PAY it Forward: Competitive Robotics Team for Youth in Katutura, Namibia in Partnership with Physically Active Youth

An Interactive Qualifying Project Report
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Abstract

Physically Active Youth (PAY), an afterschool program in Katutura, Namibia, supports underserved youth and aims to teach them 21st-century skills. We developed the infrastructure of a robotics team for PAY and helped them compete in a virtual robotics competition. Our final product is a 34-person robotics team that will compete in the Live Remote Tournament through the Robotics Education and Competition Foundation, thereby bringing learning and fun to Namibian youth.

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Executive Summary

Introduction

Under the rule of South Africa, Namibia lived under apartheid, meaning “apartness” in the Afrikaans language. Katutura, a town located on the outskirts of the city of Windhoek, is a result of this ideology. The township of Katutura comprises of a dense community of primarily black Namibians who were pushed out of the city of Windhoek during apartheid. One of the results of apartheid was a two-school system, in which the white schooling was adequately funded and constantly expanding, whereas the black school system was severely under-resourced. Although Namibia gained its independence in 1990, the country is still feeling the effects of Apartheid—unemployment, inequality, and poverty—today (Jauch Namibia 2012).

As a result of the traditional learning system and low educational retention rate, after-school programs have been implemented in Namibia to bridge the gap between traditional and project-based learning. Physically Active Youth (PAY), a non-governmental organization, located in Katutura, Namibia, and is one of those organizations supporting students by attempting to increase technical knowledge in the classroom. STEM education is becoming increasingly necessary in a world that is advancing technologically at a rapid rate, and over the past few years, PAY has been working to develop its science program.

Goals and Objectives

There is currently an education gap between the theoretical teaching style of Namibian schools and project-based learning. In Namibia there is little focus on STEM based education. This project, in partnership with PAY, aimed to show students from Katutura that they can pursue career paths beyond the limitations of their current education. Our goal was to launch a competitive robotics team and create an accompanying program with the capability to be used in both the short- and long-term. Our objectives were to:

Objective 1: Develop the infrastructure for a sustainable competitive robotics team

This includes establishing a team administrator, mentors, students, organizing the team schedule, and creating a team name and logo.

Objective 2: Enroll PAY students and participate in the Pan African Robotics Competition

This included signing the students up for the virtual competition, monitoring progress throughout the competition, and creating weekly lesson plans for the students.

Objective 3: Assess and recommend future competition opportunities

This included recommending a future competition to our sponsor, and creating a sponsor pamphlet to increase the longevity of the program.

Methods

We addressed all of our objectives while keeping the longevity of the program in mind. This consisted of establishing a team with local leaders who are willing and interested in being involved. These leaders guaranteed the longevity of the robotics team so that students at PAY would be able to compete in robotics for many years to come. In this project, we sought to develop a framework which these team leaders, and possibly future WPI teams, could use to advance the program.

In order to address Objective One, our team took the following actions: surveyed former members of robotics teams, established a team administrator, mentors, and members of the team, created a schedule for the team to use, and initiated team bonding. To address Objective Two, our team signed students up and did administrative work for the Pan African Robotics Competition (PARC), created weekly lesson plan videos for the students to use, and gathered feedback from PAY students on PARC. For the last objective our team assessed seven different robotics competitions to find the most feasible one for PAY to compete in, and we also gathered information on finding sponsors to allow us to create a pamphlet guide for PAY.

Findings

Team Infrastructure:

Our team conducted surveys for both WPI students who had been on robotics teams to gain insight on the dynamics and impact of being on robotics teams, and PAY students to understand the impact or our implementation methods.

In our survey to WPI students, we found:

- A successful robotics team can range in size from 2 to 50 members.
- Teams do not need a large number of mentors, and mentors do not need to have prior robotics knowledge when working with advanced teams.
- The most enjoyable aspects of a robotics team are: fun, teamwork, making friends, technical aspects, and trying new things.
- Being on a robotics team helped students choose a career or major in STEM or robotics, improved their teamwork skills, and helped them develop life skills such as leadership, problem-solving, communication and confidence.

Participating in the Pan African Robotics Competition:

To assess our success in preparing the students at PAY for the Pan-African Robotics Competition (PARC), we administered a survey at the end of the term so that students could give feedback on how the competition was run and what they learned as a result.

In our survey to PAY students, we created the following analysis based on the information gathered:

- Over 72% of the respondents had little to no prior experience in robotics
- Over 90% of student responses indicated that the instructional lesson plans were helpful
- The formation of the team has promoted STEM in a fun and enjoyable manner
- The competition helped students further develop skills in the area of teamwork.

Assess Future Competition:

In choosing a future robotics competition for PAY, our team made two comparison charts for the seven potential robotics competitions. Our team created a Pugh analysis chart which enabled us to tabulate quantifiable data on each competition. The chart showed that the three most feasible

competitions were the Pan African Robotics Competition (PARC), the Live Remote Tournament (LRT), and VEX IQ.

Conclusion

Deliverables

Throughout the project, we managed to deliver in various areas of the project including:

Recruited robotics team members

With the help of Mr. Kleopas, we recruited 34 students to join the robotics team.

Developed a team name and logo

By polling the staff and students at PAY, we decided on a team logo and the name “Namibots” for PAY’s robotics team. Additionally, we secured funding from WPI’s Innovation & Entrepreneurship department to print t-shirts with the new name and logo for everyone on the team.

Enrolled students in PARC

Every member of the team was enrolled into one of the PARC leagues and were divided into teams of three or four. Throughout the term, we met with various teams to check in and track their progress in the competition.

Created weekly video lessons

We created weekly videos for the STARS and Techs league of PARC explaining and breaking down complicated objectives. These videos included tutorials in C# scripting, blocked based programming, and tools available on the PARCSim software on how to build an aesthetic robot for the competition.

Developed a holistic assessment model

The holistic assessment model used in conjunction with the Pugh Analysis table, which gave scores to each competition, gave us three clear winners. Using more qualitative criteria, we narrowed it down to just two: PARC and LRT. We then explained both competitions to our

sponsors at PAY and gave them time to make the final decision on which competition their robotics team would continue with.

Recommendations

Near the completion of our project, we developed the following recommendations based on our findings which included future development of the robotics team and continuation plans. Our recommendations are as follows:

Growing the PAY robotics team

Our team took on the role of team administrators and team leaders but in order to continue the robotics club, the Namibots will need a team leader to take over. The roles and responsibilities of the team administrator have been outlined in the results sections but include: overseeing everyone involved on the robotics team, fostering healthy relationships with the students, managing lessons and team meetings, preparing the team for competitions, and overseeing competitions.

Continuing with the 2021 Pan African Robotics Competition

Our experience with PARC over the course of the project has been extremely positive. It is challenging but engaging for the students, and the organization is helpful and cooperative with us. In our interviews with the students, most of them loved working with the software. However, many did report bugs and other issues which hurt the user experience. We were able to easily address these issues due to the direct line of communication we had with Fatima Kebe, a project director at PARC. As the season continues, we hope PAY maintains this connection in order to keep the experience as seamless as possible.

Enrolling PAY in a future robotics competition

Our team developed a holistic assessment model to assess the feasibility of future competitions for PAY. Seven competitions were examined based on criteria such as registration fee, robotics kits cost, closest competition location to PAY, age range, as well as support from the parent organization. Our two recommendations were PARC and LRT. Both organizations were willing to assist PAY in their competitions and to focus and expand in sub-Saharan Africa, which was an

added incentive for PAY to join. Our team provided PAY with resources based on their decision to move forward with the Live Remote Tournament. These resources included competition dates, deadlines, past schedules for reference, organized curricula, and other resources provided by the parent organization for competing teams.

Fostering strong relationships with other Robotics Teams

Aside from PARC and LRT, our team also chose First Global as a separate option since they had good potential for PAY to work with. Due to its Olympic-style nature, we recommended it to PAY as an opportunity for some students to be on a team that participated in a large international competition with the ability to travel anywhere, without cost being an obstacle for PAY since they would not be in charge of the team. We helped foster a relationship between the First Global Namibian representatives and PAY, through which they are willing to work with PAY and have some of their students be part of the First Global Namibian team.

Getting sponsors and support resources

Getting sponsors is critical in order to continue the robotics club. Sponsors provide funds or donate resources for robotics kits, travel costs, competition fees, and other equipment. In order to assist PAY's robotics club recruit sponsors we have created a detailed sponsor pamphlet highlighting the steps to take in order to reach out and obtain sponsors. The best ways to receive sponsors are through in-person meetings and showcases where the potential sponsors are able to attend and see the students with the robots.

Overview

In Katutura, youth are not exposed to the same experiences and opportunities as most students in the United States of America. There is less of a focus on teaching students STEM and ways in which they can escape the poverty that they have grown up in. This project aimed to enable the students of Katutura to compete in robotics at local, regional and global levels, foster teamwork skills, and lastly encourage students to pursue STEM in a fun and competitive environment. By doing this we were able to aid Physically Active Youth in creating opportunities for the children of Katutura to dream big and know that they are capable of achieving whatever they set their minds to.

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1. Introduction

Namibia is a beautiful country located in Southwest Africa with a brutal history of inequality due to past colonialism. The country was colonized by Germany in 1884 and under the Germans, native tribe regulations (1905-1907) were enforced against indigenous people. These regulations resulted in the land dispossession and the forced labor of indigenous people which continued when South Africa took control in 1915 (Jauch et al., 2009). Under the rule of South Africa, Namibia was forced to live under apartheid, meaning "apartness" in the Afrikaans language. Apartheid was an ideology that called for the separation of different racial groups (*A History of Apartheid in South Africa | South African History Online*, n.d.). One of the results of apartheid was a two-school system, in which the white schooling was adequately funded and constantly expanding, whereas the black school system was severely under-resourced (*Unequal Education: Apartheid's Legacy | Fighting for Equality in Education: Student Activism in Post-Apartheid South Africa - A Journalism Case Study*, n.d.). Although Namibia gained its independence in 1990, the country is still feeling the effects of Apartheid—unemployment, inequality, and poverty—today (Jauch Namibia 2012).

Namibia has some of the highest poverty and inequality levels in the world due to apartheid. However, based on average income it does not receive the support it needs due to its rank as a high-middle-income country. Despite Namibia's high average income, its high inequality means that many of its citizens live in poverty. The uneducated make up the majority of those suffering from poverty, demonstrating how important it is for Namibian youth to stay in school so that they will be able to support themselves later in life (Ashipala, n.d.). In today's technologically progressing world, it has become even more critical for youth to have Science, Technology, Engineering, and Math (STEM) skills that will lead to prospective jobs and further educational opportunities. Robotics is an interactive field that consists of a wide range of STEM topics, such as coding, mechanics, and engineering. Robotics teams are a great option for students to be engaged in healthy competition while also learning important STEM skills. Introducing Robotics programs into Namibia is increasingly important due to the traditional education system of Namibia that focuses more on theory and less on hands-on learning. Through a robotics team, students have healthy competition that inspires them to do their best,

resulting in students who are more inquisitive, skilled in research, and can collaborate well with others.

As a result of the traditional learning system and low educational retention rate, after-school programs have been implemented in Namibia to bridge the gap between traditional and project-based learning. These programs encourage and assist students to complete high school while teaching them valuable skills and encouraging participation in sports. Physically Active Youth (PAY), a non-governmental organization, is located in Katutura, Namibia, and is one of those organizations supporting students by attempting to increase technical knowledge in the classroom. Over the past few years, PAY has been working to develop its science program. They were able to establish coding courses and even began a robotics program with the help of a local robotics school. The robotics program lacked a curriculum and in order to address that problem, a past WPI team created and worked to implement one. The prior team developed an online curriculum that students at PAY could follow at their own pace. In addition to the online curriculum, the previous team was also able to receive funding from a WPI Tinkerbox grant and a donation from the Robotics Education Competition Foundation to purchase 12 VEX robotics kits. Due to the pandemic the kits were unable to be sent while the previous team was working on the project. However, six out of the 12 kits were able to be shipped in April of 2021. Our project team created a baseline for the establishment of a sustainable robotics program at PAY. Creating a curriculum was the first step, and we followed this by developing a supplemental robotics team.

The town of Katutura, Namibia did not have any opportunities for students to compete either locally or nationally in the sport of robotics. To address this and help further the robotics program, we partnered with PAY to develop a competitive robotics team. Through the robotics team, students will be empowered to pursue higher-level education in STEM while also learning valuable life skills such as teamwork and resilience. Our goal was to encourage the students of Katutura to pursue STEM in a fun and interactive environment by developing a competitive robotics team that has the capability of being sustained by PAY. To achieve our goal, our team signed up 33 students for the PAY robotics team and took on the roles as team mentors and administrators. We entered PAY to compete in the virtual Pan-African Robotics Competition (PARC) and delivered weekly videos to assist the students with the challenges. To make the

robotics team sustainable our team after extensive research recommended two competitions PARC and Live Remote Tournament that are feasible for PAY to continue with in the future. With that we included a manual on how to get sponsors, and information on how to register the team for the competition of their choice next year. Our team assisted PAY in creating educational opportunities for youth so that they will stay in school, thus addressing the social implications of the high national youth dropout rate.

2. Background

In this chapter we discuss the history of Namibia, current life in Katutura, and why the people of Katutura face economic hardships and gaps in the education system. This chapter also goes over the importance of STEM education and project based learning. Our sponsor, Physically Active Youth, is working to create an environment where the youth of Katutura can learn and develop 21st century skills through the development of a robotics program.

2.1 Namibian History

Namibia is a country located on the western coast of Africa, between Angola and South Africa. Prior to colonialism, Namibia's population consisted entirely of tribes such as the San, the Herero, and the Nama, which still persist today. The San were nomadic people or hunter-gatherers, and the Herero and the Nama were pastoral people (*Namibian History - Facts and Information*, n.d.). Namibia was colonized by Germany in 1884 and for the first few years under German rule, the native tribes were relatively untouched and unbothered. This all changed with the violence of the Herero Genocide and wars against the Nama (Jauch et al., 2009). These terrible atrocities committed by the Germans killed approximately 80,000 indigenous people. Today, the government of Namibia is seeking reparations from Germany for the land stolen and the lives lost (*Herero and Nama Genocide — United States Holocaust Memorial Museum*, n.d.).

Under the Germans, native tribe regulations (1905-1907) were enforced against indigenous people. These regulations were accompanied by land dispossession and forced labor which continued past German rule when South Africa took over in 1915 (Jauch et al., 2009). South Africa, with a white minority in power, forced native Africans into cheap sources of labor for South African settler communities. Measures such as differential tax rates were utilized to further impoverish black Africans and drive them into wage labor (Jauch, n.d.). Under the rule of South Africa, Namibia was forced to live under apartheid, an ideology that called for the separation of different racial groups (*A History of Apartheid in South Africa | South African History Online*, n.d.). Katutura, a town located on the outskirts of the city of Windhoek, is a result of this ideology.

2.2 Life in Katutura

The township of Katutura comprises a dense community of primarily black Namibians who were pushed out of the city of Windhoek during apartheid. The Ovambo people are the most populous ethnic group, composing almost half the total population of Namibia, but Katutura consists of a multitude of backgrounds, like the Herero, Damara, Nama, and Kavango. As a result of apartheid, the community is also very poor; however, within the past years the standards have been improving. For residents of Katutura, a great emphasis is placed on getting an education, accessing better work opportunities, and improving one's quality of life.

2.2.1 Traditions and Culture

Overall, Namibians are raised by their whole community much more than in America, where the family unit consists of two parents and their children. Most Ovambo live in their homeland of northern Namibia and Windhoek, namely Katutura, where they moved for work opportunities. This group has familial customs that are unique in the world. Children in Ovambo families—and more broadly in southern African families—tend to be raised by more people outside their immediate family, more often than in other cultures. In this system, mothers and fathers will have their children live with other families, those they take care of will be from other couples, and children may move from one household to another throughout their lives. The reason for these customs is likely a matter of cultural tradition, but they may have been influenced by the HIV/AIDS epidemic throughout sub-Saharan Africa (Brown, 2011). Many children lost their parents from the disease, so the impetus was put on members of the community to raise these orphaned children. In 2011, it was estimated that at least 12 million children had lost one or more parents to AIDS. In 2006, The United Nations Children's Fund estimated that, by 2010, 20 million children will have been orphaned in sub-Saharan Africa alone (UNAIDS/UNICEF, 2006).

These unique customs are not exclusive to the Ovambo, as there are many National customs that most Namibians follow. For example, Namibians love giving gifts. The most significant events, where most gifts are given, are weddings. Wedding customs are different for the various ethnic groups in Namibia, but one thing is common throughout: they are extremely

important. In weddings with the Himba culture for example, a tribal chieftain leads the ceremony, outfitting the bride with an elaborate headdress and jewelry, while calling on the spirits to bless the new family. In the Herero culture, the bride is kept hidden for weeks prior to the ceremony, only being allowed to contact her one chaperone. The wedding then lasts three days, with the bride wearing a new dress each day. Among the San, weddings involve the couple being tattooed by other members of the community, their heads being shaved, and blood from their wounds being exchanged (World Trade Press, 2010). In the urban environment of Katutura, though, many of these customs play a smaller role in residents' lives, as multiple cultures coalesce and the area modernizes. One important aspect of Namibian culture remains, however: the struggle of one is the struggle of the many.

2.2.2 Socio-Economics and Employment

Life in Katutura is characterized by poverty amidst rapid urbanization. In Namibia, 28.7% of the population are poor and 15% of the population are extremely poor (Ashipala,n.d.), and Katutura is poor even by the country's standards. Residents are deeply affected by poverty, with malnourishment running rampant among children. From 1992 to 2000, the proportion of growth stunting in children in Katutura increased over 20%, before stabilizing by 2007. Similarly, the proportion of underweight children grew, albeit to a lesser degree, in that same time period (Nickanor & Kazembe, 2016). Children in Katutura face the brunt of the harsh face of poverty.

Poverty is higher in rural areas (37%) than in urban areas (15%) (Ashipala, n.d.). This can be traced back to apartheid, as racial segregation laws moved black Africans to rural areas on the outskirts of the capital city of Windhoek (Ashipala, n.d.). Katutura, which can be translated from Otjiherero as "the place where people do not want to live," is one of these rural towns located outside of Windhoek. Katutura is a town that suffers from high poverty and unemployment rates. Unemployment is another serious issue for the people of Katutura, specifically the youth. Katutura youth struggle to find work, and as a result, they suffer from high rates of poverty. Of Katutura residents aged 18-35, 39.2% are unemployed and 18 percent are estimated to be below the poverty line. In order to survive, young Namibians have to find alternative income methods, such as more precarious forms of entrepreneurship. Numerous entrepreneurial programs are offered at various institutions, with 78% of respondents of one

survey saying they had attended at least one of these programs (Winschiers-Theophilus et al., 2017). Training entrepreneurship and other essential job skills have helped young Namibians stay afloat in a critical economy, one of the most unequal in the world.

An important method of reducing the effects of poverty and employing youth is to provide quality education to as many people as possible. In Namibia, 80% of the poor are made up of the less educated, making education a critical requirement to escape poverty. Currently, education is an area in need of major improvement. In 2013, the literacy rate among males was 83.2% and among females was 90.6%, according to UNICEF. Only 46.5% of males and 61.5% of females even attended secondary school, and the pass rate was even lower. Unfortunately, very few students (7%) stay in school for upper secondary education. There is an alarming dropout rate for the youth of Namibia, as 16% dropout in primary school and 52% dropout during secondary school (Education Policy and Data Center, 2018). Furthermore, a total of 19% of the 15-24 year-olds in Namibia have not completed primary education, meaning that they most likely have not developed essential reading or writing skills (Education Policy Data Center, 2018). Clearly, a lack of education is a pressing issue for Namibians, especially residents of Katutura. Providing Science, Technology, Engineering and Math (STEM) education for the youth of Katutura, and Namibia as a whole is essential to alleviate the encumbering effects of poverty and to improve the quality of life for its people.

