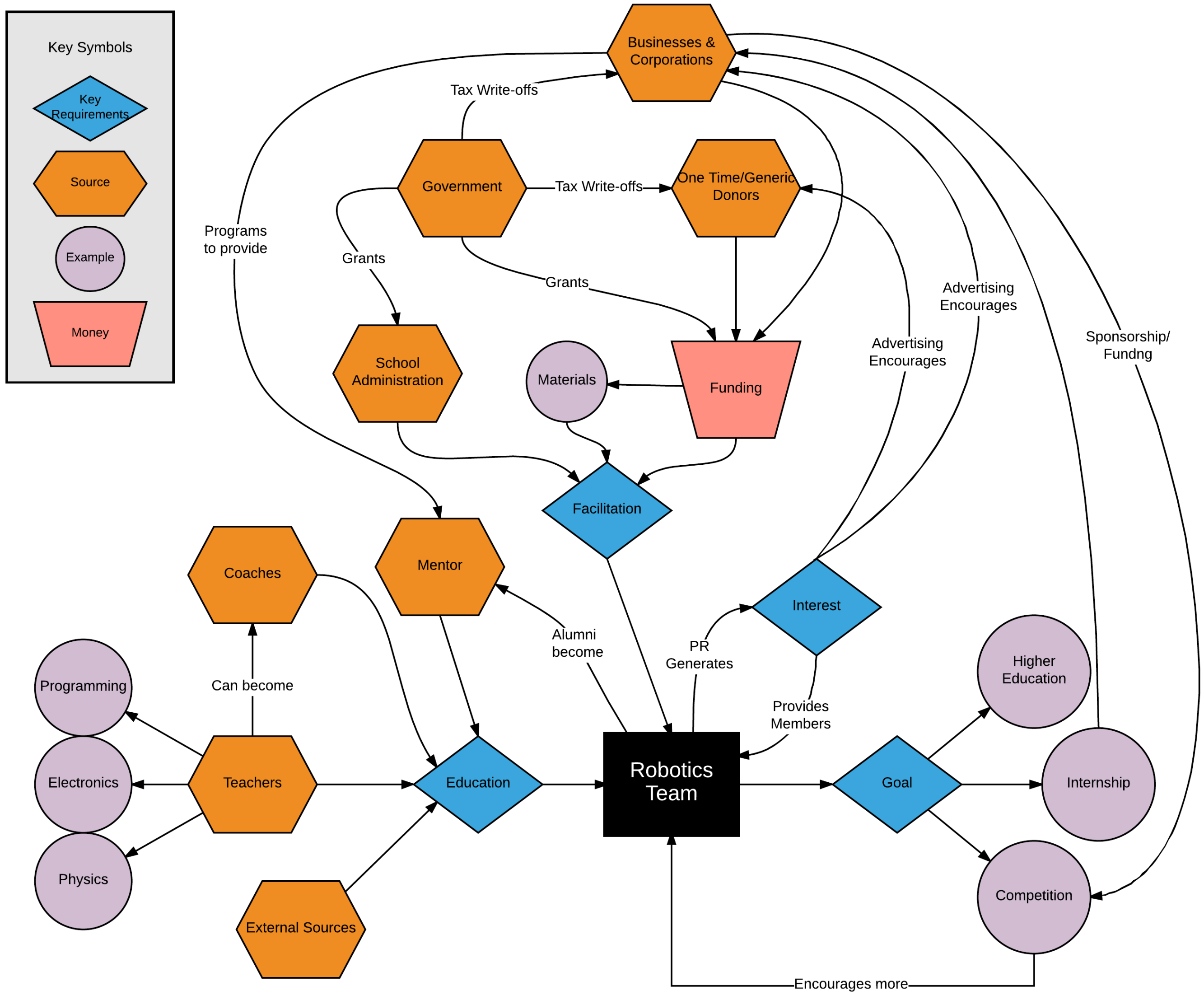


Figure 30: Map of Key Components and Relationships that Support Robotics Education in the USA

"[The club] was an immediate hit and it's been growing since then along with our school population." -Besnik Zylka

4.4.1 Robotics in America

In figure 30, we have identified the key elements and parties that contribute to the creation and sustainability of a robotics team and the education system that supports it. While this is not a comprehensive list by any means, these key elements fall into four main categories: interest, education, facilitation, and goals. Several parties, such as the government and local businesses, contribute to each key element. Each of these will be discussed in turn.

INTEREST

Robotics teams cannot exist without the following interested parties: students to participate, individuals to mentor, and companies to provide support. Interest in robotics is encouraged by school programs, clubs, and through competitions; it is generated through participation and conversation. Outreach spreads the general awareness of the robotics team to more parties, including organizations, donors, and other students- some of which end up joining as new team members. Through outreach, such as fundraisers and presentations, sponsors and general funding can be obtained for the team as well as other educational opportunities and resources.

EDUCATION

Robotics education in the US encourages teachers at the high school and college level who specialize in one aspect of robotics- physics, electrical engineering, or programming- to collaborate on a robotics curriculum. Oftentimes, teachers will decide to become coaches for robotics teams. Since they still do not know everything about robotics, they learn along with the students, and assist with administrative processes as well as providing knowledge and guidance to the team. Alongside these coaches, robotics mentors also sometimes play a role in a team's collective education. These mentors are typically either alumni from past iterations of the robotics team or are provided by an outside source, such as a sponsoring organization or company, and provide guidance through hands-on experience rather than just theoretical knowledge. In the instance that a gap in the knowledge base exists, an overabundance of external resources exist to supplement educators, mentors, and coaches of all levels.

FACILITATION

As mentioned, coaches also play an additional role in team management and facilitation. In the context of a robotics team, facilitation is the act of assisting the team in obtaining tangible assets, through funding or action from school administrations. One of the foremost assets for any team, the materials to construct the robot, is obtained through raising external funding from fundraisers or sponsors, such as technology-focused companies, or even grants from government or non-government organizations. Local technology-focused companies, such as the Bose Corporation near WPI, sponsor teams not only as a means of advertising, as their logo is shown during presentations and competitions, but also for tax purposes as the American federal tax code incentivizes such charitable actions. The government also sometimes provides grants to teams and schools looking to expand their robotics program. The school administration also, along with the team's coach or manager, assists the team by allocating appropriate time and space for them to meet and construct the robot. Additionally, the administration helps organize the necessary transportation to and from competitions, and other larger logistics.

GOAL

A productive robotics team works together towards a common goal, typically to be successful in competitions against other robotics teams. Additionally, in our collective experience, members have joined robotics teams in order to gain experience in engineering, gaining valuable problem solving skills which can, in turn, help students when applying to higher education, internships, or job opportunities.

" If they go to purely electronics, they have to understand one thing: we don't have factories here that produce electronics components" -Professor Moisi Xhaferaj

Robotics in Albania

When discussing the potential for robotics expansion in Albania, the same graphic seen in figure 30 was compared and edited against information gathered from the interviews we conducted with Professor Besnik Zylka of the Tirana International School, Professor Moisi Xhaferaj, Professor Klarens Hoxha of the Harry Fultz Institute, and Aida Hudhri an educational advisor at EducationUSA. As can be seen in figure 31, many of the links that support robotics teams in the United States are missing in Albania. Our research identified several key missing components that, in effect, facilitate supporting relationships for robotics teams in the US to flourish.