2.3 STEM Education

The Namibian economy and education system have large gaps that could be addressed in part by an increase in accessibility to education in STEM fields. In this section, we will explore those gaps, and how STEM education can help alleviate the issues which arise as a result. Additionally, we will find the best way that STEM education can be implemented to maximize its effectiveness.

2.3.1 Necessity of STEM

STEM education is becoming increasingly necessary in a world that is advancing technologically at a rapid rate. The National Research Council believes that STEM advances are “cultural achievements that reflect people's humanity, power the economy, and constitute fundamental

aspects of our lives as citizens, workers, consumers, and parents" (Popa & Ciascai, 2017, p.54). Countries can prepare for continual shifts in economic and technological developments by moving towards education systems where STEM is integrated throughout all courses as opposed to only in science and math classrooms (Ralls et al., 2020). This will require teachers to learn how to integrate STEM into curriculums starting in elementary school. Currently, "engineering education, particularly in the elementary and middle school, is severely neglected" (English, 2017).The earlier students are exposed to STEM, the easier it will be for them to develop the skills needed to keep up with a rapidly changing world, and the more likely they will be to go into STEM careers.

2.3.2 Impact of STEM

A study of Romanian college students showed that "96% of respondents who chose to study a STEM field have graduated from a high school where they studied sciences intensively" (Popa & Ciascai, 2017, p.65). Early integration of STEM can thus lead to greater student interest in pursuing STEM for their career. One key component that makes STEM education interesting for students is its relevance to real-world problems. Gaining real-world problems is important because "STEM-related jobs grew at three times the rate of non-STEM jobs between 2000 and 2010. By 2018, it is projected that 2.4 million STEM jobs will go unfilled" (The STEM Imperative, 2015). STEM-based learning also helps to "[develop] the students' critical and scientific thinking as well as an integrated perspective on science by familiarizing them with the methods designed to help them solve current real world problems" (Popa & Ciascai, 2017, p.54). This helps give meaning to problems or projects that students are working on. Often, it is hard for students to decide on pursuing STEM-based careers after only taking core math and science classes in high school because they do not see any real-life application.

2.3.3 Project-Based Learning Overview

PBL occurs when students work on a project over an extended period of time, this could be weeks or months, and they work to solve a real-life problem. The deliverables for PBL typically include a proposed solution and a presentation that demonstrates students' learnings. Some key aspects that make PBL different from "doing a project" are the use of critical thinking skills,

collaboration, and a combination of subjects (*What Is PBL?*, n.d.). This is beneficial because through PBL students are developing the necessary skills to succeed in the work-force. The combination of PBL with STEM helps to "generate meaningful learning and influence student attitudes in future career pursuit" (Tseng et al., 2013). Outside of the classroom students will encounter obstacles that do not have a clear solution, this is where their learned skills from PBL come in. They are able to critically think about the problem and come up with an effective solution as a team. By working on a team, students learn tactical life skills like meeting deadlines and overcoming adversity.

2.3.4 Impact of Project-Based Learning

STEM courses typically contain concepts that are not easy to grasp, and oftentimes students are taught through content transfer which does not give the student knowledge on the practical use of the content they learned. The current education system puts "students in a 'box,' with each subject taught as a stand-alone block of instruction" without providing any connection between the different areas of study. For students to fully comprehend STEM, they need to know how to apply what they are learning to solve a problem. This is why Project-Based Learning (PBL) is becoming increasingly popular within school systems. PBL gives teachers the ability to pose complex problems that incorporate a variety of content. This approach requires students to use critical thinking skills to come up with a solution (Euefueno, 2019).

2.4 Benefits of a Robotics Team

Within STEM, robotics teams can help students gain skills necessary to improve the community of Katutura and Namibia at large. A robotics team will teach students through skill-based education which differs from the traditional theory based learning that students in Namibia receive in school. Additionally, participating on a robotics team has been linked to increased interest in STEM and the development of important life skills. An important component is that "these positive impacts can be seen constantly across geographical or cultural differences" (Eguchi, 2016). Robotics competitions foster teamwork and responsibility which support students later on in their career. Competitions also celebrate the hard work that was put in prior

to the competition. When students see their work at a competition, they are proud of their accomplishments even if their robot does not win (Welch & Huffman, 2011). The feeling of pride that students have gives them the motivation to continue pursuing STEM.

2.4.1 Current Opportunities

Currently, there is an established school in Namibia that is teaching youth about robotics called Robotschool Namibia. This is a paid after school program located in Windhoek that teaches students STEM through project-based learning. The course sessions are bi-monthly and have a 1:2 mentor to student ratio. While the school is a great step towards teaching youth about STEM and more specifically robotics, it is not widely available for youth in Katutura due to the program fee.

2.4.2 Promotion of Positive Attitudes Towards STEM

As we stated earlier, it is becoming increasingly important to help promote STEM to the youth. Student attitudes towards STEM have been found to directly correlate to their achievements in math and science courses (Welch & Huffman, 2011). As an example, FIRST Robotics is a global robotics program with the mission of "[inspiring] young people to be science and technology leaders and innovators, by engaging them in exciting mentor-based programs that build science, engineering, and technology skills, that inspire innovation, and that foster well-rounded life capabilities including self-confidence, communication, and leadership" (Vision and Mission, 2015). Well-known, middle and high school robotics teams often participate in this program. One study comparing high school students who participate in FIRST Robotics to students from the same schools who did not participate in the program indicated that "students who participated in the FIRST Robotics Competition had a more positive attitude toward the social implications of science than students who did not participate in FIRST" (Welch & Huffman, 2011). Not only are students who participate in FIRST more likely to perform well in science classrooms, but they are also "much more likely than nonparticipants to pursue courses and careers in science and technology-related fields" (Welch & Huffman, 2011). Overall, FIRST Robotics is helping to create generations of students with positive attitudes towards STEM which helps to encourage more students to pursue STEM-related careers.

2.4.3 Promotion of Creativity and Innovation

Robotics competitions not only help to promote STEM and develop student interest in the field; they also teach students life skills that will help them in their future careers. RoboCupJunior, like FIRST Robotics, is a robotics program that helps to promote science and engineering research (Objective, n.d.). One major component of many robotics programs is the promotion of innovation. RoboCupJunior has been linked to developing "skills for innovation and creativity among participating students" (Eguchi, 2016). Most robotics programs are based on PBL, which helps "students develop competencies necessary to be [an] effective 21st century workforce, including problem solving, critical thinking, collaboration, communication, and creativity/innovation" (Eguchi, 2016).

2.4.4 Integration of Teamwork Skills

Through hands-on work and the solving of real-world problems students are able to better grasp ideas because it gives them context for the theory that they are learning in school. Through competitions, students not only develop problem-solving skills, but are also learning the importance of critical thinking and innovation which are both imperative skills for STEM careers. Perhaps one of the most important skills that students are exposed to during robotic competitions is teamwork. Most jobs are going to include a team component and developing teamwork skills early on is beneficial. Robotics competitions are team-based and thus can teach students how to effectively work on a team. According to the Springer Handbook of Robotics "building a winning team requires... substantial cooperation among team members with very different skills and backgrounds. This creates an ideal playground to address teamwork within educational programs" (Nardi et al., 2016). This not only gives students the skills for successful teamwork, but it also helps to share the importance of working with people from different backgrounds.

2.4.5 Pan-African Robotics Competition

"By 2030, there will be 375 million young people in the job market in Africa" (Pan-African Robotics Competition, n.d.). The increasing number of youth in the job market makes finding formal employment challenging. In order to help bridge the gap, the Pan-African Robotics

Competition (PARC) challenges students to create solutions to problems that Africa is facing. PARC brings middle and high school robotics teams from across Africa together to compete. The program was founded by Sidy Ndao; a Senegalese-born engineering professor at the University of Nebraska-Lincoln. Dr. Ndao believes that STEM Education has the possibility to "set a course to improve everything from sanitation systems to agriculture and can create jobs in a place with soaring unemployment" (Searcey, 2016). While math and science are being taught in schools in Africa, there is no component that contextualizes their learning by connecting the theory to real-life problems. Dr. Ndao initially began his journey to integrating robotics into Africa by founding a camp that teaches robotics to students in West Africa and later moved into founding the Pan-African Robotics Competition. This competition was first established in 2015 and has since reached upwards of 750 students from 30 different countries (Pan-African Robotics Competition, n.d.). Each year the robotics challenges are geared towards helping students develop the skills necessary to solve Africa's most pressing issues. This program has the ability to create a generation of youth who will help Africa progress technologically and economically. Physically Active Youth (PAY) aims to bridge the gap between traditional schooling and project-based learning.

2.5 About Physically Active Youth

The Physically Active Youth (PAY) program is a community-based strategy meant to help and aid children and youth-at-risk in low-income neighborhoods in Namibia (PAY constitution, 2006). It focuses on addressing the physical health, academic status, personal development, and community involvement of the youth. This helps to decrease juvenile crimes, teenage sexual activity, and substance abuse, and it also provides opportunities for support and volunteerism, allowing the youth to take ownership of their community (PAY constitution, 2006). PAY has been running successfully since 2003 at the Multipurpose Youth Resource Centre in Katutura, Windhoek. The PAY program has been endorsed and received from the Ministries of Education, Youth, National Service, Sports and Culture, Gender Equality and Child Welfare, and Health and Social Services. Through these sponsorships, the organization has the goal of expanding throughout all of Namibia (PAY constitution, 2006).

2.5.1 PAY's Model

Physically Active Youth's development model rests on three pillars as seen in Figure 1. The first pillar is quality education which embraces the totality of a child's potentials: body, mind, spirit. The second pillar is sports, which changes lives by breaking down barriers and changing attitudes, and their third pillar is life skills which defend the value of self and others, instills equality, fosters holistic wellbeing, and promotes environmental sustainability ("Our Three Pillars," n.d.). The organization currently offers six programs to their students to help them identify and develop their strengths through sports while also providing academic opportunities.

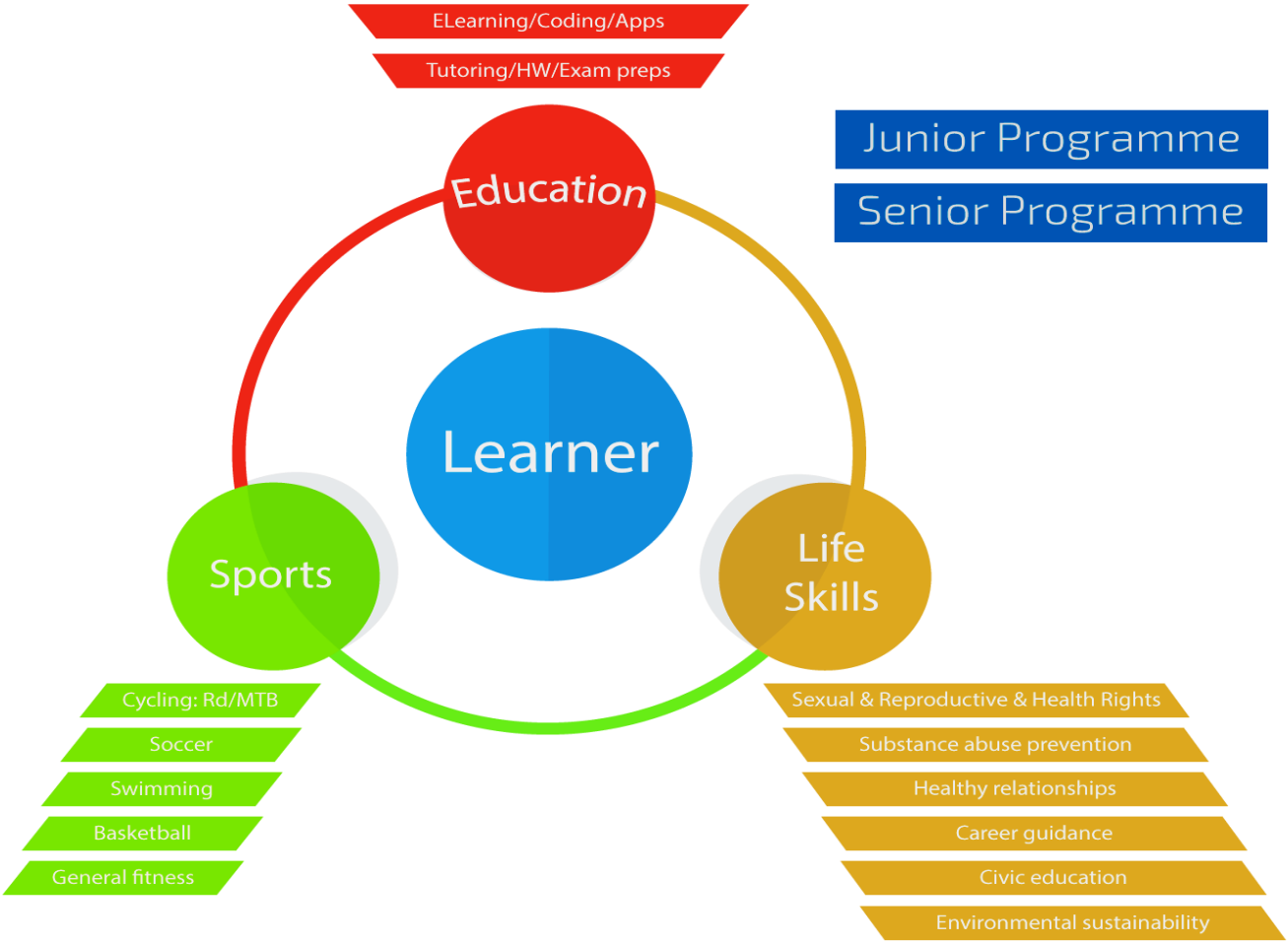

Figure 1. PAY's Three Pillars

2.5.2 PAY's programs

One of the programs PAY offers is an elite cycling program. This program aims at promoting cycling as a sport in local communities and promoting cycling as a sustainable mode of transport. The program also strives to create a professional team with the hopes of participating in the Olympics one day. In addition to cycling, PAY offers competitive soccer as an alternative sport, grouping teams by age and sex to participate on their level. The soccer initiative has brought success to the organization through trophies at all levels of competition and is a favorite for many of the students.

Furthermore, PAY offers educational opportunities through the Cambridge International General Certificate in Secondary Education program. Eight students are selected from PAY for the opportunity to strengthen their education while being supported financially. “PAY works with the Combretum Educational Trust (CET) to create a one-year collaboration and with the support of Rand Merchant Bank, to eliminate some of the financial barriers the students face” (“Cambridge International General Certificate in Secondary Education,” n.d.). In addition, PAY offers a writer’s room–a collaborative writing session–where its students create and engage their own ideas, and those of other participants in an experimental yet meaningful way. “Each session centers around a theme statement, often drawn from our Life Skills curriculum, which is engaged by participants through two writing exercises, and depending on time, a reading of the original texts created in the session may take place” (“Writers Room,” n.d.). This offers the students the opportunity to further improve their literacy level and nurture their creativity.

PAY also offers a coding program called PAY coding, which is aimed at teaching its youth Information and Communication Technology (ICT). This program has an e-learning platform available to any PAY student in regard to their literacy and their Science, Technology, Engineering, Art, and Math (STEAM) skills. They also encourage students to use platforms such as Khan Academy to better their knowledge in those areas. Currently, there are ten learners at the senior secondary phase enrolled in the Google math class who receive structured support at the mathematics extended level. The tutoring via the e-learning platform takes place once a week as well as on an ad-hoc basis. “In partnership with The Global Diploma (GD), a company based in Germany, PAY has been implementing an e-learning platform in the e-Lab in Katutura since 2013” (“ICT in Education @PAY,” n.d.). Furthermore, PAY has begun assisting the Namibian education sector in supplementing education with e-learning hardware, software in secondary schools with the help of GD.

The newest program PAY is offering is PAY robotics, which aims at providing a fun and engaging way to introduce programming to learners. PAY has been working with FABLAB Namibia to deliver robotics classes since 2017. “PAY IT Officer Macveren D Kapukare coordinates all the robotics activities between PAY and FabLab. Selected cohorts of PAY learners in Grades 1 to 10 attend FABLAB’s new technology and robotics class every Friday by following a learning module called Practical Experience in Engineering and Programming”

("Robotics @PAY," n.d.). During these sessions, students not only learn the basics of engineering and computer programming through robotics but foster their mechanical skills and creativity ("Robotics @PAY," n.d.).

2.5.3 Impact of PAY

Physically Active Youth started in 2003 as a way to support students academically, in response to the 26% Grade 10 pass rate of students in Katutura (OverSimplified, 2016). Since then, PAY has made significant contributions to the academic work and preparedness of youth in Katutura through their various educational programs and rigorous teaching methods. The pass rate for PAY students in Grade 10 was 76% compared to the national pass rate of 54% in 2016. Some other highlighted statistics from 2016 include: a Grade 12 PAY pass rate of 76% compared to the national 40%, a PAY primary phase enrollment of 95% compared to the national 91%, and a PAY secondary phase enrollment of 80% compared to the national 54% ("Our Impact," n.d.).

2.5.4 Previous Robotics Efforts

Currently, the robotics program lacks an actual curriculum and the technical knowledge to teach and implement robotics on a broader level to make a greater contribution to the students' understanding of STEAM and its concepts. A previous WPI team tackled this problem by developing an online robotics curriculum to inspire STEAM along with a supplemental facilitator's manual for PAY staff to support classroom instruction. (Educational Robotics for Physically Active Youth (PAY), n.d.). In addition, the 2020 robotics team was also able to secure 12 VEX IQ kits through a WPI Tinkerbox grant and donation from the Robotics Education Competition Foundation, but due to the pandemic was unable to send them to Namibia. In fall of 2020, WPI professor Doiron applied for and received a grant from the U.S. Embassy in Namibia consisting of $25,000 which enabled three project teams to work with PAY in the spring of 2021. The three teams are: updating the online robotics program created by the 2020 project team, providing educational resources for the robotics teachers of PAY, and developing a competitive robotics team. During the project, the 2021 teams worked to ship the VEX kits to Namibia and were able to get six of the 12 kits there. The remaining six kits will either be shipped in summer of 2021 or brought over by Professor Doiron if he is able to make the trip. The delivery of the VEX kits gave PAY the ability to teach robotics from a more hands-on perspective. Furthermore,

PAY used to have a competitive robotics team, in which they brought two teams to compete in the 2018 Pan African Robotics Competition. In this competition, both teams were successful and placed in the top ten. Unfortunately due to lack of sponsorship and funding, the team was unable to continue the following year and since then has not competed in any more robotics competitions. The robotics program is still in its infant stages but showing a lot of promise and potential as it makes strides to expand its scope.

2.6 Background Summary

Physically Active Youth is a non-profit organization that brings opportunities and supports students from underserved communities in Namibia. PAY's model falls onto three pillars: sports, education and life skills, each giving students the drive to pursue a future that they never thought would be obtainable. The education pillar, which includes a robotics program, works to close the gap between 21st century project-based learning and traditional teaching. In order to advance the robotics program, PAY hopes to include a competitive robotics team. Through competitive robotics, PAY can provide their students with a quality STEM education to help them find a career when they grow up and abate the effects of unemployment and poverty currently affecting Namibia. Our team, tasked with developing a competitive robotics team for PAY, has devised a methodology for achieving this goal.

3. Methods

This project was one of three PAY projects on bringing robotics education to Namibia. A key aspect was to make the robotics program long-lasting. This consisted of establishing a team with local leaders who are willing and interested in being involved. These leaders guaranteed the longevity of the robotics team so that students at PAY would be able to compete in robotics for many years to come. In this project, we sought to develop a framework which these team leaders, and possibly future WPI teams, could use to advance the program.