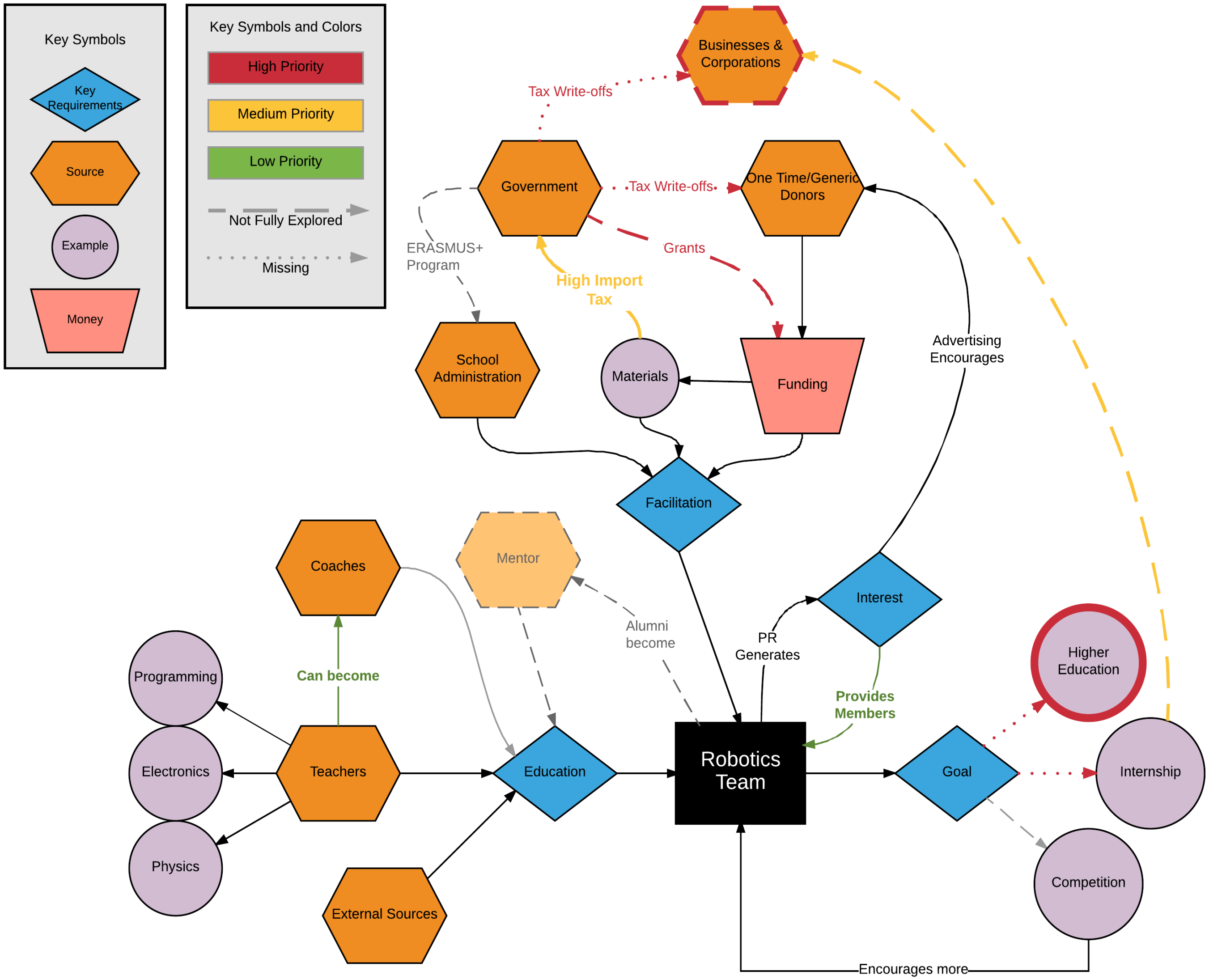


Figure 31: Map Highlighting the Key Components and Relationships Missing from Robotics Education in Albania

> *"Here in Albania, we tend to be really bureaucratic state in general...and we tend to stop ourselves, like the progress, we stop the technology progress with bureaucracy" -Professor Moisi Xhaferaj*

Facilitation and Funding

The primary barriers to robotics education in Albania are facilitation and funding. While school administrations have helped to set up select robotics programs- namely the Harry Fultz Institute's robotics club, FIRST Global team at the Tirana International School, and robotics classes at Preca College (Hudhri, A., 2017) -, funding for materials and other essential assets has been cited as a challenge (Zylka, B., 2017; Xhaferaj, M., 2017; Hoxha, K., 2017). This can be traced back to motivating factors and a perceived lack of technology-focused companies in the area. According to Professor Zylka, some funding can be obtained from school administrations, and some from local fundraising, but getting businesses to donate is challenging in its own right, as "Philanthropy, or giving money away, is not subsidized by the state. There's no tax write-off..." (2017). Without some incentive to do so, companies are less likely to provide money to purchase materials for robotics or to support teachers and coaches, which in effect cancels out the opportunity for schools to provide robotics opportunities to students, if another source of money, such as charitable donations, is unavailable.

Materials

Alongside the challenge of obtaining external funding from companies, one-time donors, and grants, teams are faced with the issue of obtaining parts. The Harry Fultz Institute club was not the only robotics organization to encounter this issue. When discussing the issue and high cost of receiving essential parts for his team, Professor Zylka said "You just have to deal with it and pay 20% over what it is at customs and you have to pay all of that nice shipping cost [too]" (2017). This tariff, which was confirmed by Professor Moisi, charges an extra 20% on whatever is passing through customs if the evaluated price is greater than a particular benchmark. This causes a great deal of strain on the coaches and other facilitators to get parts to their teams, considering more money must be spent on fewer materials. Should the tariff be reduced or removed entirely, it would allow more teams to acquire the parts necessary to maintain a functioning robot. Furthermore, if parts for robotics were manufactured in Albania, the cost would be cheaper and there would be, arguably, less delays. The shortage of factories that produce electronic components in Albania was cited as not only a leading reason to order the parts from abroad but also a discouraging factor for students to pursue STEM education in the first place (Xhaferaj, M., 2017).

Interest

Regardless of the constraints on robotics education in Albania, students have shown a keen interest in robotics both at the Harry Fultz Institute and elsewhere in Tirana. This interest has been observed at outreach events and competitions that took place throughout the time of this project. While the students involved may not have the ability to push for institutional change themselves, the pressure they can exert on their school administrations or on their parents help form new robotics programs. Student interest continues to be generated by outreach, both formally with the use of such presentations and competitions or informally via student interactions, but without an outlet such as a class or a team to participate in, this interest and student potential will go untapped.

Outlets

Earlier, it was discussed that students join teams in the United States in the hopes of being more easily admitted to an institution of higher education, internship, or simply to participate in the competition the team is geared for. While a couple of robotics competitions have been observed within Albania, the shortage of higher education opportunities presents an issue to students seeking such higher degrees. As stated in the background chapter, an estimated 80% of students who seek higher education with the help of EducationUSA choose to pursue applied sciences, such as computer science or electrical engineering (Hudhri, A., personal communication, December 4, 2017), outside of Albania, pointing to what many see as a shortage of opportunities within the country. This was also seen with several of the Harry Fultz robotics club, who discussed the institutions they were interested in based in Germany, the United Kingdom, or France. With students leaving the country to pursue higher education elsewhere, the population available to be mentors in STEM environments stays small, reducing the likelihood of robotics teams forming.

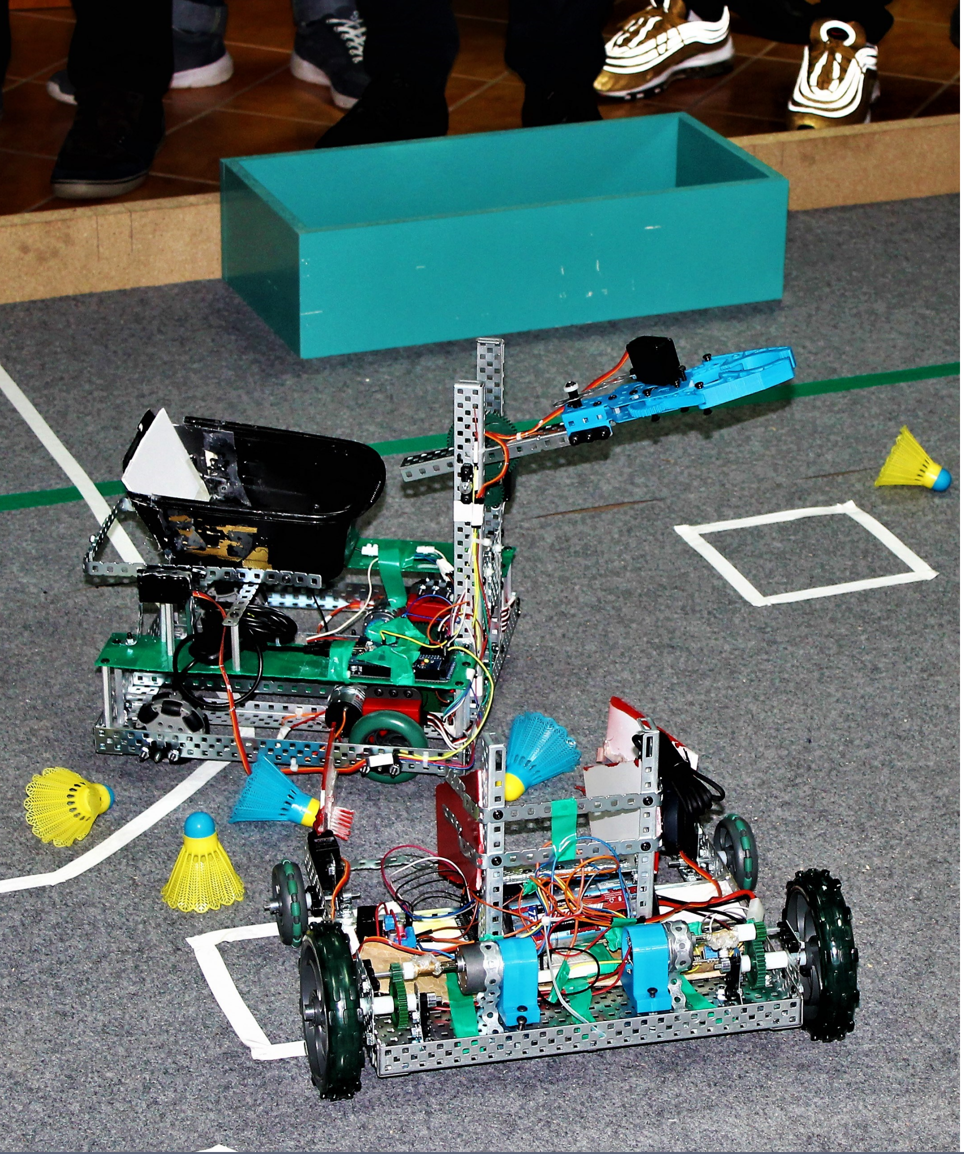
In addition to limited higher education opportunities for robotics within Albania, few internship opportunities are available for students interested in STEM. Both Professors Moisi and Hoxha stated that, at the time of this project, students at the Harry Fultz Institute did not have opportunities similar in fashion to internships offered in the United States, but did praise the concept, saying "...it would be really good to have one in place, you go there and you measure yourself up to the [other employees] there" (M. Xhaferaj, personal communication, November 16, 2017). The perceived lack of companies offering partnerships with the Harry

Fultz Institute, despite being a well established high school in the region, is not indicative of the regional trend; however, it does go to show that students of well established institutions preparing to enter the workforce are lacking in work experience opportunities outside of the classroom. Without established competitions, higher education opportunities, or potential internships, student motivation may wane along with the energy and commitment to robotics clubs. Bazylev et al. (2014) discovered that, for students to value their experiences and learn the most, they must be motivated by some ulterior motivating factor, such as a competition. In order to initiate and maintain student involvement in a robotics program, such a motivating factor needs to be in place.

As discussed, robotics education is a complex topic, and the many sources and elements essential for robotics teams are vastly interconnected. Student opportunity, being a multi-pronged issue with a perceived shortage of solutions, is not the sole detriment to current formation of robotics programs in Albania, considering that government participation, or the lack thereof, also causes ripples throughout the web of organizations described in figure 31. Despite this, some advances are being made on this front, as seen in Professor Zylka's plan to establish his own non-governmental organization solely for the widespread implementation of robotics.

Figure 32: First Lego League Competition hosted at the Tirana International School

"When it comes down to funding, they need to be the right person or know the right person. Funding is impossible." -Professor Besnik Zylka



5.0 Conclusions

"To send a ripple through the generations, you have to make them work a lot of time on it. It's not just the club. This is like a small ripple. You have to send a big ripple to have the energy to go somewhere." -Professor Moisi Xhaferaj

5.0: Conclusions

The overarching goal for this project was to help the robotics club students at the Harry Fultz Institute to learn about robotics and apply that knowledge to build robots that would compete in a final game. The term "success" when referring to this project means understanding how we could best assist the students in developing a passion for robotics and gaining essential experience in teamwork in a fun and enjoyable environment with cross-cultural mentors. Over the course of this project, we came to realize that it took time for the students to develop the teamwork skills necessary to function together effectively; for many of them, if not all, this was their first experience working in teams. We also observed that, despite being averse to it in the beginning of the six weeks, the student teams were willing to collaborate to solve common problems. Outside of the club, we assessed the feasibility of expanding robotics. In doing this, we observed that several key elements that allow for the success of established programs in the United States were missing in Albania.

Figure 33: Students from Worcester Polytechnic Institute and the Harry Fultz Institute at our final competition.

5.1: Limitations and Recommendations

While the majority of feedback we received was positive, not every student expressed their views. This may be attributed to the fact that the students knew we would be reading the results of the surveys, even though there was an option for them to remain anonymous. In talking with the students and professors, the students are not usually asked to give feedback on their classroom experiences, however, so it is likely that they did not know what constructive feedback to give. Our surveys were certainly flawed, as they failed to trigger more reflective responses. We found it difficult to phrase questions in a way that they guided the students but were not leading them. Limited time to explore the students' feelings about the opportunity or environment of the robotics club frustrated us throughout the course of the club. Because the students had less than six weeks to design and finish their robots, much more time was spent focusing on the physical products instead of the effects on the students' thoughts about the development of their skills or desires to continue their development. Many technical problems arose during our time with the students, and it was often difficult to interject during the times the club met in order to further explore this topic. Many times we would walk into the classroom and immediately be greeted by frustrated students clamoring for help on a particular problem. Further, we wanted to maintain a more

"When you get out of technical school, like here, professional development is something you have and you can produce actual things." -Professor Moisi Xhaferaj

professional mentor-mentee relationship with the students. Therefore, we did not meet with the students outside of the classroom. This would have allowed us more time to explore the students' thoughts, expectations, and experience, but our concerns caused our direct interactions with the students to be limited to the hours the club would meet every day. Admittedly, our own limitations are what truly kept us from meeting with the students outside the club, as the thought of maintaining two separate relationships: one that was professional and one that was friendly, made us nervous. We did not know how it would affect our classroom dynamic, and we did not want to risk it.

Were the students given access to the project, game rules, and materials that would be available one month prior to the start date, they would have had more time to experience the engineering design process. This allotted month would have allowed design-, programming-, and electronic-inclined teammates time to thoroughly discuss a general plan for the competition and use computer aided design programs, such as Autodesk Inventor, to generate a more complete design, before ever touching materials. As the students had prior experience with AutoCAD through the Harry Fultz Institute, it would not be difficult for the students to experiment and become familiar with Autodesk Inventor, considering they are similar software developed by the same company. Further, the professors at the Harry Fultz Institute have the knowledge base and skills that would make it possible to guide the students through the early stages of the design process and motivate them with the prospect of receiving their parts. With more time to pursue the engineering design process, students could be prevented from jumping straight into the project with the first idea they came up with and relying primarily on trial and error to achieve at their final design, while maximizing the use of their materials and time along the way. By devoting much of the club time in the beginning weeks to design, many teams were scrambling to finish tasks such as programming by the end; and few teams were able to tackle the problem of building an autonomous program at all.

Despite the building time lost to design, construction speed for each robot was greatly improved through the parts that we supplied. Accumulating donations and buying VEX mechanical sets prior to arriving in Albania certainly reduced the stress on us- as components did not need to be manufactured- as well as the students. While we brought parts with us from the USA, the parts the school ordered from, such as DC motors, were delayed several weeks. The delay of the DC motors presented the greatest obstacle,

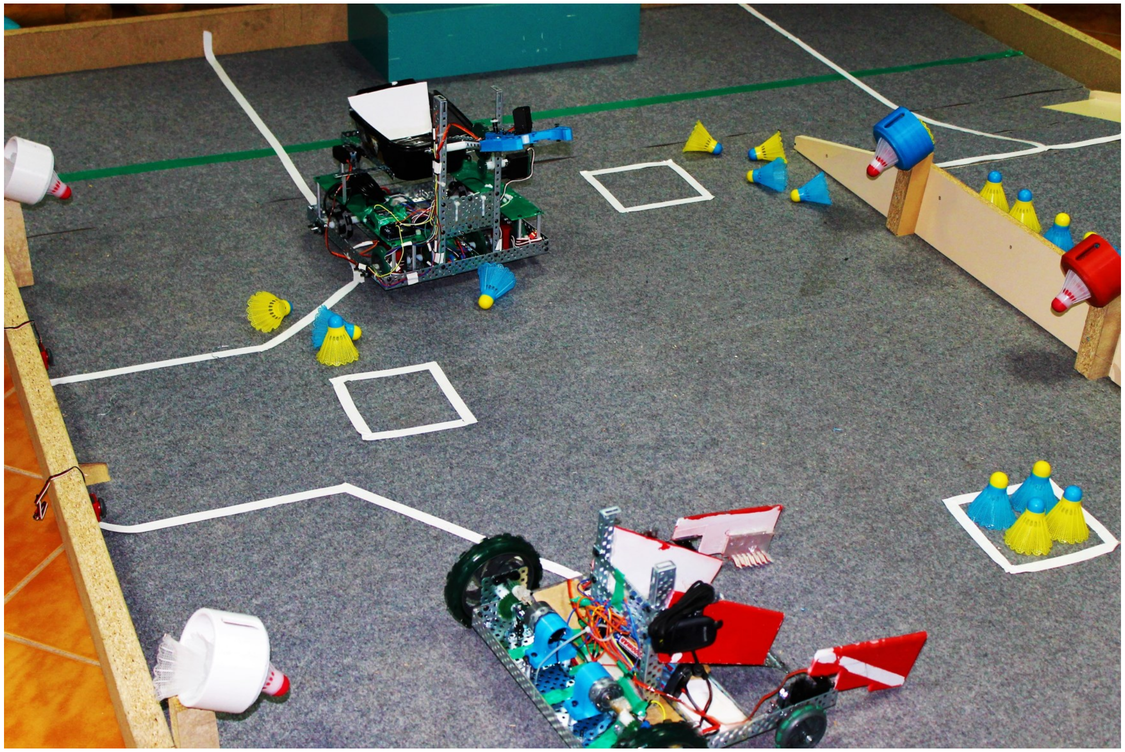


Figure 34: Robots from team E-4 (top) and team Vortex (bottom) competing for birdies on the field.

"There's not only the skill part, there's also the dedication part." -Professor Moisi Xhaferaj

as many students used their absence as an excuse not to work. It was difficult for us to make it clear to the students that it was possible to focus on different aspects of their robots or at least possible to better prepare their robots for when the motors did arrive. When the motors finally came in, these teams felt rushed and frustrated, needed to deconstruct and reconstruct their chassis, and failed to test their robots until the last few days before the competition. We shared this feeling of frustration with the students, as they felt they could not continue, and we felt we could not make them understand how to keep working. We wanted to see the students making progress; however, we had to accept that at certain points for certain teams, there was nothing that we could do about the situation apart from distribute what motors we did have for the teams to test programs with. Though the competition was a success, this demonstrates that in a project with a restricted time table, such as this six week club, it is critical that the appropriate components are gathered ahead of time to reduce as much stress as possible on both the students and mentors.