Our goal was to launch a competitive robotics team and create an accompanying program with the capability to be used in both the short-term and long-term. Our objectives were to:

Objective 1: Develop the infrastructure for a sustainable competitive robotics team

Objective 2: Enroll PAY students and participate in the Pan African Robotics Competition

Objective 3: Assess and recommend future competition opportunities

In order to achieve our objectives, we took the following actions displayed in Figure 2. We aimed to enable the students of Katutura to compete in robotics at local, regional and global levels, foster teamwork skills, and lastly encourage students to pursue STEM in a fun and competitive environment. Our successful robotics team program aided Physically Active Youth in creating opportunities for the children of Katutura in both sports and education.

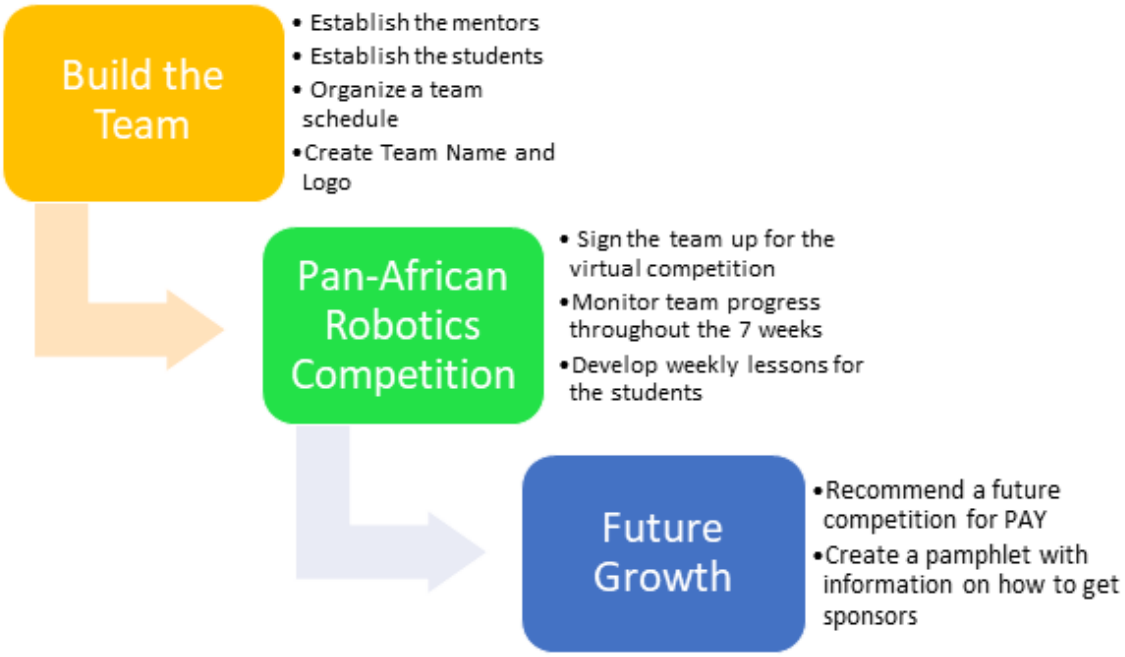

Figure 2. Visual of Team Objectives

3.1 Developing the Infrastructure for a Competitive Robotics Team

We first wanted to get a better understanding of how robotics teams function and how dynamics form within a team. We developed a survey, which can be found in Appendix C, through Qualtrics targeting students at WPI who have been on a high school or middle school robotics team. Because students at WPI come from all over the world, we received insight from a wide variety of robotics teams. The purpose of the survey was for us to better understand how participation on a robotics team impacts student development and to gather information on the structure of a successful robotics team. The questions on the survey varied, ranging from how many mentors the robotics team had to how the robotics team has impacted their education. One advantage of the survey is that we received responses from students who were on robotics teams all over the country creating a wide range of answers. A disadvantage is that one's experience on a robotics team in the United States may differ from that of someone in Katutura due to a disparity in available resources and opportunities. Our team used the information from the survey to organize the team in Katutura, and structure the team using a model based on other successful

teams. A limitation our team faced in this objective was distributing the survey to a relatively small population of students and finding people who qualify to take our survey.

Establishing a Team Administrator

One major challenge was not being able to travel to Namibia to complete this project. Due to this challenge, we had to find someone at PAY who was interested in doing ground-work for the robotics competition. This included helping find the students, running lessons, preparing students for the competitions, and taking students to competitions. During the project, we acted as a team administrator in coordination with Mr. Kleopas, a volunteer instructor at PAY. Acting as team administrator, we signed students up for the team, organized weekly lessons, registered the team for competitions, and made sure the students were on track and prepared for the competition. We communicated through Zoom, email, and Whatsapp to share the role.

The role of team administrator is a large component to making the project last because without someone at PAY who is invested in the project it will not hold longevity. Going forward, solely Mr. Kleopas will act as the team administrator. To assist him, our team created a table of roles and responsibilities that Mr. Kleopas will need to carry out in order to continue the robotics team. The list can be seen in Table 1.

Table 1. Roles and Responsibilities of a Team Administrator

Role Responsibilities	Logistical Components
Overseeing All People Involved	● Recruit students to join the team ● Find any additional mentors/coaches
Managing Weekly Meetings	● Schedule weekly lesson plans for each meeting ● Run weekly meetings or find someone to be in charge of the meetings
Preparing for Competitions	● Register for each competition ● Ensure that there is the correct equipment at PAY ● Until there is a business sub-team: use the sponsor pamphlet to find sponsors or reach out to past sponsors ● Make sure that students are on track to have a completed robot by competition ● Arrange logistical components of travel
Competitions	● Supervise students ● Oversee competition schedule to ensure students are where they need to be at a given time

This table details the preliminary roles and responsibilities for which a team administrator is responsible. All roles and responsibilities can be delegated, but the team administrator would still be in charge of checking in to make sure all components have been completed.

Establishing Mentors

Teams, whether it be soccer or robotics, often require additional mentors to assist the head coach in scheduling team meetings and supervising the students. One of the goals of our project was to find more volunteers to assist with the robotics team. However, after speaking with our sponsor PAY there are not enough staff available to provide additional mentors. Therefore, the responsibilities to help the students will fall onto Maruen Kleopas, Macveren Kapukare and Thuba Sibanda once our project is complete. Figure 3 is a rough plan for what the team

infrastructure looks like, a pyramid with the PAY administration at the top and students at the bottom.

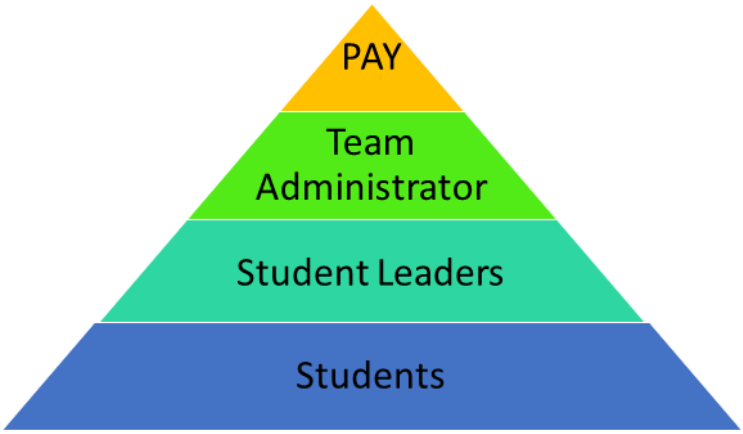

Figure 3. Model structure of PAY Robotics team

Establishing Members of the Team

In order to start a team, there must be members who are interested in participating. Our team along with the team administrator, Maruen Kleopas, created a sign-up sheet for the robotics team, containing the name of the participant and their age. With this, we signed up 33 students ranging from age 12 to age 18. The age of the students provided us with the information needed to decide what age-dependent league the teams will compete in and the number of sub-teams and mentors needed. The limitations with this component is that the WPI team was not able to be in Namibia to reach out to students and sign them up ourselves. This meant that all of the groundwork fell onto the shoulders of the team administrator, Mr. Kleopas, who is also a part time college student, making his time limited.

Organizing a Schedule for the Team

Once we established a team administrator, mentors, and members of the robotics team, the next steps were to discuss how often, when, and where the PAY robotics team will be meeting. We organized meetings over Zoom with the program director at PAY, along with the robotics team's administrator and mentors in order to set up a location for meetings which were held in the

computer room, and a schedule for the team as seen in Figure 4. We stayed involved and interactive with the team, despite being in Worcester by scheduling a weekly zoom call with a few of the sub-teams on the robotics team. The sub-teams rotated each week so that our team was able to meet with different students from PAY. The goal of these meetings was to learn more about how the team and the lessons were going from the student's perspective. By meeting with individual sub-teams it made it easier to understand what everyone was saying because only a few people were on the call. A limitation to this component is that the internet bandwidth at PAY is not that strong and therefore zoom calls would frequently freeze or cut out.

Monday	Tuesday	Wednesday	Thursday	Friday
One Hour: Lesson with STARS League Kids	One Hour: Lesson with TECHS League Kids	One Hour: Lesson with STARS League Kids		Three Hours: Robotics Club/Build Session

Figure 4. Sample schedule for Robotics team

Initiating Team Bonding

Teamwork is essential in any organization. Teamwork signifies that the members are working together towards a common goal and purpose. Once Mr. Kleopas and our team organized the robotics team's roster, the first meeting ran via Zoom in order for the team to meet the PAY students. The objective was to make this an interactive meeting with lots of participation from the students. We started the meeting with an icebreaker game to increase familiarity, and form a relationship with them. Setting the team goals gave a clear purpose and direction as well as helped the team stay on track. Team bonding led to a close-knit group and students having a better understanding of each other's interests, strengths, and weaknesses. To generate team building, plans for engineering-focused bonding activities were sent to Mr. Kleopas, in Namibia for the students to do in their respective sub-teams. In addition to team bonding, we created a team logo for the students on the robotics team, as seen in Figure 5, which included the team name and a slogan. Our team designed six logos and presented them to the Namibian cohort. The team then presented top three logos to the PAY students and let them decide on their team name. The goal of the team name and slogan was to generate team pride and excitement for the students

about what they can accomplish. A limitation faced in this component was that we were not able to be there in person and therefore the responsibility of running the team activities fell solely onto Mr. Kleopas.

Figure 5. Logo Design for PAY's robotics team the Namibots

3.2 Participating in the Pan African Robotics Competition

The Pan-African Robotics Competition (PARC) presented a great opportunity for PAY to participate in a robotics competition over the course of the project since it was held virtually due to the COVID-19 pandemic, it was free, and there was no limit to the number of teams an organization can register. Virtual robot kits based on VEX IQ robots and VEX V5 robots were used in the competition, which eliminated costs involved in purchasing and shipping kits to Windhoek. This was advantageous to PAY since VEX IQ kits are the same type of kits that were donated to them during the previous year's IQP; therefore learning and participating in this competition served as the foundation to knowing how to use the kits. There were two competition categories that students at PAY were eligible for: Techs League and Stars League. The Techs league was for participants from grades 4 to 8, and ages 11 to 15. Prior to the start of the competition teams were able to go to the practice arena on the PARC website and engage in preset challenges, written and video tutorials, and the virtual VEX IQ robots. The second competition was the Stars League which allowed participation from students in grades 9 to 12, and ages 15 to 19. There was also a virtual workshop room provided to practice building a virtual VEX V5 robot and use c-script programming, with tutorials available (*Register*, n.d.). This covered the entire age and grade range of students in PAY's current robotics program. Winners will receive a $1500 cash prize when the competition ends, and other top teams will receive

prizes from sponsors such as laptops, tablets, and robotics kits and mentoring. Figure 6 shows a pair of VEX V5 robots competing in a past PARC competition.

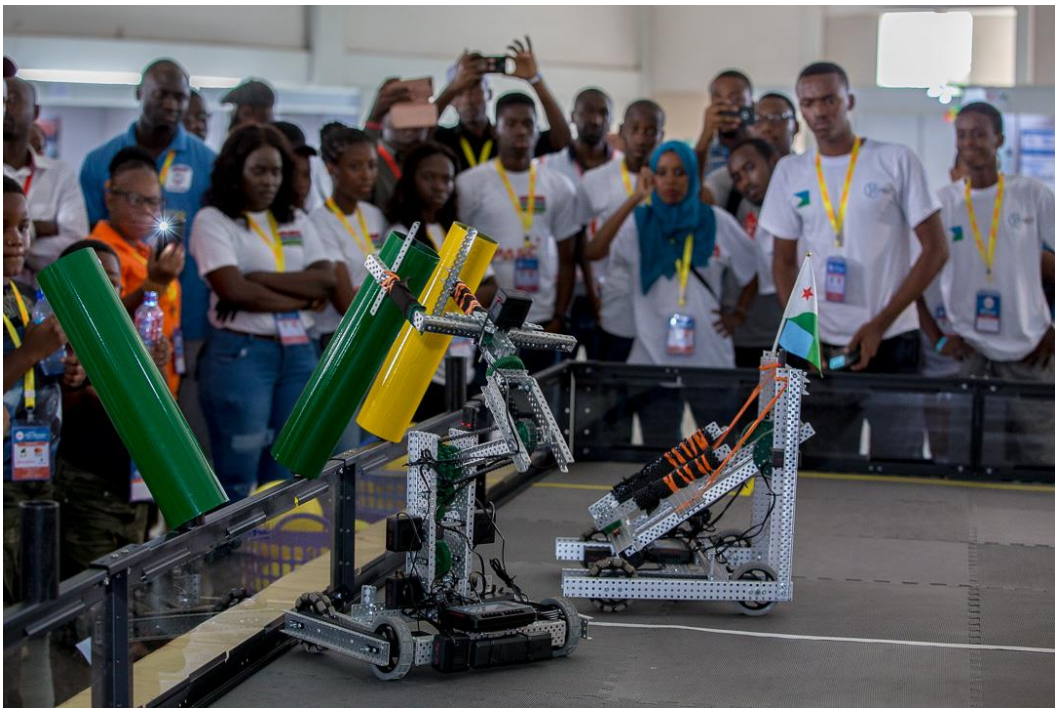

Figure 6. 2019 Pan-African Robotics Competition in Accra, Ghana

The competition began on April 1st, 2021 with challenges being published, and teams have until June 30th, 2021 to complete and submit their projects. The only caveat to this was a registration deadline of March 20th, 2021, a date during the planning and research phase of this project. This deadline made it imperative to rejuvenate the existing robotics program and set-up a legitimate team to register as soon as possible and participate in the competition. The time between the registration deadline and commencement date was enough to create the team roster and find mentors who had knowledge on block-based coding and c-scripting. Mr. Kleopas has helped with PAY's existing robotics program and found 31 students who were interested in participating in PARC across both leagues. With his help, PAY was able to create seven different teams to compete in the competition. This allowed PAY to meet both criteria to participate in the competition: interested students to participate, and a mentor to guide and coach them.

Video Lessons

Over the course of the project, we created weekly video lessons to assist the students in the competition challenges. For the Techs League, we recorded tutorials regarding various programming concepts using the PARCode block coding language. We then applied these concepts to solve one of the challenges presented by the competition. This format worked well, as the Techs League released a new challenge every two weeks, which was enough time for the team to address the challenge in a video or two.

The Stars League, which required the use of the PARCSim, was in two parts. The first component was designing an aesthetic robot that had the most sophisticated design and look, and not functionality. The second part was controlling a robot using c-script and completing preset objectives. We recorded tutorials elaborating steps in designing virtual robots and including various components of the virtual kits, and coding instructions that described how a robot could accomplish a competition objective using c-script programming.

Student Feedback

In order to further improve and advance the PAY robotics team program, we created a survey for PAY students to give feedback on PARC. This survey provided student insight on what went well with the competition, what did not go well, the educational value of the lesson plans, and what could be improved. The survey included questions such as: are you finding your mentors helpful, how has being on the robotics team improved your STEM skills, and do you want to be on the team next year. We administered the survey through Google Forms and the questions can be found in Appendix E. The feedback will allow PAY and potential future WPI teams to make program adjustments and to gauge student interest for the future.

3.3 Assessing Future Competition Opportunities

Throughout the term, our team assessed the various robotics competitions by interviewing representatives at different organizations including VEX, PARC, First Global, RECF and FIRST, as well as conducting personal research about their robotics competitions. Our interviews also included Brad Miller and Ken Stafford, two WPI robotics professors, Colleen Shaver, a

representative from FIRST, Fatima Kebe, the PARC director, Stephanie Slezyck, a representative at FIRST Global, and Dan Mantz, the CEO of REC Foundation. Whether our team was conducting an interview or doing additional research, we looked at the competitions with the future growth of the robotics program at PAY in mind. While the students at PAY participated in PARC this past spring, our team worked on helping PAY decide on a competition for them to participate in for years to come. The robotics competitions that we looked at included VEX IQ, VEX Robotics Competition, PARC, FIRST Global, FIRST Lego League, FIRST Tech Challenge, and the Live Remote Tournament. The interviews that we conducted with the aforementioned people, enabled our team to gain deeper knowledge about each competition that could not be found on their websites. One example of this was learning about the support that a team might receive from the parent organization. We learned that organizations like VEX and PARC are much more likely to help teams cover various costs and might even donate the robotics kits if necessary.

Deciding on a Competition

In order to decide on a future competition, there were many components that our team took into account. We looked at specific criteria points for each competition and compiled a holistic assessment model which can be seen in our results. Our team created the assessment model to be able to keep track of their findings, but also for us to share with their sponsor. We obtained the information contained within the table through our interviews and research to fill in the gaps. Our team used this table to compare all of the competitions at once. One major component to this objective was ensuring that PAY was able to pick the competition that they thought would be best for them to compete in for years to come. This is where the idea for the holistic assessment model came from. It is an easy-to-follow and concise list of the most important information about each competition. There were more criteria points that our team could have included, but we chose the ones that were of the greatest importance to PAY. The criteria that we chose to include are as follows:

- Registration fees
- Robotics kit cost
- Support given from parent company
- Age range of students that can compete in the competition

- Difficulty level of competition
- Programing language used
- The team size
- Number of required mentors
- Teaching resources available from parent company
- Additional fees

While the holistic assessment model gives our team an overview of how each competition meets the criteria points, there was no quantifiable data within the table. We realized that while the table is an excellent place to start as it has the most important information all gathered in one place, we were later going to need to find a way to quantify how each team compares the other competitions. To do this we created a Pugh Analysis Chart which can be seen in Table 3 of our Findings Chapter. We ranked each criteria point on a scale of one to five; one being least important and five being most important. The criteria points that we deemed most important were ones that had to do with cost and support from the parent company; money is the greatest barrier of entry for PAY. We then gave each competition a value of negative-one, zero, or one based on how it met the criteria points; the value of negative-one meant that the competition did not meet the criteria point, the value of zero meant that it was neutral, and a value of one meant that the competition met the criteria point. We then calculated a final score for each competition, with a higher score meaning the competition meets more criteria points.

Sponsors

Robotics competitions are notoriously expensive. There are high costs for robotics kits, competition fees, and travel, which makes having money imperative. While the PAY students were competing in the virtual PARC Competition, funding was not critical because the competition was free. Going forward, PAY aspires to compete in in-person competitions that have high costs. Finding sponsors is a key component of robotics teams. Without having decided on competition, we were unable to contact sponsors because most sponsors want a team to have a concrete plan before giving them money. In order to get around this obstacle, we created a pamphlet that includes information on having a business sub-team, how to create a budget, where to find sponsors, and a template email to send out to sponsors. This will give PAY and future WPI teams the ability to reach out to sponsors with the foundational work done.