The information presented herein concerning the expansion of robotics education was significantly curtailed by the availability of sources. Interviews with several key informants- such as representatives from Protik, the Ministry of Education, and assorted public and private schools throughout Albania- failed to take place, despite our efforts. Various methods of contacting these representatives were implemented, however, replies were never received. Therefore, the information presented is largely dependent on a smaller sample of interviews and our own personal experiences. With the information we were able to obtain, we would like to recommend two courses of action in respect to Albanian robotics education in regards to the Harry Fultz Institute and throughout Albania.

We recommend that the Harry Fultz Institute look into establishing a VEX robotics competition team in the near future. When compared to other established international competitions, VEX is inexpensive to participate in and has teams from numerous countries around the world. Should the Harry Fultz Institute be home to the only VEX team in all of Albania, they would immediately qualify to participate in the annual international competition. With the metal kits and parts provided to the robotics club this year, the Harry Fultz Institute is well situated to begin the transition into starting a team and participating in VEX competitions. VEX robotics also supplies its own curriculum and lessons that have been used in classrooms around the world, a helpful resource in the instance the leaders of the club feel they do not possess adequate knowledge for a particular topic. In general, access to robotics parts and funding is necessary for the success of robotics education. In order to set something in motion, we recommend reaching out to organizations outside of Albania, such as the U.S. Agency for International Development (USAID), the Peace Corps, or a similar European non-profit to sponsor events that may raise awareness and funding.

5.2: Ethics

The primary ethical concerns for this project involve providing an opportunity for students to engage in STEM in a country where such opportunities for students that want to pursue it are lacking beyond high school. Instilling a passion for robotics was our hope, but we do not want our work to lead to a feeling of frustration among the Harry Fultz Institute students by emphasizing a lack of local opportunity for them, and a world of opportunity for us. Additionally, throughout our time here, we have taken note of who robotics education is accessible to, and for the most part, it seems that students at private schools receiving specialized educations, such as at the Harry Fultz Institute or Tirana International School, have the most opportunity. Though we were unable to contact the Ministry of Education or any public schools in our time here, to our understanding, public school students do not have any robotics opportunities. The ethical issue being, robotics education should not only be offered to those with money. For these reasons, we hope our interviews created the beginnings of a conversation among students, schools, and organizations that will stimulate the growth of robotics education within Albania

5.3: Reflection

Overall, this project has been a great experience for all of us. We learned how to solve problems under various pressures such as when parts are delayed due to circumstances out of our control or when students weren't paying attention. When issues with the students arose, we did our best to understand their perspective and tune our teaching and mentoring styles to better maintain student attention and interest. Each of us became more confident in our abilities as teachers and mentors as we worked to adapt to the students' needs through increased communication and knowledge of the material, as well as pushing the boundaries of our personal comfort zones. Each of us had our own shortcomings as well as strong-suits with regards to different aspects of this project. We had varying levels of robotics knowledge, public speaking skills, and leadership abilities. Our shortcomings in any of these skills contributed to an overall sense of frustration early on in this project, as we worked to improved ourselves in the areas we were the weakest.

In addition to this, it was inspiring to watch the students grow and begin to develop the essentials skills to become capable engineers over the course of the six weeks of this project. They repeatedly came up with innovative new ideas and began implementing them with less and less requests for help. Each team individually came up with unique designs for their robots, reinforcing the fact that there is more than one way to approach a problem. Over the course of our time with the students, it was interesting to see how their attitudes became friendlier and more open towards us over time. In the beginning of our presence at the club, we were repeatedly referenced as "the foreigners" in student survey responses. One student, in the first weeks of the club stated: "Each of the foreigners was very cheerful and happy to take on any question we would throw at them." This seemed to be the overarching first impression of us as mentors to the club. The students became more familiar with us over time which allowed us to develop positive mentor-mentee relationships. Being able to joke with the students and be a part of their robotics experience helped each of us grow as we became more confident, yet humbled, mentors and individuals. Throughout this project, we not only learned how to communicate across cultural boundaries, but also how to communicate with people of different backgrounds and personalities in general. We feel that this has been the most valuable team experience thus far in our time at WPI, as the lessons learned about how our team and others' function when dealing with stress, frustration and when in close contact for extended periods of time will provide valuable experience when managing future teamwork-based projects. We also believe this is an important skill that we will carry with us as students, employees, and into any other roles life may put us in.

Our priority was supporting our students throughout this process and evaluating what we could do that was most beneficial for them, which led to sacrificing some of the hands-on activities and self-directed learning opportunities that were originally planned. Through the experience we were able to provide and the environment we were able to create, the students saw the value in teamwork, in keeping an open mind, and in expanding their interests. In this, we pride ourselves.

Figure 35: Very pleased WPI Mentors, (left to right) Benjamin Wagner, Jennifer Whelehan, Marek Travnikar, and Rebecca Miles on the day of the competition.

"This experience has really helped me to become more confident both in myself as well as my ability as an engineer." -Rebecca Miles

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Appendix A: Informed Consent Agreement

Informed Consent Agreement
Harry Fultz Institute Robotics Program WPI IQP
Created by: *Nathan Beeten, Jacob St. Germain, Josie Leingang, Ben Titus*
Edited by: *Rebecca Miles, Marek Travnikar, Ben Wagner, Jenn Whelehan*

Purpose: The goal of the WPI Robotics student project is to create an effective robotics competition at the Harry Fultz Institute by teaching robotics topics to students, providing and creating a support system for the competition, and introducing cooperation and an element of competition into a learning environment.

Harry Fultz Institute student involvement: As a part of the WPI student project, the team will be analyzing the effects of competition on teamwork and student learning, through inviting the Harry Fultz Institute students to voluntarily participate in surveys, interviews and WPI students' observations. The WPI students will only use the data collected for academic purposes and will not share information gathered with any sources outside of the Harry Fultz Institute and WPI.

Confidentiality: Students' names will not be used when reporting information gathered from surveys, interviews or observations. All data will remain anonymous unless consent is given by the student.

Photography: The WPI Robotics project team may use photographs of the Harry Fultz Institute students and their work to be included in a final report. These photos will not be distributed outside of the report unless given consent by the students involved.

Voluntary participation: Your participation in this project is completely voluntary. There is no penalty if you decide not to participate.

If you have any questions you may contact the WPI student group (a17robotics@wpi.edu) or the WPI academic advisors Robert Hersh (hersh@wpi.edu) and Leslie Dodson (lldodson@wpi.edu).

Agreement: I agree to participate in the WPI Robotics project as described above.

Your Name [printed]: ____
Your Signature: ____
Date:
____

Appendix B: Interview Protocol and Questions

Informal Course Reflection Interview

Questions

- What has been your most significant/memorable/enjoyable classroom experience?
    - If answer pertains to club, what about prior to joining the robotics club?
- Were the game rules confusing at all? How?
- How is your team looking to approach the task at hand?
- How do you find the lectures for the club?
- How was the lecture/club today?
- What do you think we could do better?
- What kind of difficulty have you faced and how are you overcoming it?
- What role does each person have on your team?
    - Do you like how your team is structured?

Semi-Structured Interviews with Outside Organizations:

Script

We are a group of students from Worcester Polytechnic Institute in Massachusetts, USA. We are working with the robotics club at the Harry Fultz Institute on a competition. We are interested in learning more about how to include other schools in the city or region in a robotics competition and would like to learn your views. Your participation in this interview is completely voluntary and you may withdraw at any time. This interview will take approximately 30-40 minutes. Please remember that your answers will remain confidential. No names or identifying information will appear in any of the project reports or publications unless consent is given. Your participation is greatly appreciated. If interested, a copy of our results can be provided at the conclusion of the study.

We can be reached via email at a17robotics@wpi.edu.

Protocol

- Coordinate time and location for the interview such that they are convenient for the Outside Organization. Should an in person interview not be possible, a video-meeting could be conducted instead, though this is not recommended.
- If applicable, submit predefined list of questions and or topics to the interviewee such that they have ample time to consider responses. The questions should likely be reviewed by the project advisor(s) prior to submission.
- After introductions and making the interviewee aware of the information presented in our script, reconfirm permission to audibly record the interview, and give brief summary of what the interview is designed to achieve.
- The interviewers should consist of two to four project members, business casually dressed, who remain professional at all times. Interviewers can share the responsibility to ask questions if necessary, though it's not required.
- During the interview, interviewers should note interesting points or other notable facts and the time of the interview. These points should later be reviewed and transcribed from the recording if deemed significant.
- Interviewers should promote the responses of the interviewee by remaining attentive and with periodic affirmations of understanding, but

should also avoid changing the contented of the conversation extensively by seeming overly interested or excited about a topic. The interviewers should attempt to keep a calm but positive persona, regardless of topic.

- After completion of the predefined topics, the interviewers should bring up a limited number (0-2) of additional topics if deemed pertinent to the conversation. The interviewers should also prompt the interviewee for any other topics they would like to share.
- The interviewers should then thank the interviewee and conclude the meeting. Later, the Interviewers should follow up with an email, if possible, thanking the interviewee for their time and responses.
- The interviewers should transcribe written notes to the Drive, and link to uploaded recording.