3.4 Summary of Deliverables

Our team's deliverables helped PAY create a robotics team and introduced them to robotics competitions. For each research objective, the data we collect will contribute directly to the creation of a deliverable, so we categorized each deliverable by objective. After completing the research, the team delivered:

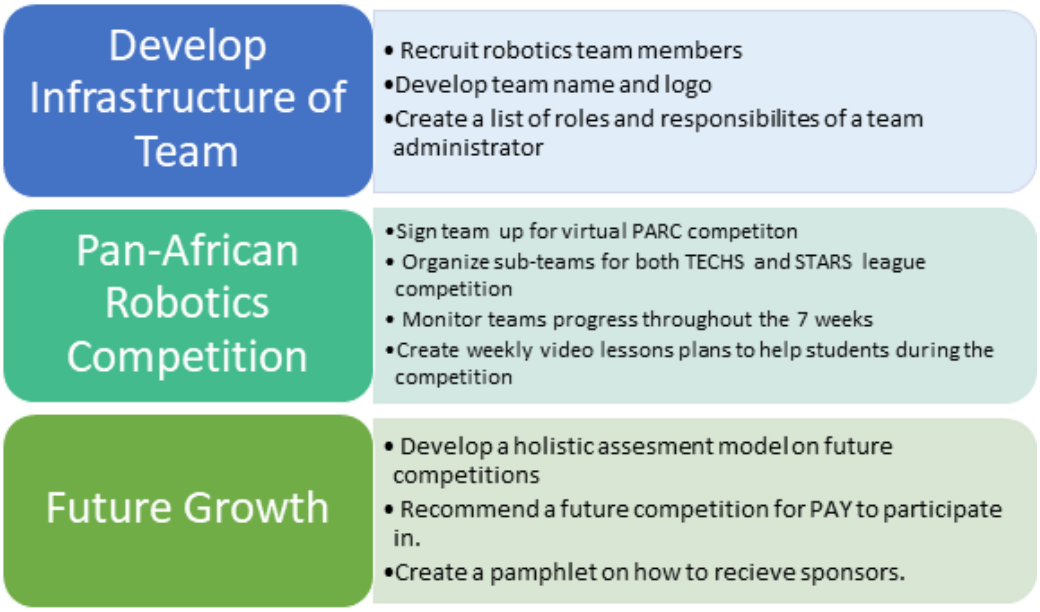

Figure 7. Summary of deliverable chart.

4. Findings

We followed our methodology to achieve our objectives to develop the infrastructure of the robotics team, participate in the Pan African Robotics Competition, and make recommendations for future competitions and ways to continue the team. This chapter will explain our results and findings.

4.1 Developing Team Infrastructure

To better understand how to develop the infrastructure of the Physically Active Youth Robotics team, our team distributed a survey to WPI students with experience on middle-school and/or high-school robotics teams. We used the survey to analyze how a robotics team is successful in regards to their structure, team dynamics, and what the students take away from the team.

Our team wanted to make sure that the robotics teams we were analyzing and basing the PAY robotics team on were successful teams. One measure of a successful competitive robotics team was based on how well their team worked together. Our survey questioned people on how well their team worked together on a scale of one to five. Of the 27 people who took our survey and said they were on competitive robotics teams, 100% of the respondents said their team worked somewhat well to very well together, as seen in Figure 8. In addition none of the respondents stated that their team did not work well together. From these results we concluded that all of the robotics teams were successful and that we can infer some of the information from the survey as a model for building the PAY competitive robotics team.

Figure 8. Graph illustrating responses to a survey question on team cohesion

4.1.1 Team Infrastructure

By analyzing our survey results from WPI students with experience on competitive robotics teams, our team found the following insights on team size, number of mentors, mentors with prior robotics experience, and gender ratio, as a foundation for the structure of a youth robotics team:

Team size

A successful robotics team can range in size. The number of teammates does not directly relate to the team's success. The range varied for all responses -- from 2 to 50 members in a team as seen in Figure 9 -- and most of the responses claimed their teams worked well together.

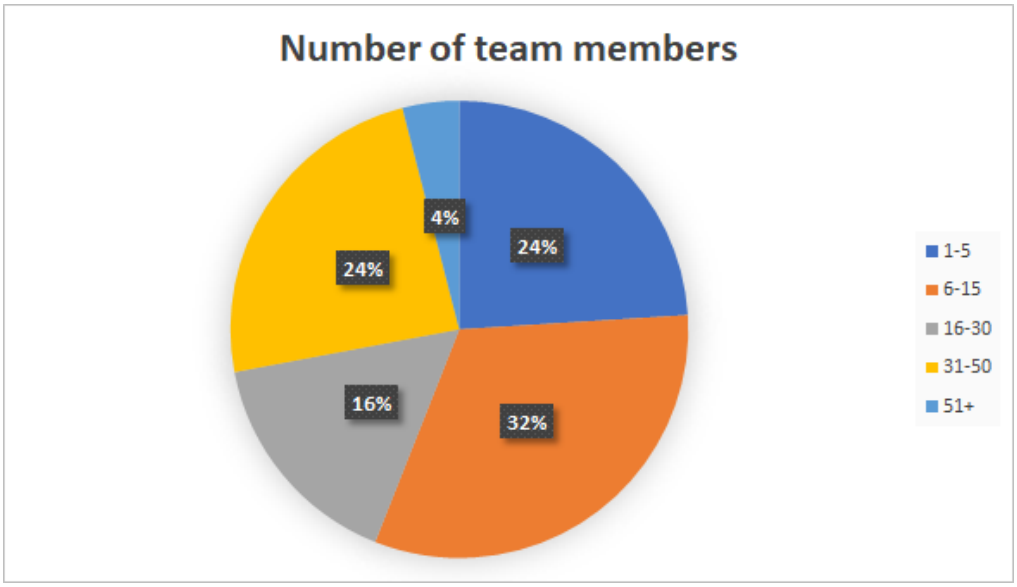

Figure 9. Chart of the number of team members on a competitive robotics team

Mentors

Teams do not need a large number of mentors. These mentors also do not need to have prior robotics knowledge, since they mainly act as facilitators for practices before a competition in advanced teams. 52% of responders said their teams consisted of 1-2 mentors, averaging at about 5 - 10 students per mentor. Out of all respondents, about 30% had mentors with no prior robotics experience, as seen in Figure 10.

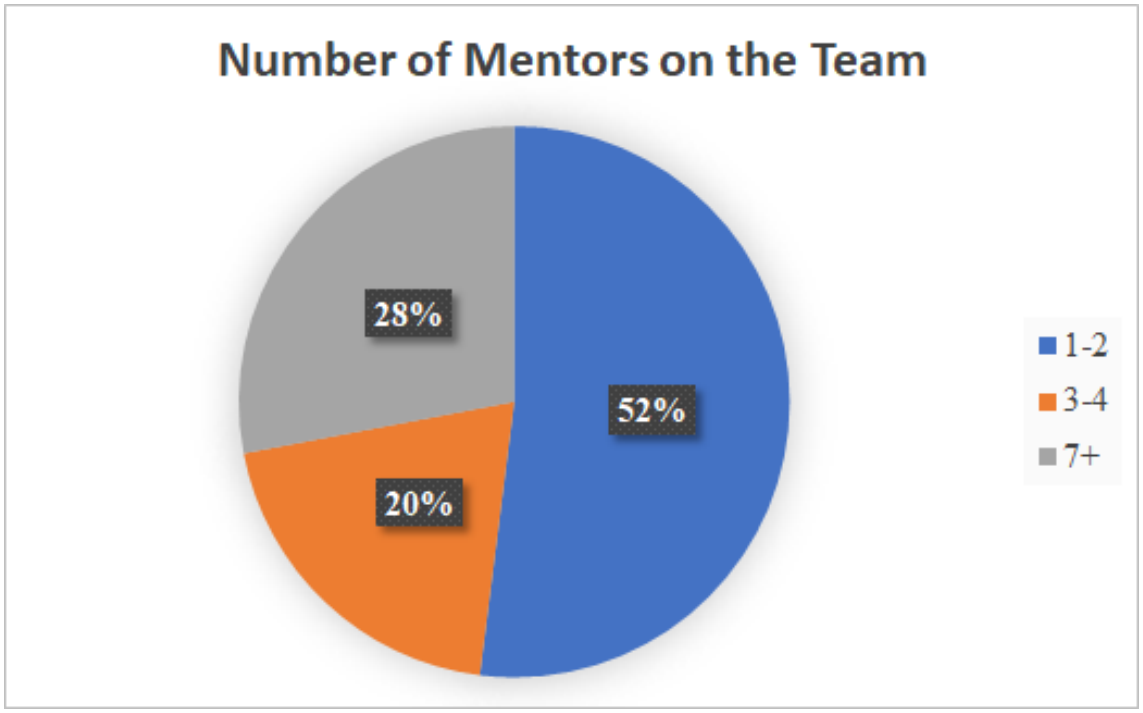

Figure 10. Chart of the number of mentors for the team

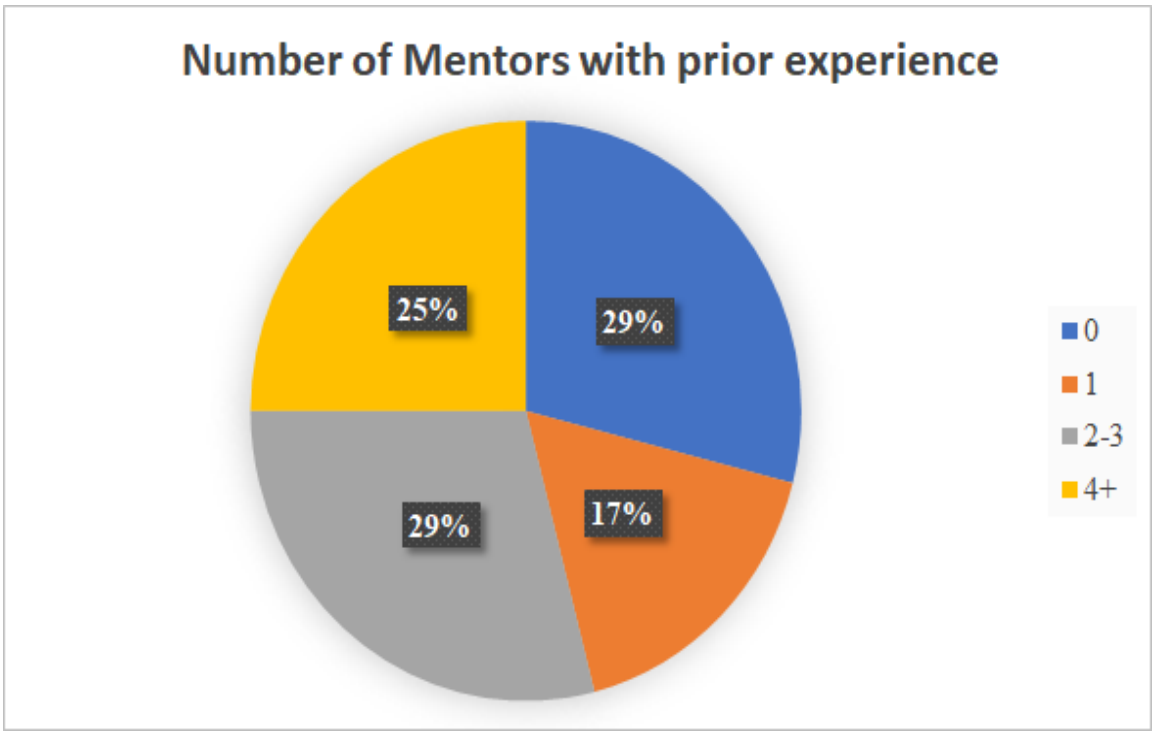

Figure 11. Chart of the number of mentors with prior experience

4.1.2 Team Dynamics

In our survey, we asked WPI students with past experience on robotics teams what they enjoyed the most about being on a robotics team. Their short responses, which can be found in Appendix I, were coded by our team into categories as seen in Figure 12.

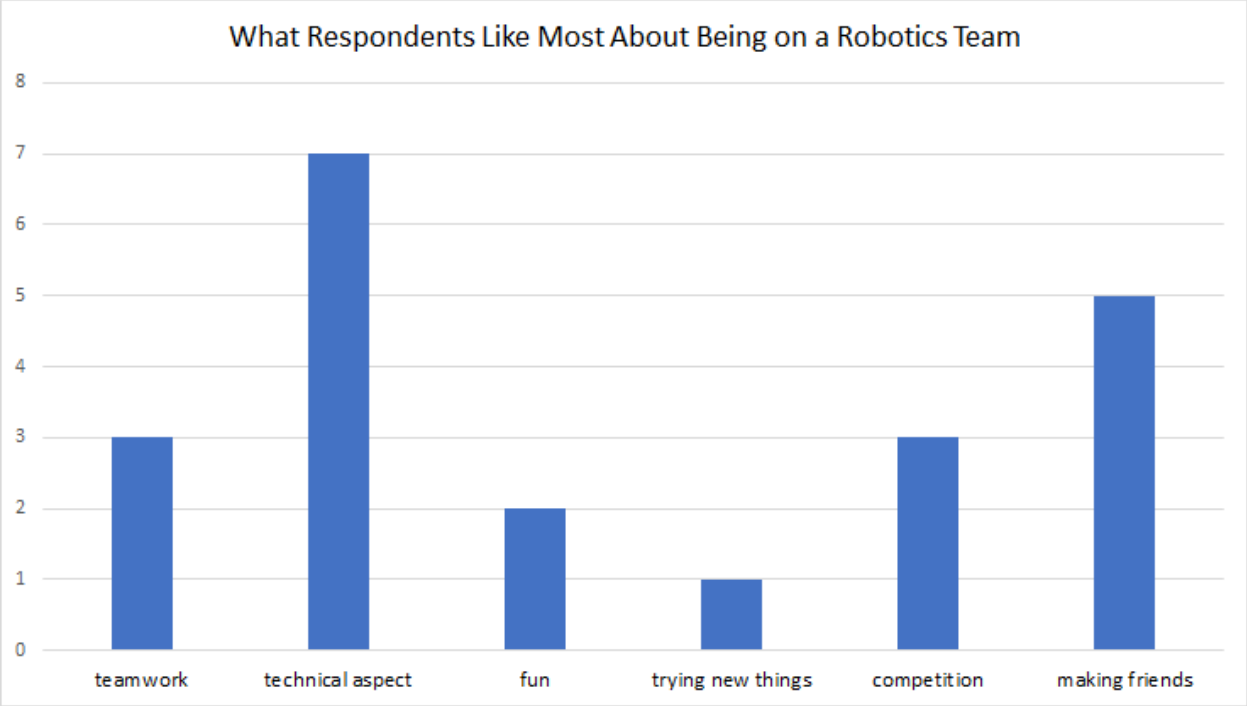

Figure 12. Graph of What Respondents Like Most About Being on a Robotics Team

After analyzing the data, our team came with the following findings about the type of dynamics, environment, and relationships formed within a successful robotics team:

Solving Technical Challenges as a Team

Learning the technical aspects of robotics, such as building, programming, and problem solving with other team members, contributed to an enjoyable robotics experience. Seven people responded to the survey stating that they liked learning and solving the technical challenges presented while on a robotics team. In addition, three people responded that they liked solving the challenges as a team and working with others. A respondent stated in the survey, “I enjoyed collaborating on ideas for completing competition tasks and helping design the robot.”

Fun Environment and Trying New Things

A fun environment made learning STEM and trying new things more positive. Three respondents of the survey stated that they enjoyed the robotics team because of how fun it was. One respondent stated that they liked how being on a robotics team gave them the opportunity to try

new things. A respondent states: “we had a lot of fun, and built on our relationships as well as the robots. They gave me memories I’ll never forget.”

Competitions

The competitive aspect of being on a robotics team makes the members work harder and is rewarding to the team. Two of the respondents liked the competition side of robotics and one respondent stated specifically that he liked “the combination of the creative and competitive aspects.”

Making Connections

The friends and sense of community that comes with being on a team helps to create the environment of a successful team. Five of the respondents indicated that they enjoyed forming relationships within the team and the sense of community that came with it, as seen in the qualitative responses in Appendix I. One states “I enjoyed the building, and designing and programming of the robot, but I also enjoyed the friendships and connections I made. Some of my closest and best friends are from robotics, several of them from hundreds of miles away and we would not have met if it were not for robotics.”

In the same survey, we asked WPI students what their least favorable aspect about being on a robotics team was. Their short responses, which can be found in Appendix J, were coded by our team into categories as seen in Figure 13.

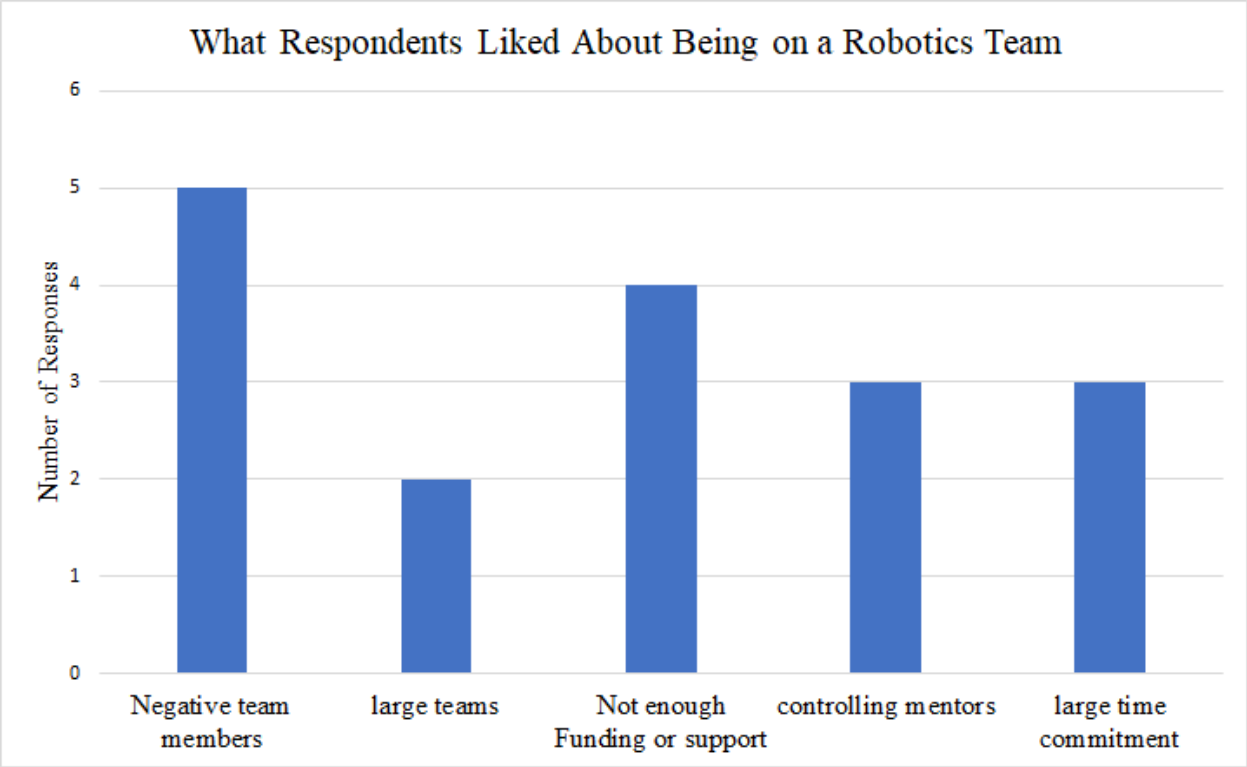

Figure 13. Graph of What Respondents Like Least About Being on a Robotics Team

After analyzing the data, our team came to the following findings about the negative dynamics formed within a robotics team:

Negative Team Members

Negative team members that do not want to be there oftentimes bring the team down. The most common aspect that people disliked about being on the robotics team was having negative team members; five of the respondents expressed this. One respondent stated “we definitely had some team members that weren't really into it and were just doing it because their parents wanted them to. It was very hard to work with these team members and it was tough to see them so unhappy with the work.”

Large Team

Having too large of a team and not enough tasks for individual members to work on creates an unenjoyable team environment. Two people filling out the survey responded that they disliked

having too large of a team because it meant that they could not work on the robot as often.

Funding and Support

Challenges with finding enough funding and additional support for the team was a dislike for many people. Four respondents stated that not having enough funding and support was stressful. Specifically, "being on a small inexperienced team without major funding meant the competitions were basically hopeless." Another stated that "we were not well supported by the school administration and that caused various issues with our ability to compete."

Controlling Advisors

Respondents indicated that they did not enjoy having mentors and advisors who were too controlling and restrictive to their projects. Three of the 17 respondents stated that they disliked how controlling their mentors or advisors could be. Robotics teams are supposed to promote creativity and collaboration between the team members.

Late Hours and Time Commitment

The large time commitment to the team is another dislike of three people who have participated on robotics teams. One stated that they disliked "late night hours" and another stated that what they disliked the most was "the time commitment and fighting."

4.1.3 Outcome of Being on a Robotics Team

In our survey, we asked WPI students the most significant outcome of participating on a robotics team and how it has helped them today. We gave them open-ended questions to gain more personalized views on the effects being on a robotics team had on each respondent. Their responses, which can be found in Appendix K, are summarized in Figure 14. Responders were in consensus that being on a robotics team improved their teamwork skills in general. Of all the participants in the survey, eleven agreed that it had enough of a positive influence on them to persuade them into STEM career paths as seen in Figure 14.

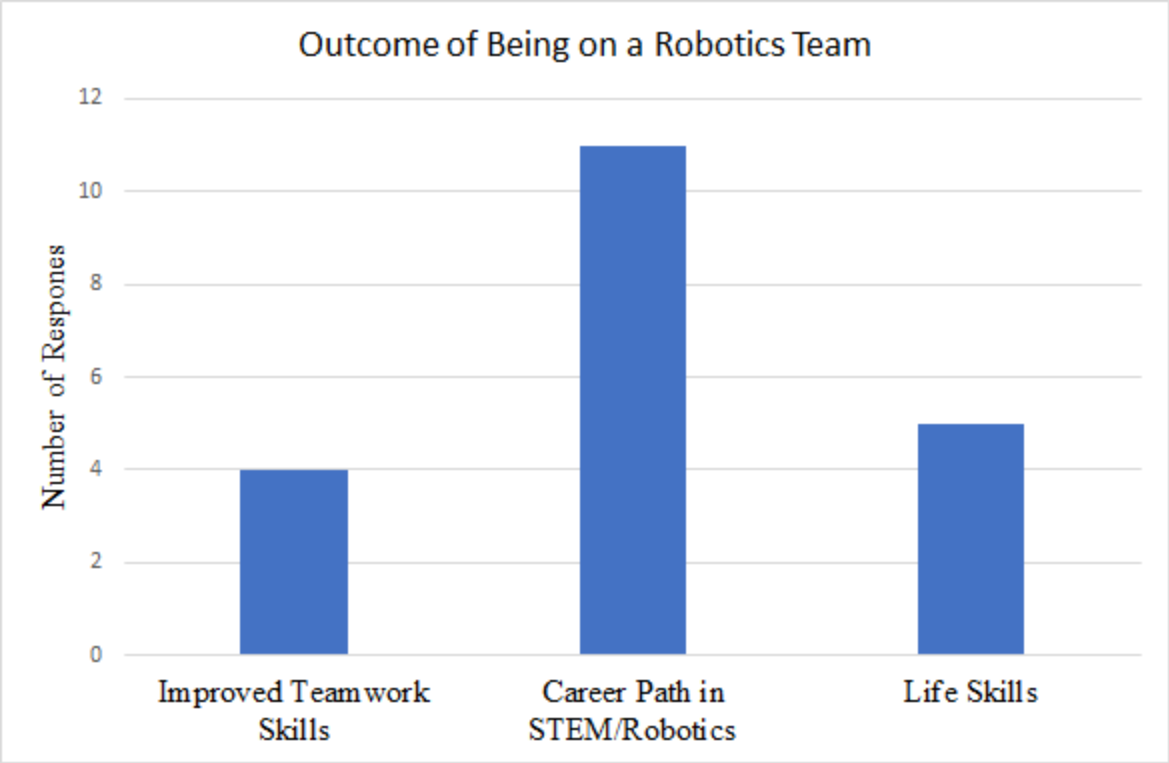

Figure 14: Outcome of Being on a Robotics Team

Most respondents agreed that being on a robotics team helped them choose a career path in STEM, such as majoring in Robotics in college. One respondent said, “It helped me learn and grow as a person. Being on a robotics team directly influenced my career path; I would not have become a robotics major if I hadn't done robotics in high school.” Five respondents also acknowledged the positive influence it had on improving their life skills such as problem solving, leadership, communication, and confidence.

4.2 Participating in the Pan-African Robotics Competition

Throughout the term, students at PAY competed in the Pan-African Robotics Competition. We made sure that they knew the content they needed to complete and monitored them along the way. The purpose of this was to get the students engaged in a competition as soon as possible and for us to learn about the challenges faced by a robotics team during a competition and adapt the team to address these challenges. Additionally, compiling these findings at the end of the

term helped us make recommendations on how future projects could improve and continue developing the competitive robotics team at PAY.

4.2.1 Feedback from PAY Staff and Students

Throughout the term, we periodically checked in with the students and staff of PAY to receive feedback on our lesson plans and shape them to PAY's needs. We met with three teams of students every Friday, and from these meetings we learned that they found the videos engaging and clear in their explanations. One team gave constructive feedback in that they would like the videos and lessons to be taught at a faster pace.

Meetings with the staff also taught us ways to improve our efforts. We often met with our main contact, Mr. Kleopas, usually about twice a week. His feedback was invaluable in helping us deliver the most effective lessons to the students, which resulted in the following:

Video Lessons

Initially, we wanted to live stream the student lessons so we could interact with the students more closely. Mr. Kleopas suggested recorded videos, as there is limited network bandwidth at the PAY center. Additionally, videos are helpful in that they allow each student to move at their own pace, as they can simply rewind if they ever lose focus.

4.2.2 Interview of Team Leader: Maruen Kleopas

To assess our success in acting as mentors and assisting the team leader Mr. Kleopas prepare the students for the Pan-African Robotics Competition, we interviewed Mr. Kleopas at the end of our project. The interview gave Mr. Kleopas the opportunity to reflect on what went well with forming the team and competing in PARC, in addition to what needs improvement.

In regards to the weekly videos and lessons, Mr. Kleopas stated that they were a big help and gave the team a sense of direction, contained clear instructions, and helped Mr. Kleopas understand the competition himself. Competing in PARC, according to Mr. Kleopas, improved the students' STEM skills. The groups had good collaboration and when they would work together they would share information and the skills that they had picked up on. The students developed teamwork skills and were able to "learn how to work as a team, not just as individuals. That is far more important than working alone on it." Mr. Kleopas also mentioned

that the team is working well together, however some of the students are still shy and don't always want to take part with kids they are not comfortable with.

Our team asked Mr. Kleopas what he would currently change about the robotics team, he responded that the structure and organization of the lesson plans along with the lesson delivery method can be better organized. Mr. Kleopas also stated that as the team leader, he can improve on figuring out what lesson he should deliver based on the stage of the competition. In addition, challenges that the team has faced is having technical difficulties running the PARCode which uses block based coding, the specific difficulties are in connecting the blocks and saving premade codes. In regards to what can be kept the same about the team, Mr. Kleopas stated the positive team atmosphere and reshuffling the students into different groups every month so they work with new people. Lastly, Mr. Kleopas would not want to change having the virtual platform to compete on due to how accessible it is.

4.2.3 Survey of PAY Students

To assess our success in preparing the students at PAY for the Pan-African Robotics Competition, we administered a survey at the end of the term so that students could voice their opinions on how we handled PARC and what they learned as a result. The survey questions can be found in Appendix E. This survey was administered via Google Forms because Mr. Kleopas expressed that it would be the easiest mode for him to distribute. Here are our findings.

Robotics Experience

Students on the robotics team did not have much prior experience in robotics. According to Mr. Kleopas, being at PAY was the first time some students had the opportunity to interact with a computer and most had little to no understanding of how robots worked. In the survey, about 9% of respondents said they had no prior robotics experience, and about 74% of them said their prior experiences were only through PAY's robotics program, as seen in Figure 15.

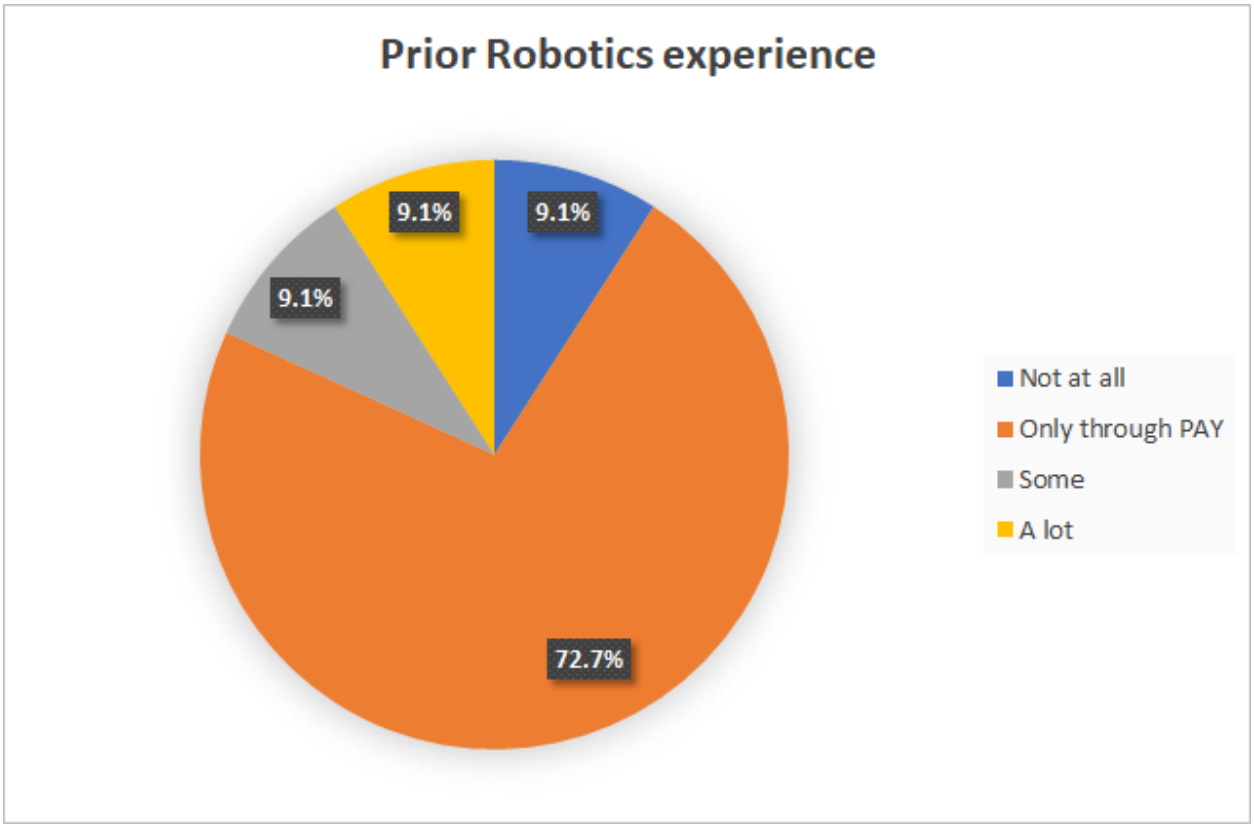

Figure 15. Chart of students prior robotics experience

Videos and Lesson Plans

Throughout our project, our team made ten educational videos for Mr. Kleopas to show the students during their lessons. These videos were created to assist the students solve the PARC challenges. Based on the responses of our survey the videos on both PARCode and PARSim have been very helpful during the competition.

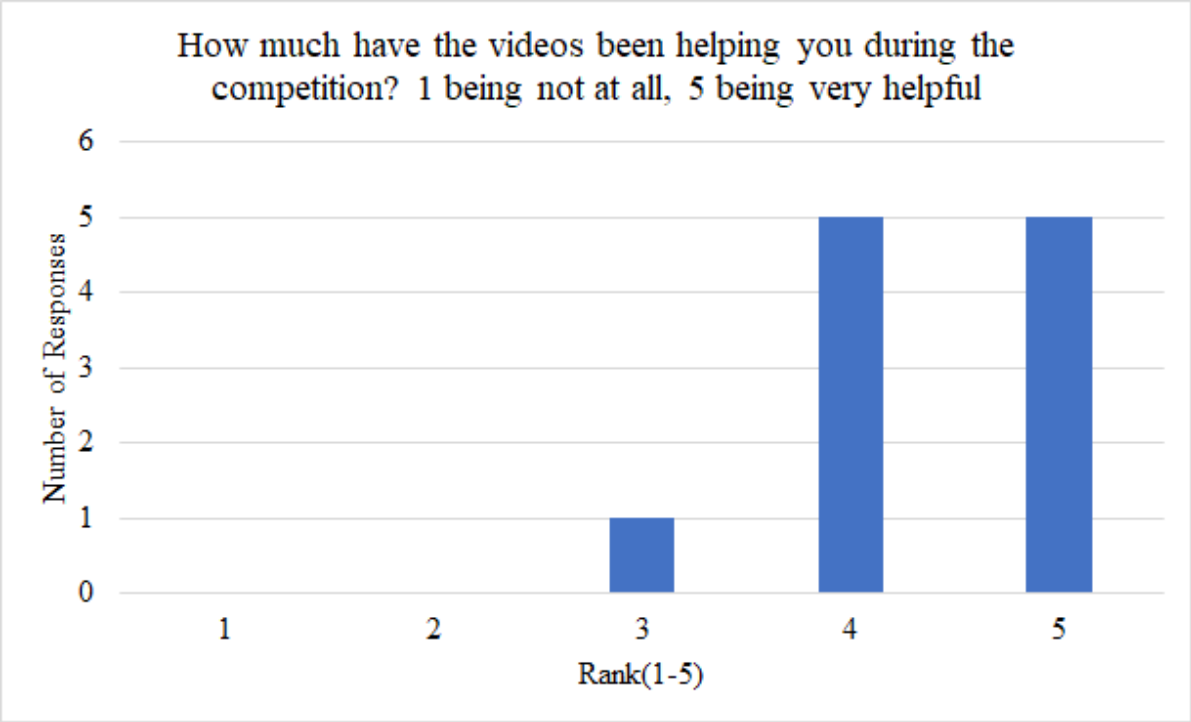

Figure 16. Graph of how helpful the videos were during the competition

Team Impact

The development of the team has had an overall positive impact on the students and has positively influenced their attitudes towards science, technology, engineering and math. The responses on the survey demonstrate that the formation of the team has promoted STEM in a fun and enjoyable manner.

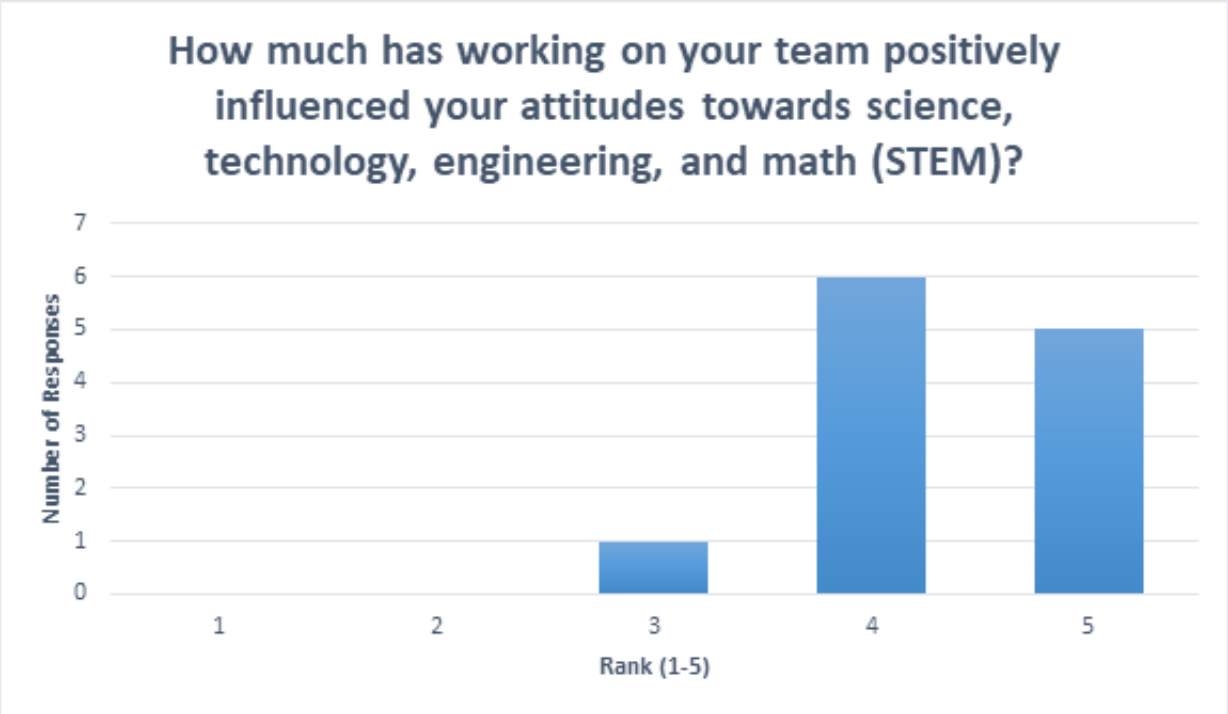

Figure 17. Graph on how being on the team has influenced attitudes towards STEM

In addition to improving the students' positive view of STEM, the formation of the PAY robotics team has improved the students' teamwork skills. This is a result of the students sharing their knowledge and having to work together in smaller sub-teams to figure out the challenges.

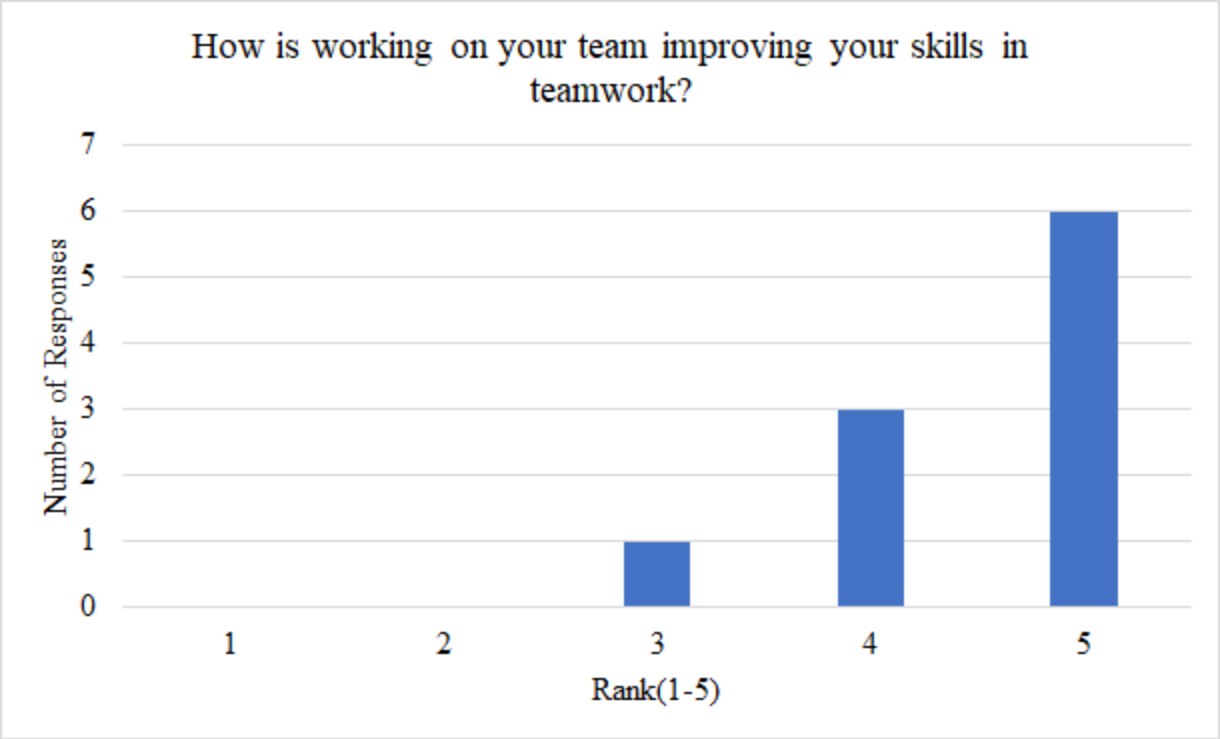

Figure 18. Graph on how working on the team has improved teamwork skills.