Questions

General

- What is your current background with robotics or any STEM related field?
    - I.e. describe your job
    - What have been some challenges implementing robotics in your school, business, etc.?
    - How big of an investment is robotics and has it paid off?
    - Where does the funding come from?
    - Are there rules, laws, or standards regarding intellectual property rights/patents?
- Where do you see the robotics industry in Albania in 5, 10, 15 years?
    - What do you think could get it there?
    - What is the industry like currently?
    - What factors do you think hold back the industry?
- Have you been in contact with anyone or any other organization that is invested in robotics?

Professor Besnik Zylka

- Have you had any progress generating funding or interest in robotics programs?
- What outcomes to you expect from your efforts?
    - What made you decide to move from increasing the International School's involvement in robotics to all of Albania?
- How have you approached organizations to start this conversation?
- Have you had interactions with Protik?
    - Do you know of other organizations that are similar to Protik?
- What other organizations do you have contact with?
    - How do their interests differ?

International School

- What has motivated your school's interest in robotics?
- How did the students' interest in robotics develop?
- How is robotics education structured?
- Are there multiple people at the school who could potentially lead the robotics program?
    - If not, how might the program continue to function if the current leader left?
- What are your hopes for the future of the robotics team?
- What are your views on interscholastic collaboration and competition?

- What is the status of the FIRST Robotics team?
    - What issues have you faced in fielding a successful team?
- What resources are at your disposal for robotics education?
- Do the students use kits?
    - How do you think this affects their learning?

Education USA

- What is your current position with EducationUSA?
- How did you become involved with EducationUSA?
- How has your experience made you feel about the Albanian education system and opportunities for students?
- Where do you see the robotics education in Albania in 5, 10, 15 years?
    - What do you think could get it there?
    - What is education like currently?
    - What factors do you think hold back this advancement?
    - Is there interest within companies, organizations, or the government in the expansion of robotics, to keep up with student interest?
- What percentage of students that you interact with are interested in stem fields?
    - What about robotics specifically?
- What is the percentage of students that go to Polytechnic Universities?
- Limitations of Albanian education system in regards to robotics (or STEM if robotics is too specific)?
    - Is there a lack of interest in the students?
    - Lack of higher level of knowledge of the subject?
    - Both?
- Have you found a difference in the education received by public and private schools?
- Do you know how classes are typically run or structured in Albania?
- Do you know someone within a public high school that you'd be able to connect us with?
- Do you think they are interested in the possibility of expanding robotics education?
- Who else do you think would be familiar with these topics?

Semi-Structured Interviews with Professors and Previous WPI Students on this Project:

Protocol

- Coordinate time and location for the interview such that they are convenient for the interviewee. Should an in person interview not be possible, a video-meeting or interview via email could be conducted instead, though this is not recommended.
- If applicable, submit a predefined list of questions and or topics to the interviewee such that they have ample time to consider responses. The questions should likely be reviewed by the project advisor(s) prior to submission.
- After introductions and making the interviewee aware of the information presented in our script, reconfirm permission to audibly record the interview, and give brief summary of what the interview is designed to achieve.
- The interviewers should consist of two to four project members, business casually dressed, who remain professional at all times. Interviewers can share the responsibility to ask questions if necessary, though it's not required.
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- After completion of the predefined topics, the interviewers should bring up a limited number (0-2) of additional topics if deemed pertinent to the conversation. The interviewers should also prompt the interviewee for any other topics they would like to share.
- The interviewers should then thank the interviewee and conclude the meeting. Later, the interviewers should follow up with an email, if possible, thanking the interviewee for their time and responses.
- The interviewers should transcribe written notes to the Drive, and link to uploaded recording.

Questions

Harry Fultz Institute Professors Moisi Xhaferaj and Klarensi Hoxha

- What brings students interested in robotics (or STEM) to Harry Fultz?
- What attracts students to Harry Fultz over a public school?
- Is the tuition cost a factor?
- What does the Harry Fultz Institute look for in potential students?
- Do students tend to go right into the workforce or to university?
- How well do you think the Harry Fultz Institute prepares students to go directly into the workforce?
    - What resources are available to the students to facilitate this?
    - Some high schools in the United States offer internships where students can get experience working with a real company. What might be similar to this opportunity at Harry Fultz?
- How are students selected to join the club?
- What do you picture as a successful year of robotics club? Number of robots? Quality of learning? Seeing teamwork? Etc.?
- How do you think robotics could be expanded in Albania?
    - How and where would that occur in schools and industry?
    - How do you think robotics may have a place in education in high schools?
- We've noticed that at points in both our, and Professor Hoxha's lectures it can be difficult to gather and maintain student attention and silence. Is this specific to the robotics club and/or our presence or is it prevalent throughout Albanian education? Why?
- What do you think the biggest difference is between education at Harry Fultz today and when you were in high school?

Previous WPI Students on this Project

- Were there any problem students? How did you deal with them?
- What was most frustrating about your experiences with the students?
- About how many of your twenty four students seemed passionate about the whole of robotics as opposed to one aspect of it (electronics/design/programming)?
- If you could change something that would have been in your control (not Albania's delivery system), what would that be?
- How did you get students to participate in surveys?
- How did Enxhi participate in the classroom?
    - Did he help the students during build time?
    - Did he tell the students when to be quiet for the lecture?
    - Did he coordinate the lecture schedule or deadlines?
    - Did he debug component problems?
    - Did he buy parts as you/the students needed them?
    - Did he gather student attention during lectures?
- When you lectured, did you have issues gathering the students attention? If so, how did you motivate them to listen/gather their attention.

Appendix C: Brainstorming Procedure and Questions

Protocol:

- The exercise should be completed in a distraction-free environment as possible. It should be conducted by one group member, though others may be in attendance.
- Each participants of the sample group should be provided paper and a writing utensil.
- The format of the exercise should be explained clearly, though the overall purpose of collecting the data (i.e. what it will be analyzed for) should not be revealed. Should a participant be concerned, they should be informed that responses are optional yet encouraged, and they should not feel pressured.
- The conducting member should ensure that participants are informed that there are no correct answers, and that they should simply write what comes to mind, without much additional thought.
- The conducting member should ensure that the participants know that the responses are anonymous, and that their name should not be written on it.
- The conducting member should read a question aloud to the students. During this the conducting member should attempt to not speak or risk influencing the answers.
- At the end of the question period, the papers should be collected and the participants should be thanked.

Questions

- What have you learned in robotics club so far?
- What is necessary for a winning robotics team?
- What things can robots be used for in Albania?
- What do you like/dislike about the Robotics Club?
- Where do you think you could use a robot in your everyday life?
- Where have you seen robots before?
- What goes into building robot?
- What kind of robots would be around in 20 years?

Example Team Evaluation Survey with front page, fun questions, and team evaluation questions

Team Evaluation

You've been working in teams for a little while now. In order for us to best help each group, we would like to know what goes on behind the scenes, and get a peek into how each group operates

* Required

Name: *

Your answer

What team are you on? *

- ○ E-4
- ○ VorTex
- ○ Caliber
- ○ Alpha
- ○ Knights
- ○ Edge Logics

Alpha Team Evaluation

Please take this time to seriously consider the efforts of all of your group members. Feel free to talk about any of their accomplishments, failures, or discussions you may have had. If it is easier to write in Albanian, please do so.

What are you more interested in

- ☐ Building the physical robot
- ☐ The electronics that go into it
- ☐ Programming the robot
- ☐ Designing the robot
- ☐ Other: ______

Who would each team member be if you were the Justice League? *

	Superman	Batman	Wonder Woman	Cyborg	The Flash	Aquaman
Rei Arifaj	○	○	○	○	○	○
Marti Lama	○	○	○	○	○	○
Endri Seferi	○	○	○	○	○	○
Aldi Shehu	○	○	○	○	○	○