Challenges

Although enrolling the students in PARC had a lot of positive impacts on the students, it did come with its own limitations and challenges students had to overcome. Since the virtual aspect of PARC was new, there were often issues with their software that hindered the students' progress. In the survey, students were asked what their biggest challenge was, and some did mention the issues with the software, and communication regarding the competition as seen in Figure 19.

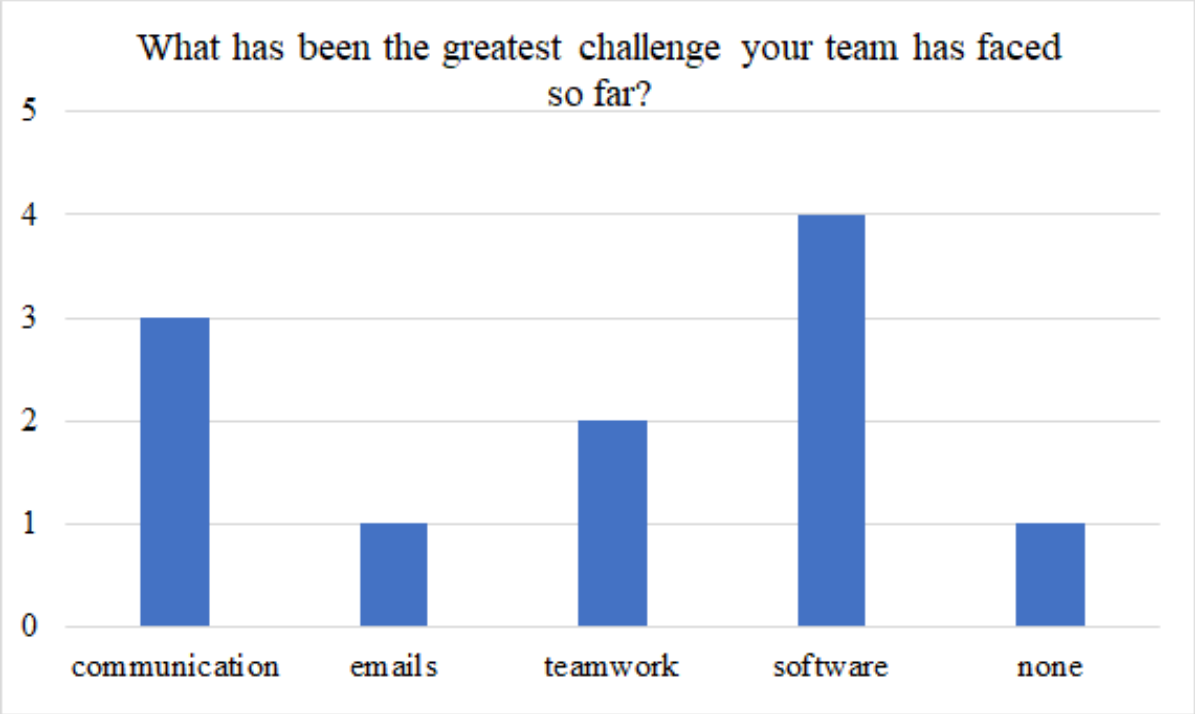

Figure 19. Graph on challenges PAY teams have faced so far

4.3 Assessing Future Robotics Competitions

Our team found seven different robotics competitions that we believed PAY could compete in. To narrow down the competitions and find the most feasible option for PAY, we learned more about each competition and then compared all of the data. Our team conducted interviews, researched, and made comparison models to have sufficient data to share with our sponsor.

4.3.1 Interviews

Our team held interviews with representatives from the different robotics organizations, such as Dan Mantz, the CEO of Robotics Education Competition (REC) Foundation, to gain a deeper understanding of how feasible each competition would be for PAY. Through the interviews, we learned about the support each parent organization offered to teams. This included but was not limited to financial support, waiving registration fees, and donating robotics kits and materials. We formed strong relationships with the representatives that will benefit PAY in the future regardless of which competition they choose. The interviews showed us that regardless of which competition they choose, having connections within the organization is important for the program's longevity.

4.3.2 Competition Information

The seven competitions that our team looked at were VEX IQ, VEX Robotics Competition, FIRST Lego League, FIRST Tech Challenge, FIRST Global, PARC, and LRT. In order for our team to compare the competition we compiled data first about each competition. This acted as a brief synopsis for our team to look back on when referring to each competition. Information about each competition can be found in Appendix H. This information came from interviews and additional research our team did. While the information found in our comparison tables is specific to our criteria, the information in our synopses was more general and described each competition. This was beneficial when speaking with our sponsor because before we got into the specific criteria points we could first give them an overview of the competition.

4.3.3 Comparing the Competitions

After completing our interviews and doing additional research to gather information on the most important criteria for our sponsor, our team compiled all of the data and developed a holistic assessment model as seen in Table 2. We obtained the information contained within the table through our interviews and research. Our team used this table to compare all of the competitions at once.

Table 2. Holistic Assessment Model Comparing the Seven Competitions

	VEX IQ	VEX RC/V5	First Lego League	First Tech Challenge	First Global	PARC	Live Remote Tournament (LRT)
Registration Fee	Registration fee for additional teams in same challenge is discounted. $150 for first team and $100 for additional teams	Registration fee for additional teams in same challenge is discounted. $150 for first team and $100 for additional teams	$300 (includes registration and challenge materials)	$275	$1600-$1800 (Includes Kits)	$250	No Registration Fee
Robotics Kit	$380-$580 (12 kits donated)	$1000-$1650	$410-$535	$1,200	$1000+ (Included in registration)	Provided (may have to pay for shipping)	$380-$580 (Dan Mantz will donate more kits if needed)
Closest Location	Morocco, Egypt	United Arab Emirates	South Africa	South Africa	International: Varies	East Africa (Rwanda 2020)	At PAY
Company Support	Already have 12 VEX IQ kits donated	Grants available to apply for	Limited support, some grants and scholarships are available to apply for	Limited support, some grants and scholarships are available to apply for	Financial Aid for Countries	Scholarships available	Dan Mantz wants to help run this at PAY. Willing to help fund the project.
Age Range	9-15	14-18	9-16	12-18	14-18	11-15, 15-19, 18+	9-18
Difficulty Level	Easier kits to use, and students have experience with them	Moderate-High Difficulty Level	No technical experience is required, and all skills levels and interests are welcome.	All skill levels and interests are welcome, experience not required, but helpful	Olympic Style: All skill levels are welcome	Varies by league. There are 4 leagues ranging in difficulty level	Easier kits to use, and students have experience with them
Programming Language	Block Based	Block and Text	Word Blocks based off of Scratch	C/C++, LabVIEW, and JAVA	Scratch or Java	Scratch, C Script	Block Based
Team Size	Average size 4-6 but no maximum	Average 5-7 but no maximum	Up to 10 students	Up to 15	1-2 students from PAY	4-6	No maximum but having more teams that are smaller would be better
Number of mentors	2	2	At least 2	At least 2	At least 2 (none from PAY)	1-2	2
Teaching Resources Available	Virtual lessons, free software, and a team manual dictating team roles, registration, how to prepare for competition, sponsors, and what to expect	Lessons, free software, and how to create a team manual	Has a challenge guide for distance education. Uses Google Classroom	Programming resources, challenge guide, fundraising resources, and robot building resources	Programming lessons available	They are working on creating a curriculum for teachers and students on their website	Virtual lessons for students and mentors to use and the software is entirely free
Additional Fees?	N/A	N/A	Partners may charge an additional fee to participate in their events	Partners may charge an additional fee to participate in their events	N/A	N/A	A video camera and a game field (Dan Mantz will provide game field)

After compiling all of our findings into the holistic assessment model our team created a Pugh Analysis Chart which can be seen in Table 3. The final scores for each competition did not surprise our team. The four competitions that scored five points and under, VEX RC/V5, FLL, FTC, and First Global, all did not meet many of the important criteria points while the three competitions that had the highest scores, VEX IQ, PARC, and LRT, each met most if not all of the top criteria points. The top three competitions all ranked within a few points of each other with the LRT scoring the highest and PARC scoring the lowest of the three.

Table 3. Pugh Analysis Table Comparing the Seven Competitions

		Competitions						
Things to Consider	Score	VEX IQ	VEX RC/V5	First Lego League	First Tech Challenge	First Global	PARC	LRT
Registration Fee	4	1	1	0	0	0	0	1
Robotics Kit	5	1	-1	1	-1	-1	1	1
Closest Location	4	0	-1	1	1	-1	1	1
Company Support	5	1	0	-1	-1	1	1	1
Age Range	3	0	0	0	0	0	1	1
Difficulty Level	1	0	0	0	1	1	1	0
Programming Language	2	1	1	1	1	1	0	1
Team Size	2	1	1	0	0	-1	-1	1
Number of mentors	1	0	0	0	0	0	0	0
Teaching Resources Available	3	1	1	0	0	0	1	1
Additional Fees?	3	1	1	-1	-1	1	1	0
Total (Weighted)		24	5	3	-6	0	22	28

The values are subjective, which can bias the data, and in order to ensure that our opinions are not getting in the way, our team will use the scores as a way to group the competitions as opposed to a way to rank them. We created two groupings. The first grouping was competitions that scored below five. Our team found these competitions not to be feasible for PAY. The second grouping was competitions that scored above 22. The three competitions that fall into this category are **VEX IQ, PARC,** and **LRT**. These competitions are all similarly feasible for PAY because they have the lowest barrier of entry. Our team was then able to discuss the three competitions in order to make a recommendation to our sponsor.

4.3.4 Sponsor Information

Our team collected sponsorship information to create a concise pamphlet guide for PAY. The pamphlet can be seen in Appendix L. The sponsor information came mainly from manuals on the PARC, FIRST, and VEX websites with additional findings from meetings with competition representatives. Our team was able to meet with fellow classmate Jackie Aaron, a founding member of her high school's robotics team. She focused a lot of her efforts on sponsorship during her time on the team because like PAY, there was no prior funding to start the team. Ms. Aaron was able to provide our team with valuable advice on best practices a new team should

take when looking for sponsorship. This included how to best market your team and suggestions on meeting with potential sponsors in-person if possible. We compiled information in three different sections for the pamphlet. The first section is titled “Get to Know Yourself” and includes a team portfolio, a budget, and information about the team’s online presence. The second section is titled “Reaching out to Potential Sponsors” and contains a list of potential sponsors, a template email, and information on how to follow-up with sponsors. The last section is titled “Host a Showcase Event” and this section contains information on the importance of showing sponsors what your team is doing to gain their interest and on hosting smaller-scale fundraisers. All of this information combined will act as a guide for PAY to follow in the future.

4.4 Summary of Findings

Our team used our findings to help PAY establish the infrastructure for their robotics team, adjust lessons based on how PARC went, and recommend a competition for PAY to compete in for the future. The information we gathered allowed us to leave behind instructions for PAY and potential other IQP teams. Our team accomplished a lot during our seven weeks, but there is still more to be done in the future. For this reason, we left behind a proposed plan for future teams to continue our project, which we describe in the next chapter.

5. Conclusions

This chapter is an overview of our deliverables, recommendations, and continuation plan based on our findings chapter. Throughout the term our team worked on three objectives:

1. Develop the team infrastructure
2. Participate in the Pan African Robotics Competition
3. Assess and recommend future competition options

We developed findings for each of these objectives through interviews, surveys, and research. These findings informed us as we continued with the project, to produce the best deliverables, make the highest quality recommendation, and create the most thorough continuation plan. For example, through our surveys of students at PAY and former members of robotics teams, we were able to receive feedback on both how a robotics team should be structured and how it was being implemented at PAY. Additionally, through research, analysis, and interviews, we gathered information regarding various competitions in which PAY would potentially participate. We then used a Pugh analysis chart to make a decision on the most feasible option. These varied findings were essential in informing our conclusions.

When creating our deliverables and making recommendations, sustainability of the program was our first thought. This included creating deliverables that will aid PAY and future teams with continuing our project and leaving behind resources that we believe will help the team in the long run. When analyzing our findings to make recommendations our team took certain criteria into account more than others for its ability to help the team in the long run. By doing both of these things our team was able to create deliverables and recommendations that will ensure the longevity of the robotics program and team.

5.1 Deliverables

Throughout the project, we created as many deliverables as possible in order to maximize the effect of our work. In the end, we managed to deliver:

Recruited robotics team members
With the help of Maruen Kleopas, we recruited 34 students to join the robotics team.

Developed a team name and logo

By polling the staff and students at PAY, we decided on a team logo and the name Namibots for PAY's robotics team. Additionally, we secured funding from WPI's Innovation & Entrepreneurship department to print t-shirts with the new name and logo for everyone on the team.

Enrolled students in PARC

Every member of the team was enrolled into one of the PARC leagues and divided into teams of three or four. Throughout the term, we met with various teams to check in and track their progress with the competition.

Created weekly video lessons

We used video lessons to assist the students in the competition and to give them the tools they need to succeed. Every two weeks, a new challenge was released for the TECHS League, so we recorded a video detailing it. On weeks in between, we gave updates on the STARS League, like different ways to build the robot and introductory C# lessons. In total, we recorded eight videos: four about the TECHS League, and four about the STARS League.

Formulated Live Remote Tournament Continuation Plan

The continuation plan for LRT was compiled and can be found in Appendix M. The plan contained logistical information including when the live remote tournament is scheduled to start, notes from our meetings with the CEO of the Robotics Education Competition Foundation, registration fees, and equipment needed. The continuation plan also included teaching resources, and contact information of the representatives we have formed connections with who will be able to assist PAY in the future.

Created a sponsor pamphlet

This pamphlet, found in Appendix L contains detailed actions that PAY could take to recruit sponsors and raise funds. We compiled information from the websites of various robotics competitions and teams, then tailored that information specifically for PAY. This included a list of potential sponsors, a sample email for PAY to send, and ideas for fundraising events.

5.2 Recommendations

In the final stage of our project, our team developed the following recommendations based on the results of our research. Our recommendations involved PAY's future development of the robotics team and continuation plans for various aspects of that development.

The recommendations are:

1. Growing the PAY robotics team,
2. Continuing with the 2021 Pan African Robotics Competition,
3. Enrolling PAY in a future robotics competition,
4. Fostering strong relationships with other robotics teams, and
5. Getting sponsors and support resources.

Growing the PAY Team

Due to the COVID-19 pandemic, our team was unable to travel to Namibia and directly interact and talk to PAY's students and staff. Despite this fact, we were still able to create a robotics club, "The Namibots," from the United States and with the help of Mr. Kleopas, signed 33 students up for the club. Our team took on the role of team administrators and team leaders but in order to continue the robotics club, the Namibots, will need a team leader to take over. Based on our research and survey results, below we have outlined the roles and responsibilities of the team leader that will assist them in running the robotics club and team.

Oversee all people involved on the robotics club

This includes recruiting students to participate and finding additional mentors/coaches to assist with the team. To help manage the team, it might be helpful to have a list of current team members and have a sign-up sheet for new students to get involved. To find additional volunteer mentors/coaches reach out to other robotics organizations within the area, university students, and local tech companies.

Fostering Relationships with Students

As the team leader, it is necessary to have great communication skills and to make sure the students are getting along and working hard to achieve their goals. To make sure that the team is doing well, it would be helpful to schedule one-on-one check-ins with the team to make sure that

they feel like what they are doing is important and contributing to the team. As a team leader it is important to listen to your students and make changes when necessary.

Managing Weekly Meetings

It is important to have a set schedule for the team to work on their robots and attend coding lessons. To ensure a smooth team meeting, the team leader should prepare lesson plans a few days prior to the team meeting. For example, if the lesson is on Wednesday, the team administrator should create the lesson plan on Monday. There are many online resources that can be used to assist creating lesson material. In addition to creating lesson plans, the team leader is responsible for running the team meetings/lessons or finding another person to run the lesson.

Preparing for Competitions

One of the larger roles and responsibilities of being team leader is to register the team for competitions. This entails being aware of deadlines, how many students are allowed to be registered for one team, required equipment, travel logistics, and costs. We have recommended two future competitions: Live Remote Tournament and PARC for PAY to compete in the following years.

Competitions

It is the job of the team leader to oversee the students while they are competing in a robotics competition. When at competitions it is beneficial to have at least two adults present, one to watch the students who are competing and give feedback and support, the other to watch the other students who are not competing. The team leader should also make sure that all the students are following the schedule and are where they need to be at a given time.

Continuing with PARC 2021

Our experience with PARC over the course of the project has been extremely positive. It is challenging but engaging for the students, and the organization is helpful and cooperative with us. In our interviews with the students, most loved working with the software, but many did report bugs and other issues which hurt the user experience. We were able to easily address these issues due to the direct line of communication we had with Fatima Kebe, a project director at PARC. The competition is scheduled to complete June 30th, and we recommend that PAY continues to work on the competition and challenges. In order for them to continue, we gave Mr.

Kleopas, the team leader, Ms. Kebe's contact information, so that as the season progresses, PAY can maintain this connection and keep the experience as seamless as possible.

Enrolling PAY in future robotics competition

Our team developed a holistic assessment model to assess the feasibility of future competitions for PAY (Table 2). Seven competitions were examined based on criteria such as registration fee, robotics kits cost, closest competition location to PAY, age range, as well as support from the parent organization. These competitions included VEX IQ, VEX RC, First Tech Challenge, First Lego League, First Global,The Pan African Robotics Competition (PARC) and Live Remote Tournament (LRT). Our two recommendations were **PARC**, and **LRT**. Our team presented our recommendation and gave a list of pros and cons for each competition to our sponsors. We did this to ensure that our sponsor chose the competition that they wanted. PARC and LRT were the top two options because both organizations were willing to assist PAY in their competitions and have goals to expand in sub-Saharan Africa.

After further speaking with Dan Mantz of the REC Foundation, our team saw great benefit for PAY if they were to participate in LRT. The amount of support the REC Foundation would offer was unmatched by other parent organizations, and Dan Mantz had a personal interest in the PAY robotics team and helping it take off. Our team then went back to our sponsor explaining that we recommend LRT over PARC. As our team continued to speak with PAY, it became clear that PAY does not currently have the resources to explore more options while engaged in a competition. Our team provided PAY with a resource document for going forward with LRT, as seen in Appendix M. These resources included connecting PAY with program directors like Dan Mantz, providing competition timelines, competition deadlines, past schedules for reference, and organized curricula and other resources provided by the parent organization for competing teams. Finally, we organized a meeting between PAY, Dan Mantz, and Paul McKnight, a representative from the RECF office that handles their business in Africa.

Fostering strong relationships with other robotics teams

Our team was able to form a relationship with the FIRST Global Namibian team, and although we did not recommend it as the competition PAY should solely go forth with, it is a strong connection to have. We recommended it because it served as an opportunity for some students to

be on a team that participated in a large international competition that travels around the world without cost being an obstacle for PAY since they would not be in charge of the team. We were able to connect FIRST Global and PAY to help them form their own relationship. The FIRST Global Namibian team expressed interest in allowing one or two PAY students to participate on the team. PAY and FIRST Global have since continued their relationship and have spoken about having the FIRST Global team have team meetings at PAY.

Getting sponsors and support resources

Gaining sponsors is critical to continue this robotics club. Sponsors provide funds or donate resources for robotics kits, travel costs, competition fees, and other equipment. In order to assist PAY's robotics team get sponsors we have created a detailed sponsor pamphlet, which can be seen in Appendix L, highlighting the best ways to reach out and obtain sponsors. We recommend that PAY's robotics team use this pamphlet in the future when the team needs to obtain funds to attend or participate in a competition.

This sponsor pamphlet contains example emails, phone calls, and steps to take to host a showcase event. From our research we have concluded that the best way to go about getting sponsors are the following:

- Initially reach potential sponsors through email and/or phone call to ask for an in-person meeting
- Describe the goal of the robotics team to potential sponsors (example: purchase new robotics kits, travel to competition),
- Have team members reflect on how the robotics club has helped them,
- At in-person events make sure to have the students talk to the potential sponsors and showcase their robots and/or projects,
- Always follow up with a thank-you email or phone call to potential sponsors,
- Host an event where multiple potential sponsors come to PAY and the students showcase their robots, and
- Use social media to promote the team.

5.3 Continuing the Agenda

In this section we discuss ways in which PAY and future teams can continue our work. The following will ensure that the robotics can continue for many years:

Continue Developing Relationships with Outside Organizations

To ensure the longevity of the robotics team at PAY, establishing and strengthening relationships with other organizations is essential. Relationships with outside organizations provide resources, knowledge, and other teams to compete against and learn from. PAY already has formed relationships with outside organizations, including FIRST Global's Team Namibia, PARC, and Robot School Namibia. Continuing the connection with FIRST Global can provide PAY students with experiences they would otherwise not have, such as traveling to other countries and working on advanced robots. PARC is a valuable asset, as they provide free-to-use educational videos and other competition resources. We have established a relationship with the PARC program director, Fatima Kebe, who has expressed her willingness to help PAY's robotics program as it correlates with PARC's goal to spread robotics throughout Africa. Finally, Robot School Namibia has worked with PAY in the past to help them establish a robotics program using Lego Mindstorms EV3 kits, but this program was unable to be sustained due to a lack of funding. Re-establishing this relationship may help PAY to share more robotics resources and potentially host a competition with them.

In addition to strengthening previous connections, PAY can form new ones with other local organizations. Finding and contacting nearby robotics teams, even if only virtually, will help PAY through the sharing of experience and expertise. Additionally, the REC Foundation is looking to expand into Africa, and can help in many ways, such as providing competition playing fields and more robotics kits, preparing PAY to compete, and even supporting PAY if they decide to host their own event. Dan Mantz, the CEO of the REC Foundation, has even expressed interest in traveling to Namibia. Continuing to develop relationships with outside organizations will only benefit PAY's robotics program as it will lead to more resources and opportunities. By forming these relationships, PAY's robotics team will be both successful and sustainable.

Finding External Resources

As we stated in our goal, it is imperative that the team be sustained after our project ends. To accomplish this, PAY needs external resources that can provide assistance and supplementary teaching tools to bolster the team. The parent organizations of the aforementioned competitions, such as VEX IQ and the Live Remote Tournament, have teaching and robot building resources on their websites that will be useful in learning more about the capabilities of the VEX Kits they received. Additionally, it would be beneficial for another IQP team to work on recruiting sponsors for the PAY robotics team. The IQP team can follow the sponsor pamphlet that we created and reach out to companies in Namibia and large companies in the United States. Another component to the project could be PAY coordinating and hosting a showcase event where they can bring in local companies to garner interest. Having a future IQP team work on gathering sponsors would be advantageous for PAY because it would give the program the ability to continue and grow.

Connecting the PAY Projects

This year there were three Physically Active Youth project groups, each tasked with a different aspect of improving the robotics program at PAY. One project group continued to further develop educational materials for the students and update the website, another created resources for the teachers so that they can create their own robotics lesson plans, and our team developed a competitive robotics team for PAY. Each team achieved their goals and made great progress within their own realms that benefitted the robotics program at PAY. While the three teams worked closely together, and had weekly update meetings, there still could have been more overlap. In the future our team would like to see more interconnectedness between the teaching resources, the student resources, and the robotics team. A continuation IQP project could work on bridging the three projects and create transitions between the resources for the teachers, resources for the students, and joining the competitive robotics team so that they are related to each other. This would assist PAY in continuing the newly created robotics team and help the students do well in competitions by teaching them the material required of them in robotics competitions. This would additionally assist the teachers, who are also the team leaders of the robotics teams, run both the robotics curriculum and the robots if the facilitator's manual was tailored to help the teachers teach material specific to the competitive aspect of robotics. The

PAY robotics program holds a lot of promise but will require future IQP teams to continue to push them forward and champion them for success.

5.4 Final Thoughts

Throughout this project, we learned from the students and mentors at PAY about the culture of Namibia, such as the different types of food and how much of an impact sports like cycling and soccer have on Namibians. Mr. Kleopas even taught us a few words in his native language of Oshivambo. We also learned from talking with the students that they are all driven and have goals of being doctors, pilots, and engineers. However, not being able to travel to Namibia to complete our project was our greatest limitation. To alleviate this limitation, our team stayed in close communication with our sponsor in order to develop a project that would positively impact their community. Initially we were unsure how much our team could accomplish during our project, but we were luckily able to foster strong connections and give the students at PAY an opportunity to participate in a robotics competition. During every interview that our team completed we learned how many people and organizations wanted to help promote our project and ultimately bring robotics to Africa at large. Our team is confident that the connections we made and the relationships we helped PAY form with outside organizations will last long into the future. We are all excited to see where future teams take our project and how the integration of robotics continues to grow through Africa.

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Appendices

Appendix A: Informed Consent Form for Participants

Consent Statement

This study has been approved by the WPI Institutional Review Board for the Rights of Human Participants in Research and Training Programs (IRB). Any questions about human rights issues should be directed to the IRB Chair, Ruth McKeogh, Tel: 508-831-6699, Email: irb@wpi.edu.

Confidentiality

The survey does not ask for any identifying information, and all responses will be kept fully anonymous. Responses cannot be traced back to you. All information collected will be kept confidential, and the data will only be accessed by researchers on this project.

Risks

The survey poses minimal risks to participants. There will be a question regarding gender, but there is an option to not answer the question. The team understands that this question may make respondents uncomfortable and if that happens, participants may stop the survey at any time. If any other questions make respondents feel uncomfortable, they may stop the survey at any time.

Contact Information

For more information about this research or about the rights of research participants, or in case of research-related injury, contact Augustine Asumadu, Devan Blechinger-Slocum, Maggie Gunville, and Sarah MacDonald, Email: gr-ID2050Team3@wpi.edu. The supervisors for this research are Nancy Burnham and Alex Smith. They can be reached by email at nab@wpi.edu and adksmith@wpi.edu respectively.

Appendix B: WPI Student Survey Information

Purpose of this survey?

We are a group of students at Worcester Polytechnic Institute partnered with Physically Active Youth that would like to learn more about the infrastructure of a competitive robotics team. By participating in our survey you will help us understand the dynamics and how robotics teams function. Our goal is to create a youth robotics team in Katutura, Namibia in order to create further opportunities in STEM for the students of Namibia.

Who are we surveying?

- WPI students who have been or are currently part of a robotics team
- Adults 18-24 years of age

How will this survey be conducted?

- The survey will be conducted online via a Qualtrics form.

What information will be collected?

- The information collected will be regarding the structure, function, and dynamics of a robotics team.
- We are interested in learning what your favorite and least favorite parts of being on a robotics team are.
- The information collected will regard the impact participation on a robotics team had on the respondents' future educational pursuits.

What will we do with this information?

- We will use this information to help make a plan regarding how we will implement our robotics team in Namibia.
- No individual data will be reported; Individual answers will be combined with those of all respondents for analysis and reporting.

Appendix C: Survey Questions for WPI Students

Have you been on a competitive robotics team?

1. Yes
2. No

Which gender do you most identify with?

1. Male
2. Female
3. Gender Variant/Non-Conforming
4. Other
5. Choose Not to Say

Are you pursuing an education in robotics?

1. Yes, as my major
2. Yes, as my minor
3. Yes, but not as my major or minor
4. No, but I am pursuing an education in STEM
5. Not pursuing an education in robotics or STEM

What is your level of experience on a competitive robotics team?

1. Beginner
2. Intermediate
3. Advanced

In what competition did your team compete? Adapted from: (Witherspoon et al., 2016)

1. FIRST Robotics Competition
2. FIRST Tech Challenge
3. FIRST Lego League
4. VEX IQ
5. VEX EDR
6. Other (Please Specify)

How old were you when you participated on this team? Adapted from: (Witherspoon et al., 2016)

1. 7-9
2. 10-12
3. 13-15
4. 16-18
5. 19+

How many members were on your team?

1. 1-5
2. 6-15
3. 16-30
4. 31-50
5. 51+

How well did your team work together? 1 being terrible, 5 being very well. Adapted from: (Wagner et al., 2018)

1. 1
2. 2
3. 3
4. 4
5. 5

How many mentors were on your team?

1. 1-2
2. 3-4
3. 5-6
4. 7+

How many of your mentors had robotics experience? Adapted from: (Simoneau & Sanchez Chavarria, 2016)

1. 0
2. 1
3. 2-3
4. 4+

In how many competitions did you compete in a season?

1. 1-2
2. 3-4
3. 5+

How important is the competitive aspect of the team to you? Adapted from: (Stein, Cathryne, 2004)

1. Not important
2. Somewhat important
3. Very important

What percentage of participants on your team were female? Adapted from: (Sullivan & Umashi Bers, 2019)

1. 1 - 10%
2. 10 - 25%
3. 25 - 50%
4. 50 - 75%
5. 75 - 100%

Before being involved in the robotics team, how much prior knowledge of robotics did you have? Adapted from (Tomko et al., 2014)

1. None.
2. Some Knowledge.
3. I have taken robotics classes.

Was your time on the team overall a positive or negative experience?

1. Very Positive
2. Somewhat Positive
3. Neutral
4. Somewhat Negative
5. Very Negative

Did working on your team positively influence your attitudes towards STEM? Adapted from: (Welch & Huffman, 2011)

1. Definitely
2. Somewhat
3. Neutral
4. A Little
5. Not At All

Did working on your team improve your skills in STEM?

1. Definitely
2. Somewhat
3. Neutral
4. A little
5. Not at all

Did working on your team improve your skills in team-work? Adapted from: (Menekse et al., 2015)

1. Definitely
2. Somewhat

3. Neutral
4. A Little
5. Not At All

How has being on a robotics team helped you today? (write in answer)

What did you like the most about being on a robotics team? (write in answer)

What did you like the least about being on a robotics team? (write in answer)

Appendix D: PAY Student Survey Information

Survey Objective:

Survey the students of PAY who participated on the PAY robotics team and document their experience. Learn more about their overall experience, what went well with the team, what needs improving, and what they would like to have in the future.

Target Audience:
PAY students that participated in the virtual Pan African Robotics Competition
Ages 11-19

Sample Size: 40 students

Mode: Google Form

Distribution: A PAY worker will be sent the link and then distribute the survey to the students.

Limitations:
Most students are under aged per Namibian law, thus requiring parental consent is imperative to completing the survey.

Appendix E: Survey for PAY Students

How old are you?

1. Fill in blank

With what gender do you most identify?

1. Male
2. Female
3. Gender variant/non-conforming
4. Other
5. Choose not to say

In which competition are you participating?

1. TECHS League
2. STARS League

How many people are on your team?

1. 1
2. 2
3. 3
4. 4

Did you have any prior robotics experience?

1. Not at all
2. Only through PAY's robotics course
3. Some
4. A lot

Do you enjoy being on the team?

1. Yes it was fun
2. No, not for me

Do you have a good understanding of the competition and what you are doing?

1. Yes
2. Somewhat
3. Not really
4. No

How do you find working in a virtual environment? 1 being terrible, 5 being very well.

1. 1
2. 2
3. 3
4. 4
5. 5

How well does your team work together? 1 being terrible, 5 being very well.

Adapted from: (Wagner et al., 2018)

1. 1
2. 2
3. 3
4. 4
5. 5

How much time a week do you spend working on the competition?

1. 1 hour
2. 2 hours
3. 3 hours
4. 4 hours
5. 5 hours

Do you enjoy the videos that our team has been sending?

1. Yes! I enjoy watching them
2. They are alright
3. I don't really like watching them
4. No, they are boring

Have the videos been helping you during the competition?

1. Yes! They are very helpful
2. Some of them are helpful
3. Most of them are not helpful
4. No, they have not helped me

Does working on your team positively influence your attitudes towards science, technology, engineering, and math (STEM)? Adapted from: (Welch & Huffman, 2011)

1. Definitely
2. Somewhat
3. Neutral
4. A Little
5. Not At All

Has working on your team improved your skills in STEM?

1. Definitely
2. Somewhat
3. Neutral
4. A little
5. Not at all

How is working on your team improving your skills in team-work? Adapted from: (Menekse et al., 2015)

1. Definitely
2. Somewhat
3. Neutral

4. A Little
5. Not At All

Are you finding your mentor(s) helpful?

1. Not at all
2. Somewhat not
3. Neutral
4. Somewhat
5. Very helpful

How often do you go to your mentors for help?

1. Not at all
2. Once a week
3. Twice or three times a week
4. More than three times a week

Do you want to be on the team next year?

1. Yes
2. No

What do you do when your team has trouble with programming or building the robot? (write in answer)

Currently, what would you change about the robotics team? (write in answer)

Currently, what would you keep the same about the robotics team? (write in answer)

What is going well with the team? (write in answer)

What has been the greatest challenge your team has faced so far? (write in answer)

Appendix F: Survey Protocol

The team conducted surveys using a Qualtrics survey with WPI students and PAY students as the participants. We made the questions beforehand, aimed at getting information about experiences on robotics teams, as well as feedback from PAY students regarding the effectiveness of robotics teams and lessons. Survey questions for WPI students can be found in Appendix C, and survey questions for PAY students can be found in Appendix D. A statement of consent was presented at the beginning to make sure participants were aware their answers were being recorded and used in the project. Guardians and caretakers of students had to fill out consent forms acknowledging the participation of their child in the survey. We compiled the results on a spreadsheet with graphs to quantify them.

Appendix G: Interview Protocol

The team conducted and recorded interviews via Zoom with the consent of the interviewees. The team conducted interviews with representatives with each robotics organization, Physically Active Youth, and people actively involved in the robotics world. Questions were prepared beforehand, with a chair person assigned to speak in order to prevent interruptions and confusion, and to create a free-flowing interview. The interviews were transcribed using a transcribing software, and an assigned note taker manually took notes from each interview. The notes and audio transcription were compiled and stored in a shared google Drive folder, where they served as references.

Appendix H: Competition Information

VEX IQ

Last year's IQP team worked to get funding for 12 VEX IQ kits. The kits can be viewed on the VEX website by typing "VEX IQ Kits" into your internet browser. These kits use plastic pieces and block-based programming, which is easy to learn and use. VEX IQ kits are also very familiar to PAY students because it is what many of them used during the virtual PARC competition. Block-based coding, similar to programs like Scratch, is taught at PAY. One caveat is that VEX IQ competitions are designed by VEX primarily for middle schoolers, because there is a more challenging league for the high schoolers, the older students would not be able to compete in VEX IQ. Our team was able to learn more about VEX robotics through speaking with Dan Mantz, but because he is involved with a branch off of VEX he would not be able to offer direct support for a VEX Competition.

VEX Robotics Competition

The VEX Robotics Competition is a more challenging version of the VEX IQ competition. VEX Robotics Competition uses aluminum parts and a block-based programming language. The VEX V5 robots are what the older students at PAY learned to use virtually through PARC and the more difficult block-based programming language that combined block-based coding with C Script. The kits for this competition are difficult to use and are also very expensive. This creates a larger barrier of entry for PAY.

Live Remote Tournament

The Live Remote Tournament (LRT) is a competition that was developed during the pandemic to allow robotics teams to compete in competitions from anywhere. The Robotics Education Competition Foundation (REC Foundation) created the tournament, which is closely linked with VEX and aims to inspire and motivate students to excel in STEM education. The ability to compete remotely eliminates the need for travel while still allowing teams to use physical robots. The elimination of travel allows teams like PAY, where money is more scarce, to still compete. There are multiple divisions within the LRT, but PAY would compete in the VEX IQ division. There is a very low barrier of entry into this competition compared to others because the only elements that a team is required to have are a playing field, robot kit, webcam, and a computer

with wifi access. This is beneficial to PAY because there would be no travel costs, and they already have the robot kits and computers with wifi access. Our team spoke with Dan Mantz, the CEO, and Chairman of RECF, and learned about his goal of expanding LRT throughout Africa. He is very interested in our project and would like to help us get PAY involved in the LRT by donating playing fields and potentially more VEX IQ kits.

Pan-African Robotics Competition

The Pan African Robotics Competition poses great opportunities for PAY in the future. The PARC Competitions, when in person, use VEX IQ and VEX V5 kits, something that the PAY students are familiar with. Our team spoke with PARC Director, Fatima Kebe, to gather information on the feasibility of PAY competing in this competition once it moves back in-person. We learned that the in-person competitions are typically held in West Africa, however PARC covers the cost of the robotics kit, lodging, and food. PARC also has multiple age groups under the same umbrella of competition. This means that at one competition, students of all ages will be competing; this is very different from other competitions we looked at. PARC is also set to expand in the coming years, with the goal of organizing competitions in various regions in Africa, followed by a continental competition for winners at the regional level. Through forming a relationship with Fatima Kebe we received access to information that is not yet published on their website, like their expansion plans. We also learned more about the online curriculum that is currently being developed. This showed us that while PARC might be in its early stages, there are expansion plans that go beyond the other competitions based in the United States.

FIRST Global

FIRST Global tries to connect the world through robotics with its Olympic-style competition, in which every country sends a team to represent its flag. Our team spoke with Stephanie Slezycki, a representative from FIRST Global, and learned about the financial components of the program. The organization uses a financial aid system to cover costs for countries that may be unable to afford them, such as travel expenses, robot kits, and lodging. While the program offers a lot of support for each team, FIRST Global only allows one team from each country. As a result of Namibia already having an established team that has been going to FIRST Global for the past few years, PAY would not be able to send their entire robotics team to the competition. Stephanie Slezycki connected our team with the current Namibian team, allowing us to form a

connection with their team leaders. The Namibian Team expressed interest in working with PAY which will give the opportunity for one or two PAY students to participate on the FIRST Global Team.