Appendix D: Surveys and Evaluations

Please rate Rei's work *

Choose

Why? *

Your answer

Please rate Marti's work *

Choose

Why? *

Your answer

Please rate Endri's work *

Choose

Why? *

Your answer

Please rate Aldi's work *

Choose

Why? *

Your answer

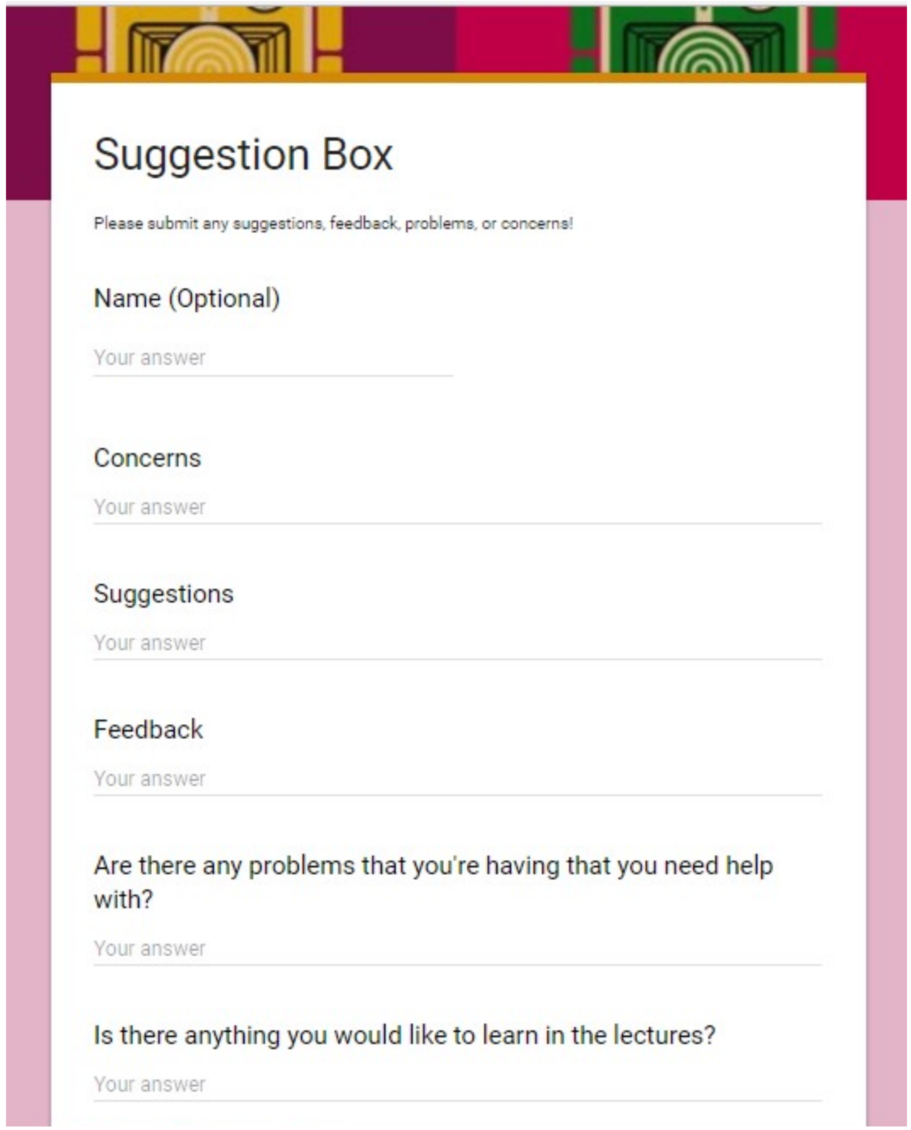
Anything else you would like to add concerning your team?

Feel free to talk about any accomplishments you've had, or issues you may have encountered.

Your answer

Appendix D: Surveys and Evaluations

Digital Suggestion Box



Suggestion Box

Please submit any suggestions, feedback, problems, or concerns!

Name (Optional)

Your answer

Concerns

Your answer

Suggestions

Your answer

Feedback

Your answer

Are there any problems that you're having that you need help with?

Your answer

Is there anything you would like to learn in the lectures?

Your answer

Team Success Potential Survey

How well did the team work together?

1	2	3	4	5	6	7	8	9	10
○	○	○	○	○	○	○	○	○	○

Common Purpose

	1	2	3	4	5	
Everyone is going in completely different directions	○	○	○	○	○	Everyone is working well together for the same common goal

Psychological Safety (Stress level, comfort around us, confidence of the students)

	1	2	3	4	5	
We really need to address this	○	○	○	○	○	They appear very comfortable and happy

Role Clarity

	1	2	3	4	
1+ member is sitting around while the rest of the group is working	○	○	○	○	All members are working an equal amount and respect the group leader

Mature Communication

	1	2	3	4	5	
Loud, disruptive, cussing	○	○	○	○	○	Quiet, polite, respectful

Conflict Resolution

	1	2	3	4	5	
Fighting, name-calling, refusing to listen to each other	○	○	○	○	○	Working well alongside each other

Accountable Interdependence

	1	2	3	4	
One person is doing all of the work	○	○	○	○	The workload is well spread between team members

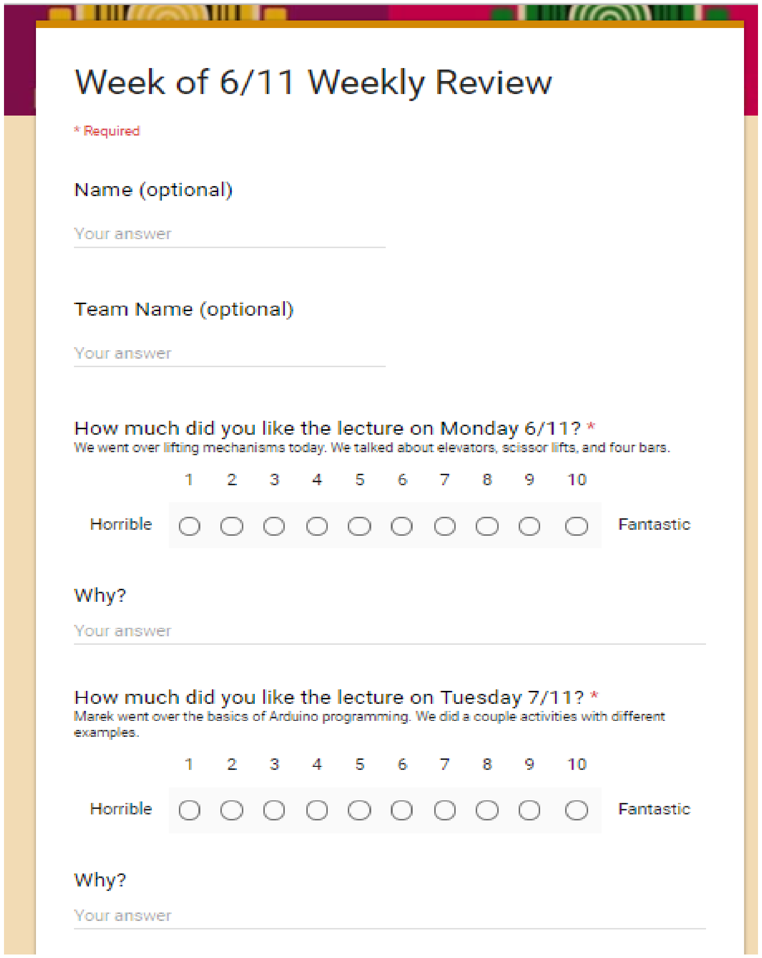
Specific Issues

Your answer

Additional Comments

Your answer

Example Weekly Survey on Lectures



Week of 6/11 Weekly Review

* Required

Name (optional)

Your answer

Team Name (optional)

Your answer

How much did you like the lecture on Monday 6/11? *

We went over lifting mechanisms today. We talked about elevators, scissor lifts, and four bars.

	1	2	3	4	5	6	7	8	9	10	
Horrible	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	Fantastic

Why?

Your answer

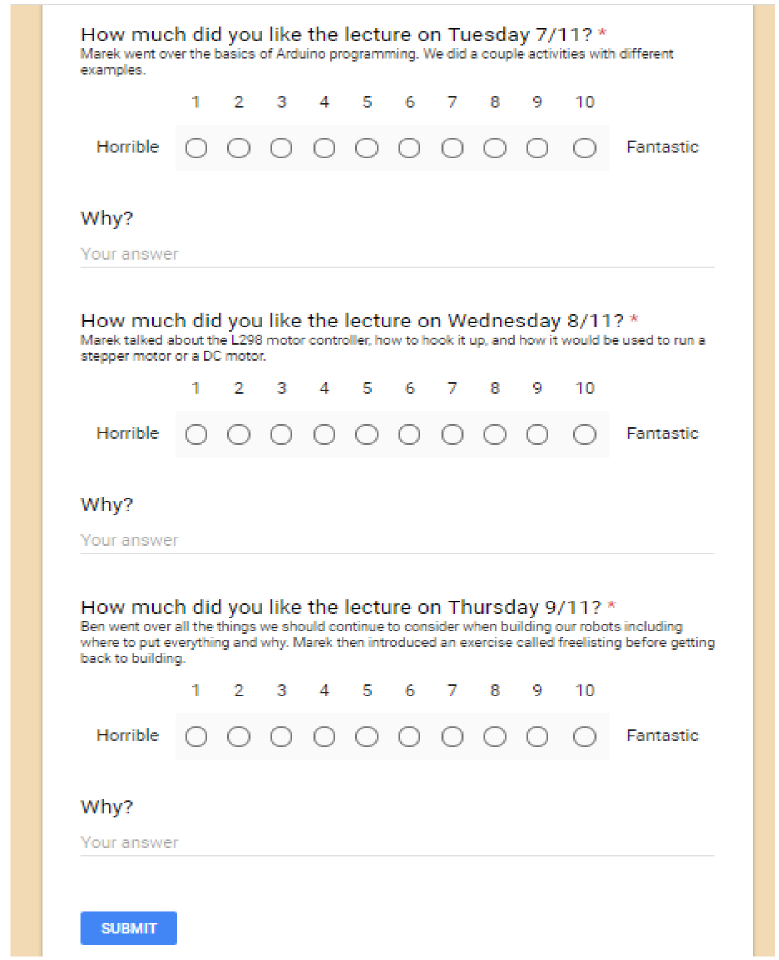
How much did you like the lecture on Tuesday 7/11? *

Marek went over the basics of Arduino programming. We did a couple activities with different examples.

	1	2	3	4	5	6	7	8	9	10	
Horrible	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	Fantastic

Why?

Your answer



How much did you like the lecture on Tuesday 7/11? *

Marek went over the basics of Arduino programming. We did a couple activities with different examples.

	1	2	3	4	5	6	7	8	9	10	
Horrible	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	Fantastic

Why?