FIRST Lego League

Like VEX IQ, FIRST Lego League (FLL) is a program designed for middle school students. It uses Lego Mindstorms EV3 parts. PAY previously worked with these kits when it partnered with Windhoek's Robot School, so there is some familiarity with the kit for this competition. However, after speaking with Colleen Shaver, a WPI faculty member and representative at FLL we learned that the competition has more components than just building a robot and playing a game with it. It also involves a research project portion, in which students must write a report on a certain STEM topic. Colleen Shaver was also able to inform us that FIRST offers little financial support for its teams, and she ultimately recommended not choosing FIRST as our competition

FIRST Tech Challenge

For older students, FIRST offers FIRST Tech Challenge, which uses aluminum parts and Java-based programming. This is the most advanced of all competitions, so PAY students would gain experience in advanced manufacturing and coding techniques. However, it is more expensive than other competitions, and after learning from Colleen Shaver that FIRST offers little financial support, the competition became less feasible.

Appendix I: WPI Student Survey Written Responses

What did you like the most about being on a robotics team?

Responses:

- I enjoyed collaborating on ideas for completing competition tasks and helping design the robot.
- I loved learning all of the technical parts of robotics and that gave me a solid foundation for where I am today. I also enjoyed making friends with like-minded people. Most of those friendships only lasted for high school, but some of them are going to live long friendships.
- The environment was fun and everyone wanted to be there
- Being given the freedom to experiment and try new things. Especially in middle and high school when so many projects were all about checking boxes on rubrics, the goal-oriented projects of the robotics competition was an amazing freedom.
- I liked seeing the other team's robots and seeing all the different ways teams would go about solving the same challenge
- The ability to get hands on with tech, programming, etc. There was no engineering or CS classes at my HS so access to that was life changing. Especially in a form where your work becomes a physical moving device
- The combination of the creative and competitive aspects
- I enjoyed the community. As frayed as it may be at times, these people inevitably have your back and want you to be your best self for the sake of the team's goal. Others will help you learn to improve
- We had a lot of fun, and built on our relationships as well as the robots. They gave me memories I'll never forget.
- Building stuff
- the constant problem solving
- The camaraderie
- The sense of community
- I enjoyed the building and designing and programming of the robot, but I also enjoyed the friendships and connections I made. Some of my closest and best friends are from robotics, several of them from hundreds of miles away and we would not have met if it were not for robotics.
- I liked how it introduced me to people with similar interest from different towns and states
- My favorite part about robotics in high school was having ownership of a project and going through the design process from start to finish.
- Overcoming challenges and finding solutions was rewarding.
- The team element makes it very social and I found most of my friends through it.
- Autonomy to shape the team into what I envisioned
- I found the challenges of design to be very fun

Appendix J: WPI Student Survey Written Responses

What did you like the least about being on a robotics team?

Responses:

- What did you like the least about being on a robotics team?
- Our team did not have much support because we only had one advisor and they did not have much experience.
- There are always people that aren't fun to work with, both teammates and mentors. Most of my negative experiences on a robotics team came from chronically negative teammates and mentors.
- The team was really big
- We definitely had some team members that weren't really into it and were just doing it because their parents wanted them to. It was very hard to work with these team members and was tough to see them so unhappy with the work.
- I disliked how difficult it was to start out. When I participated in the team it was the first year it had been created and it was hard to get interest in the team and resources for help since our mentors didn't have a background in robotics.
- Being on a small inexperienced team without major funding meant the competitions were basically hopeless
- Working in too large of groups or not having enough to the correct parts
- Probably the long hours building the robot, although I kinda enjoyed that since I love to build.
- Advisors took too much control
- the separation of different skills within robotics
- Late night hours.
- My least favorite thing was honestly probably dealing with the sexism myself and my team faced when interacting with some other teams. But those instances were much less common than the positive ones.
- Working with school politics to get funding
- My least favorite aspect was working with people not willing to compromise.
- The time commitment and fighting. It quickly becomes the only thing in your life and has dangerous effects on your mental health
- Controlling Mentors, As leader spent too much time with administrative work
- We were not well supported by the school administration and that caused various issues with our ability to compete

Appendix K: WPI Student Survey Written Responses

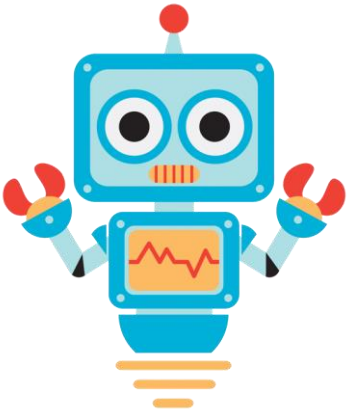
How has being on a robotics team helped you today?

Responses:

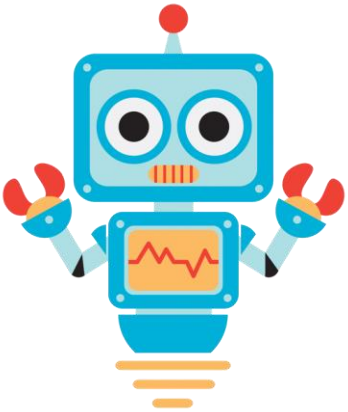
- It has provided some key teamwork and project management skills because we had to work together to make competition deadlines.
- It helped me learn and grow as a person. Being on a robotics team directly influenced my career path; I would not have become a robotics major if I hadn't done robotics in high school.
- It influenced my decision to be a robotics major
- I learned a lot about working together in a team and balancing each person's unique skill set.
- It strengthened my interest in STEM/robotics and helped me grow more confident expressing my thoughts and ideas to others
- It led me to WPI and my major
- It inspired me to have a career in stem and it taught me a lot about problem solving
- Provided me with marketing experience actually. We needed to “sell” our team since I worked on the chairman’s side of things
- It helped me to realize that in a team, everyone excels in different parts of the process. In Robotics it was either the build, programming or controlling the robot. It’s helped to identify people’s strengths and use them where they will be most helpful
- Helped me find more opportunities in stem
- it gave me a very clear picture of what STEM is
- Job promotion
- Leadership skills, communication skills, real life STEM application knowledge
- It honestly and truly made my life what it is today. I had felt very alienated from some of the robotics programs I had done as a prior to doing FRC in high school were really negative.
- By finding my team and being given the opportunity and resources to become confident in more of my technical abilities as well as really develop my interpersonal skills I became the person that I am today. Without them, I don’t know where I would be or what would be doing.
- Helped me decide what I wanted to go to college for
- Participating on a robotics team helped develop my love for working on hands-on technical projects.
- I think the biggest influence is the direction that it gave me. Being young and smart I had a lot of options and very low motivation and joining robotics helped guide me so that I had something to work for.
- First Leadership Role
- I am a robotics major now because of it, so it basically decided my career path

Appendix L: Sponsor Pamphlet

The PAY Official Guide To:



Getting Sponsorship



Contents:

Created: May 2021

Introduction

Hello! This is a guide for PAY's competitive robotics team to get fundraising in order to register for competitions, cover travel costs, and buy equipment. This handbook is a comprehensive guide designed to assist the Namibots secure the necessary funds to compete and continue the team. The information found in this packet was taken and modified from the *PARC Guide to Fundraising - Becoming Mansa Musa* more information can be found on the PARC website at https://parcrobotics.org/ . We hope that this is helpful for the Namibots at PAY.

Step One: Get to know yourself

Establish a Team Portfolio

A Team Portfolio may be helpful in guiding you while putting together documentation and presentations to share with sponsors. Ask all team members to reflect on the following questions and then record your answers in a document:

- What is the value in participating in robotics competitions?
- What are your desired outcomes?
- How will your team be impacted if they do not participate in a competition?
- What has your team gained so far through competitive robotics?
- What has your team accomplished so far?
- Why should others support your team?

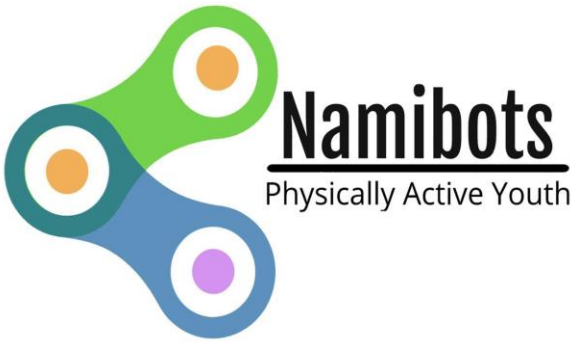
What does PAY do?

Sharing PAY's mission and the impact that PAY has on the community of Katutura can assist in getting funds and/or support from sponsors. Additional information from team members should be added to the statement. Below is an example of an overview of PAY. This statement can be shared with sponsors when reaching out to them or applying for scholarships.

The Physically Active Youth (PAY) program is a community-based strategy meant to help and aid children and youth-at-risk in low-income neighborhoods in Namibia. It focuses on addressing the physical health, academic status, personal development, and community involvement of the youth. PAY offers after-school programs for students to engage students such as the robotics program with a goal of developing their skills and improving their attitudes towards STEM.

Team Logo

Establishing a team logo to put on emails, t-shirts, and social media will help PAY and The Namibots Robotics team gain support both locally and nationally.



Establishing a Target

To get started, you should determine how much money you will need to raise. Take inventory of any funding you may already have and assess all costs related to team activities that you will have to incur.

Details about expenses and your target amount of finance will guide you over the course of your team fundraising journey. It is recommended that you keep a cash flow statement or an income and expenditure account to track your finances and measure your progress. See the sample (which you can customize to your specific needs) below to help you get started.

PARC Team Income & Expenditure Sample *please note this sample is not representative of actual costs.

Income:

PAY Budget Allocation	$50
Membership Fees	$50
Sponsors REC Foundation Private Donor X	 $200 $50
Online Gofundme	 $150
	Total: $500

Expenditure:

Registration Fees	$350
Robotics Kits	$500
Camera	$40
Travel Flights Passports	 $2500 $400
Other T-Shirts Flag	 $300 $60
	Total: $4,150

Social Media Presence

It is useful to leverage the Internet to spread awareness about your team and its activities. Posting on team social media pages (and a team website if possible) may serve as evidence of your projects as well as a method for sponsors to validate your impact. Additionally, it may bring in attention from media organizations that can help with attracting more sponsors e.g. radio stations and news channels.

Here are some notes when posting on Social Media.

- Post frequently on platforms when at competitions or competing
- Tag the competition you are competing in. Ex. @parcrobotics
- Include lots of pictures of the team while building and learning

Social Media Platforms:

- Instagram
- Facebook
- Twitter
- TikTok

Step Two: Reaching out to Potential Sponsors

There are many organizations and individuals who would be willing to help the PAY robotics teams with their needs either by directly funding specific services/items (i.e. in-kind donations) or by donating some amount of money for the following reasons:

- PARC/LRT provides opportunities to market their organization.
- PARC/LRT challenges students to think critically and become accustomed to solving real-world issues.

- PARC/LRT team members may eventually join the workforce and thus help boost the economy.
- PARC/LRT students cultivate leadership qualities while learning the importance of collaborative skills.
- PARC/LRT encourages students to learn about relevant current affairs to propagate future development.
- PARC/LRT gives students the platform to apply theoretical knowledge and enhance innovative abilities.

Creating a list of target sponsors:

Here are a few examples of potential sponsors that you could reach out to:

• Diplomats
• Banks
• Relatives
• Friends
• Charity Organizations
• Community leaders
• Transportation companies
• Organizations that align with and support the objectives of PARC
• Other businesses that you, a family member or a friend is a customer of/is employed in/owns
• Current sponsors of the robotics organization

It is important to determine the best person to contact at each organization. This person will be your Point of Contact. Departments like Corporate Social Responsibility might be the most ideal to reach out to. If your team has a connection to anyone in the organization, they can help you decide who your Point of Contact should be.

Once you have a list of potential sponsors, create a database of all of them that includes the following information:

• Organization Info: name, website, type of firm, address
• Status (Are they a potential sponsor, current sponsor or partner for a particular event?)
• Point of Contact Info: name, contact details (email, phone number)
• Funds/services from organization: target, actual received
• Details about the last time they were contacted by the team: date, method (phone, email, in person), team rep(s), follow-up date, additional notes
• Team Appreciation (writing thank you notes etc.)

Reaching out to sponsors:

The first step in reaching out to potential sponsors is to send them a sponsor request letter accompanied by a "Team Needs and Sponsorship Form" (see sample below). You can follow up with a phone call in a few days if you do not get a response. The phone call is a great time to schedule an in person meeting, share details of sponsor benefits, and give them more information about the robotics competition.

Examples of sponsor benefits:

- Recognition and sponsor's logo on team website
- Recognition on social media (e.g. by posting pictures with sponsors or pictures of the teams holding sponsor banners)
- Sponsor's logo on team shirts
- Sponsor's logo on robot
- Connecting team members as potential interns

Team Needs and Sponsorship Form

This is important for sponsors to be able to clearly see what expenses they can help you with while maintaining paperwork about the agreement for the sponsor's records as well as your team's. Note that if you want to ask sponsors for help with only specific items/services (i.e. not

all your expenses), you may edit the table of expenses to reflect this. Ensure each party involved in the agreement has a copy of this document.

Example templates for sponsor request letter and "Team Needs and Sponsorship Form":

Physically Active Youth
[address]
[date]

Pan-African Robotics Competition Sponsorship Request Letter

Dear [potential sponsor/partner organization name],

My name is [first name, last name], I am a [captain/member/team leader] of the Physically Active Youth (PAY) competitive robotics team. We are looking to raise money in order to form our team and compete in the 2022 Pan-African Robotics Competition (PARC).

PARC is an annual event hosted by SenEcole that brings together students from all over Africa and the diaspora for a three day robotics competition themed on a real-world topic relevant to science and the sustainable development of the continent. Media coverage has ranged from the New York Times, BBC, Le Monde, France 24, Voice of America, RFI, and Aljazeera, just to name a few.

Through PARC, my team and I collaborate to think critically and apply our theoretical knowledge of Math and Science by building and programming purposeful robots. My team consists of [#] members and our coach, [coach's name]. As you may be aware, the STEM field holds immense power to positively impact communities and it is vital that the youth is able to explore and engage in it through opportunities like PARC.

In anticipation of this year's competition in [month and year of competition], we are, from [potential sponsor/partner organization name], seeking [details of services/items/amount of funds you require

from this sponsor/partner]. Every single dollar donated will get us closer to forming a competitive team, as well as inspiring future scientists and engineers. Whatever you are able to give will give you our everlasting appreciation, as well as [company] logo on our t-shirt, banner, and robot, depending on the size of your contribution.

Our team would like to plan a meeting with you to explain why we are so keen on attending PARC. We would also like to communicate the benefits of [partnering/sponsoring] us. In the next few days, [coach /team member name and role], will be calling to request a meeting. You may also contact [him/her] at [coach phone number] or send an email to [team e-mail address].

More information about Physically Active Youth can be found at https://paynamibia.org/ . Further information about PARC can be found at www.parcrobotics.org.

Thank you for the sponsorship consideration. We hope to work with you soon!

Sincerely,
[name], age [#]

Namibots Needs and Sponsorship Form

Team Needs:

Expense	Quantity	Single Item Cost	Total Cost

Thank you for agreeing to sponsor the Physically Active Youth Namibots. We sincerely appreciate your support!

Sponsor Name: _____

[Insert Sponsor Contact Details]
Contribution Amount: _____

[Insert details of Payment Method]
[Insert Details of Benefits that Sponsor will receive]

Sponsor Signature and date:

_____

Team Representative Signature and date:

_____

Follow-up Phone Calls

1. If they haven't contacted you after saying they'll think about the sponsorship/partnership: Tell them you are happy to answer any further questions they may have. Ask if there are any concerns they would like you to address. Reiterate the advantages of the sponsorship/partnership. Offer to set up a meeting with your team or give them a robot demonstration.
2. If they have agreed but you have not received any funding: Tell them you are happy to answer any further questions they may have. Ask if there are any concerns they would like you to address. Ask when it would be a good time to pick up their filled-in sponsorship form. Keep following up with them every few days until you receive the donation, or they decline the proposal.

Thank the sponsors

Once you have secured a sponsorship/partnership, it is important to thank the sponsor/partner in effort to maintain your relationship. Here are some guidelines:

- **Highly recommended and expected: Send them a thank you letter.**
- Send them a thank you card signed by students.
- Invite them as "VIP" to team events.
- Invite them for a robot demonstration.
- Send them thank you team photos/videos made by the team (especially once you get to the PARC venue).
- Ensure they have received all benefits you promised them.
- Encourage your members to apply for internships at their organization.
- Update them about your robot building journey as you progress.
- Send them reviews/reflections about your team's time participating in the competitions and how it benefited the participants.

Step Three: Hosting a Showcase

An effective way to garner interest from potential sponsors is to invite them to showcase events. These events are an opportunity to display your robot, how your team works, and what goes on in a competition. There are many ways to hold a showcase event and many settings, including:

- At the PAY Center
- At a local community center (e.g. library, rec center, etc.)
- At a potential sponsor's office
- At a competition

At the PAY Center

Inviting a potential sponsor to the PAY center is an effective strategy, since they could see directly the impact their money would have. An event here is a good opportunity to display the process through which the students learn and the space where they create their robots. Students can give a demonstration on how their robots are built, how they are programmed, and what they do.

At a Community Center

For events that take place in a community center, the team presenting will have to be much smaller. Although the presentation is smaller, these settings are an opportunity to cater to more than just a single potential sponsor, but other members of the community who might spectate, like students who may consider joining the team, or people who may donate to the team.

At a Competition

Bringing a sponsor to a competition is undoubtedly going to have the greatest effect on a potential sponsor. The atmosphere of a competition is encouraging and collaborative, showing sponsors the future of engineering and putting them in a good mood.

Live Remote Tournaments (LRT)

LRT was developed by the Robotics Education & Competition (REC) Foundation during the Covid-19 Pandemic to give teams the ability to compete in robotics competitions safely. In LRT, teams will compete in head-to-head matches with other teams in a newly-developed environment similar to an in-person event.

PAY would be participating in LRT using VEX IQ robots for the 2021/2022 competition. It begins May 29th, 2021 and goes until the end of April 2022.

REC Foundation's Mission:

To increase student interest and involvement in science, technology, engineering, and mathematics (STEM) by engaging students in hands-on, affordable, and sustainable robotics engineering programs.

Logistics:

- PAY can register up until March 2022 (we spoke about PAY trying to start in January 2022)
- Register the team through robot events (instructions under tournament resources)
- Recommended that teams compete at least twice during a season, but teams can compete as many times as they'd like
- Dan Mantz will donate playing fields
- Dan Mantz will waive the registration fee for the first year
- Typically, registration fee is $150 for the first team registered, any other team registered under the same organizations is an additional $100 per team.
    - Dan Mantz is looking to subsidize this cost and create a flat organization fee.
- All ages are welcome to compete in the regular VEX IQ tournament games, however when competing in a championship game only students ages 9-15 are able to compete.
- You will get a **virtual** robotics kit, and engineering design notebook when you register
- Tournaments are every Wednesday, Thursday and Saturday

Equipment needed:

Each team will need a robotics kit (VEX IQ), computer, a webcam, internet connection, and a full field with game elements. Teams may not share any of these items if competing in the same LRT event. The number of fields an organization has is the limit to the number of teams that can

register for any given event. Carefully review the LRT Team Setup and Instruction documents for detailed equipment requirements.

Becoming an Event Partner:

Becoming an Event Partner is a great opportunity for individuals who share our passion for robotics and seek to establish a revenue stream to sustain and grow their own robotics program. First step in becoming an event partner is to contact your Regional Support Manager (RSM). Your RSM will explain the requirements, show resources available to you, and connect you to the community of other EPs. Your RSM is Paul McKnight and his contact information can be found below. For more information on becoming an event partner see tournament resources below.

Tournament Resources:

Team Setup and Instructions

Registering a Team

Event Partner Guide

Teaching Resources:

VEX IQ Educator Certification Course

VEXcode Resources

VEX IQ STEM Labs

Contact Information:

Dan Mantz (CEO of REC Foundation):
dan_mantz@roboticseducation.org

Paul McKnight (RSM for Africa):
paul_mcknight@roboticseducation.org