Your answer

How much did you like the lecture on Wednesday 8/11? *

Marek talked about the L298 motor controller, how to hook it up, and how it would be used to run a stepper motor or a DC motor.

	1	2	3	4	5	6	7	8	9	10	
Horrible	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	Fantastic

Why?

Your answer

How much did you like the lecture on Thursday 9/11? *

Ben went over all the things we should continue to consider when building our robots including where to put everything and why. Marek then introduced an exercise called freelisting before getting back to building.

	1	2	3	4	5	6	7	8	9	10	
Horrible	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	Fantastic

Why?

Your answer

SUBMIT

Appendix E: Proposed Curriculum Breakdown

WEEK 1 (10/23 - 10/27 *POSSIBLY EXCLUDING 10/23) - Drivetrain and Chassis*

Day 1

- Introductions
- Free listing
- Ice breaker
- Possible Questions:
    - Would you rather be indoors or outdoors?
    - Do you prefer to play or to watch sports?
    - Which is worse: bad breath or body odor?
    - Would you rather go hiking or go to the beach?
    - Do you like chocolate?
    - Would you rather travel to the past or the future?
    - etc.
- Intro to robotics (15 min)
- Intro to the game (20 min)
- Intro to drive train (60 min.) with Demos & Mini Workshops
  - Station 1
    - Gear & gear ratios
    - Torque vs Speed
    - Race with 3 lanes (High torque, direct drive, high speed)
    - Wrestling match with 3 combatant
  - Station 2
    - Wheel base
    - Center of gravity/tipping
  - Station 3
    - Omni vs traction
    - Tank vs arcade
    - Types of wheels
    - Types of steering
  - Example chassis design
- IF TIME: Brainstorming drive train/chassis design
- Get a consult before starting to build
- Encourage on paper

Day 2

- Intro to CAD Lecture
- CONT. Brainstorming drive train/chassis design
- Design drive train/chassis
- Build in CAD

Day 3

- CONT. Building in CAD
- Propose drive train/chassis to us

WEEK 2 (10/30 - 11/3)- Drive train and Chassis

Day 1

- What is an Arduino? Lecture & Examples
    - Loops
    - If statements
    - Sequential programming (importance of lines & order)
    - State Programming
- Examples: Hello World program, Blinking an LED, etc.
    - Printing for debugging
    - Have LED circuit prebuilt for each team, that they'll hook up to an Arduino (Hopefully each team will have an Arduino and can follow along)
- Example program with things missing (2 lines)
    - Give them the commands

Day 2

- Motor driver & H bridges lecture
- Motor control via Arduino
    - Students learning how to do it on a motor, but not on their robot
- Give each a motor and motor controller (w H bridge) & teach them how to control the motors and how to take care of them
    - Stalling -> DEMO
- Generators and motors are inverses
    - Cool demo with hand crank generators
- Give them most of the code and read through so they can tell us how to do it

Day 3

- Apply Day 1 to your robot
    - Start programming the drive train
    - Put motors on robot
    - Wiring, & neatness
- Drivetrain Demo

WEEK 3 (11/6 - 11/10)- Wrapping up programming & Intake

Day 1

- Address issues from Week 2 Day 2 with short lecture if needed
- CONT. programming the drive train
- Control via joystick Lecture
    - Commands written, styles of controlling, understand code, and adjust it to apply to what they want

Day 2

- Start with group drivetrain demo?
    - Both tele-op and autonomous (drive forward, square, or circle)
- Intake lecture
    - Pros & Cons of each option
    - Four bar mechanism
        - Use brads and pieces of paper (cardstock or flashcards for rigidity?) to demonstrate
    - Scissor lift
        - Same as Four bar
    - Rack and pinion elevator lift (similar to forklift)
    - Rubber band intake
        - Link to tractor harvesting
    - Gripper
- Will all depend on game rules
- Design your intake
- Don't make them feel constrained to pick one of the above

Day 3

- CONT CAD Lecture
    - Provide complex models
- Build design in CAD
- Propose design to us
    - Suggestions for improvement
    - How to approach building

Day 4

- Code for intake system

Day 5

- Tele-op demo of intake system
    - Help with corrections if failed

WEEK 4 (11/13-11/17)- Sensors & Programming (Trade off with Prof. Hoxha)

Day 1

- Begin discussion of robot autonomy
    - Whole class vs in paired teams?
- Intro to sensors
    - Bump
    - Limit switch
    - Ultrasonic
    - Line follower
    - IR
- Lab to get familiar with sensor-Arduino interactions
    - How does a bump/limit switch react to when you press it?
    - How much force does it take to activate a limit switch?
    - Accuracies/limits of ultrasonic, line follower, (and IR if we do it)
- Brainstorm what sensors to use for final project

Day 2

- Brief look into filters
  - Low pass

Day 3

- State machine
  - Draw diagrams
  - Consider different states for autonomous
- Plan for autonomous section

Day 4 & 5

- Free building days

WEEK 5- Extra Topics & Building (11/20 - 11/24)

Day 1

- Gauge completion status

Day 2

- Extra topic based off of student interest

Day 3

- Extra topic based off of student interest

Day 4 & 5

- Free building days

WEEK 6 (11/27 - 12/1 *Possibly not 11/27 &28)*

Day 1

- Competition Soft date
- If not ready, today is designated as a free building day

Day 2

- Free building day

Day 3

- Competition hard date

Appendix F: Lecture Topics and Activities

Lecture 1

- Introductions
- (planned on an ice breaker, had to skip it due to time restraints)
- Basic definition of robotics
- Robot example videos
    - From RBE2001, 2002, 3001 (WPI Robotics Courses)
- Team Building Challenge
    - Spaghetti Tower (15 min)
- Introduce Vex parts
- Introduce the competition
    - Name, concept, game pieces
    - Show bots from last year
    - Floor plan this year
- Ask each team to line up for a picture, and come up with a team name for Lecture 2

Lecture 2

- Collect team names and emails of students
- Introduce way of organization
    - Google Drive
- Explain/show feedback surveys
- Go over Last years game briefly
    - Student interaction! ask them about last year
- Outline rules, gameplay, timing, scoring etc for this years game
- Present field design
- Introduce Checkpoints to keep students on track
- Speak more about Vex metal
    - Vex Bearings
    - Keps nuts
    - Lock nuts
- Build time!
    - Each team builds a car (getting creative)
    - 20 min

Lecture 3

- What is a Drive Train
    - Chassis, Wheels, Gear Ratios
- Wheels
- Steering
    - Ackermann, Tank Drive, Skid
- Omniwheels, no sideways friction
- Controls
    - Tank drive and arcade drive
- Gears
    - Pitch
    - Driven gear
    - Driving gear
- Gear Ratios
- Play with sample robots and start designing!

Lecture 4

- Done by Prof. Hoxha about Drivers and H bridges
    - DC motors, servos, stepper motors, H bridges, wiring
- Announcements about
    - Game stuff
        - Birdie buttons
        - TBS
        - Points
        - Soccer ball trough
        - Batteries
- Weekly survey for week 1
- Deadlines & Calendar
- Assignment: Submit in your google drive folder a picture or scan of

your robot design so far, focus on the chassis for now as we will be going over intake designs later. Give a top side front drawing with an orthographic view if desired. Be ready to CAD this design tomorrow.

Lecture 5

- Inventor/AutoDesk

Lecture 6

- Mechanisms
  - Things to put on a Robot
    - Lance
    - Scoops, Pitchforks, & Buckets
    - Intake roller
    - Grippers and claws
- Announcement
    - Must show design to us before getting their kits!

Lecture 7

- Lift Systems
  - Things to put on a robot
    - Elevator
    - Scissor Lift
    - Four-Bar vs Three-bar
    - Three Bar

Lecture 8

- Arduino Intro

Lecture 9

- Motor Controller: L298

Lecture 10

- Placement of components on robot

Lecture 11

- Sensors

Lecture 12

- PID

Lecture 13

- State Machine

Lecture 14

- Quadrature Encoder

Appendix G: Student Schedule

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
WEEK						OCTOBER 21	22
1	23	24 Club Meeting: Introductions	25	26 Club Meeting: Organization, The Game, and Vex	27 Club Meeting: Intro to Drive Trains Weekly Survey	28	29
2	30 Club Meeting: Motor Driver & H bridges	31 Club Meeting: CAD (Inventor) Initial design due	November 1	2 Club Meeting: Mechanisms Weekly Survey	3	4	5
3	6 Club Meeting: Lift Systems Drive trains due	7 Club Meeting: Arduino Intro	8 Club Meeting: Motor Controller, L298	9 Club Meeting	10 Club Meeting Weekly Survey	11	12
4	13 Club Meeting Team Evaluation Survey	14 Club Meeting Team Evaluation Survey Game play mechanisms due	15 Club Meeting: Sensors	16 Club Meeting: PID	17 Club Meeting	18	19
5	20 Club Meeting: State Machine Submit preferred sensors & motors by end of class	21 Club Meeting: Quadrature Encoder Lecture Weekly Survey	22 Club Meeting	23 Club Meeting	24 Club Meeting Sensor based autonomy demo due	25 Club Meeting Extended Hours 10:00 to 12:30	26
6	27	28	29	30 Club Meeting	December 1 Club Meeting Extended Hours: 10:00 to 19:30	2 Club Meeting Extended Hours 10:00 to 17:30	3
	4 FINAL COMPETITION	5	6	7	8	9	10

Objectives:

Teams will present the knowledge that they have learned throughout the course in the form of a remote controlled robot that is able to collect and score objects on the field. At the end of the match, the team with the highest number of points will win.

1.0 Gameplay: General Rules

1.1 Common sense applies to all rules.

1.2 All referee decisions regarding rules of play and judgements are final

1.3 Any team that attempts to damage or pin robots, or otherwise violate the rules of the game will be disqualified and automatically lose the match. This includes flipping.

> 1.3.1 A robot is considered pinned when an opposing robot is held against a field obstacle and rendered unable to move either forward or backward due to the presence of another robot.

1.4 At the start of the match, teams must place their robot in the starting location of their color defined by the outer boundary of the tape.

1.5 Robots may not physically interact with anything outside of the field.

1.6 Any Birdie that leaves the field during a match will not be returned to the field and is ineligible to be scored.

1.7 If the Savage Ball leaves the field during the autonomous period, it will be returned to the neutral position before the start of driver control. If the Savage Ball leaves the field during driver control, it will not be returned to the field during the match.

1.8 Referees reserve the right to disqualify any robot that is determined to be a safety hazard.

1.9 Team members may only interact with their robot during a match through the use of their joystick. Only designated Drivers may be in contact with the joystick controllers during the match.

> 1.9.1All team members must stand behind their respective side lines for the duration of the match.

1.10 Damage to the playing field, objects, other robots, or the control system may result in disqualification at the discretion of the referees.

> 1.10.1 Referees may request that teams alter any portion of their robots that are considered safety hazards or damaging to the playing field or scoring objects at any point during the competition. It is the right of the referees to prevent teams from playing in matches until such changes are made to the robot.

1.11 All parts of the robot must remain attached to the robot for the duration of the match and must not cause any hazard of entanglement to the other robots. Any infraction of this rule may result in an immediate disqualification. Minor pieces which unintentionally become detached from the robot, or are the result of improper design/construction and do not affect the outcome of the match, will not cause a disqualification.

1.12 Teams are allowed to modify their robots between matches so long as the robot continues to follow all of the rules and specifications outlined in this manual. Any modification must be brought to the attention of the referees or head inspector prior to the start of the team's next match. Teams may be subject to re-inspection at the discretion of the referees/head inspector.

1.13 Multiple robots per team are not allowed.

1.13.1 A robot must meet the specifications outlined in section 6.

1.14 Teams will not be permitted to touch their controllers during the autonomous period.

2. Gameplay: Game Definitions

2.1 Landing Zones (LZ): Areas at the ends of the field, indicated by colored tape where the robots begin the match.

2.2 Birdies: Irregularly shaped plastic game objects typically found in badminton tournaments.

2.3 Box: a 15 cm tall, 61cm wide, 30cm deep clear, walled off area within the LZ wherein the Birdies are scored.

2.4 Tubular Birdie Source (TBS): Tubes at the forward edge of the field and in front of the ramps where teams may get Birdies.

2.5 Savage Ball: A regulation size 4 soccer ball.

2.6 Trough: the area that contains the Savage Ball.

2.7 Ramp: Structure at the rear edge of the field that leads up to the Trough.

2.8 Red and Blue colored panes located at either end of the trough, which are used to determine control of the Savage Ball.

2.9 Birdie Button (BB): Buttons that deliver Birdies when pressed during autonomous mode.

2.10 Birdie Starting Location (BSL): Marked squares on the field where Birdies are located at the beginning of each match.

3. Field Specifications:

3.1 The game will be played on a 2.4m (8ft) by 3.7m (12ft) field with a ground surface of "high-traffic" carpet that may have minor bumps and surface irregularities.

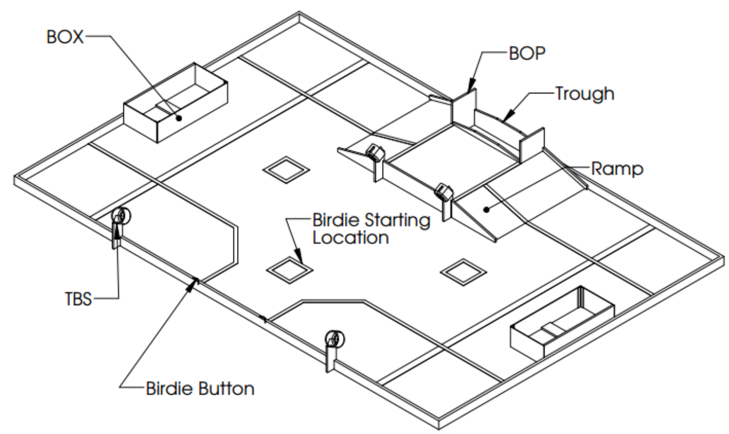
3.2 Robots will begin the match in the LZ area for their respective team colors (Red or Blue).

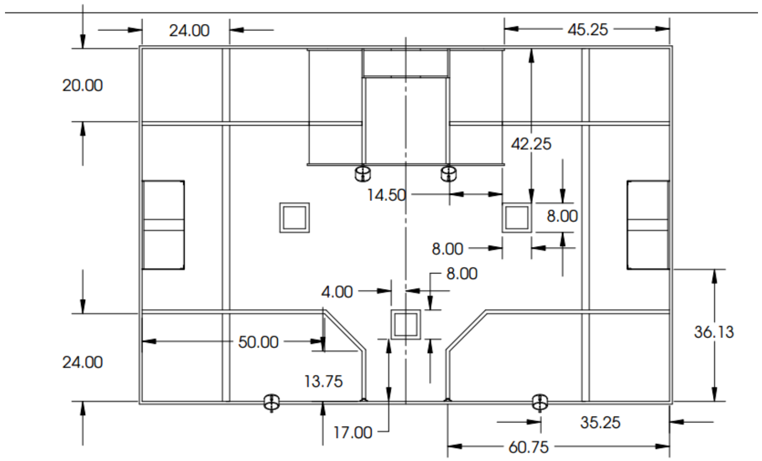
3.3 There are 16 Birdies located on the field at the start of the match. Eight will be red; eight will be blue. There are an additional 16 white Birdies at the start in the TBSs, four per TBS.

3.3.1 The red and blue Birdies will be arranged as follows:

- 3 groups of 2 red and 2 blue Birdies each, one group located in each of the separate Birdie starting locations.
- 4 Birdies (2 red, 2 blue) start the match on top of the ramp, against the wall opposite the Trough.
- Birdies in the BSLs and on the ramps start feather-side down, with the team's color Birdies closest to their LZ.

3.4 All field dimensions should be considered to be +/- 2cm





4. The Match:

Each match will last a total of 2 minutes and 30 seconds, the first 20 seconds of which will be autonomous where team members will not be allowed to touch their controllers. Once the winner of the autonomous period has been determined, the drivers for each team will pick up their controllers and the match will continue under driver control. After one minute, there will be a 10 second period of time for the drivers to hand over the controls to another teammate to continue as driver for the remainder of the match.

Time	Activity
0:00 - 0:20	Autonomous Period
0:20 - 1:20	First Driver Control Period
1:20 - 1:30	Driver Switch
1:30 - 2:30	Second Driver Control Period

5. Scoring:

5.1 All scoring will occur after all robots, Birdies and the Savage Ball have come to rest.

5.2 A Birdie is considered to be in a scoring position if the Birdie is supported only by the field wall, the floor of the LZ, the BOX, or another Birdie considered to be in a scoring position. Additionally, the Birdie must be at least partially within the LZ and not in contact with a robot from the scoring coalition.

5.2.1 Red and Blue Birdies are considered to be in scoring position if they are within the zone of their color, in addition to meeting the above criteria.

5.3 The Savage Ball is considered controlled by a team if the ball is in contact with the BOP corresponding to its team color and with both edges of the Trough.

5.3.1 Robots that are touching the Savage Ball at the end of the match will be removed in reverse order in which they made initial contact before control of the Savage Ball is assessed.

5.4

Action	Number of Points
Control of Savage Ball at End of Autonomous	12
Button Pressed During Autonomous	8
Birdie in LZ at the end of the Match	4
Birdie in BOX at the end of the Match	5
Control of the Savage Ball at the end of the Match	8

5.5 The team with the highest number of points at the end of the match wins.

5.5.1 In the event of a tie, the team with control of the Savage Ball wins.

6. Robot Specifications:

6.1 Each robot must be able to fit within a 38 x 38 x 38 cm (15 x 15 x 15 inch) box at the start of the match.

6.2 The robot must be fully self- supported, in contact with only the horizontal, carpeted (or taped) surface of the playing field when started.

6.3 Teams may only construct their robots out of parts that are equally accessible by every student.

6.4 Each robot's weight must not exceed 4 kg (8 lbs).

6.4.1 The battery weight is not included in the robot's weight.

6.5 Each robot must be designed to operate by reacting only against features within the confines of the playing field boundaries.

6.6 Gaining traction by use of adhesives or by abrading or breaking the surface of the playing field is not allowed and will be considered to be damaging the playing field and subject to disqualification.

6.7 A robot may not intentionally contaminate the playing field or an opponent's robot with lubricants or other debris.