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Board 112: A STEM Training Program to Improve Middle and High School VEX Competition Outcomes

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A STEM Training Program to Improve Middle and High School VEX Competition Outcomes

Abstract

The VEX Robotics International Competition, presented by the Robotics Engineering and Competition (REC) Foundation, provides an annual engineering challenge in STEM education for middle and high school students. The VEX competition promotes STEM to students and learning communities internationally while aiding the development of such skills as teamwork, leadership, presentation, and communication. This paper presents the development of a one-year afterschool course which provides middle school and high school students who had little to no experience in VEX robotics, with the knowledge and skills necessary to succeed in the VEX Robotics International Competition.

This course was designed for students to work with experienced VEX competition team members after-school and weekends during the school year. The veteran team members were individuals who have experience competing on VEX high school and college teams and were able to act as coaches and mentors. The participating students were divided into teams of 10 members for the high school division and 12 members for the middle school division. During summer and winter break, students were given intensive training three days per week, which provided the necessary knowledge and skills to increase their capability in both VEX Robotics and robotics engineering. The training course incorporated the working principles of mobile robots, engineering design, computer aided design (CAD) software, mathematics, physics, computer programming, and technical writing. Throughout the course, students were given the tools and experience necessary to develop their presentation, public speaking, interview, teamwork, leadership, and communication skills.

As the students continued their participation in the course, they attended local competitions and tournaments hosted by the VEX REC Foundation. Attending each of the competitions depended upon the completion of the design and implementation of three robots which could achieve the competition tasks efficiently and effectively. Once this requirement was met, students were able to test their newfound skills and knowledge while coaches and mentors evaluated the students' progress. In this paper, the VEX high school and middle school teams, named Overclock, 16099 (A, B, and M) were used to effectively test this new STEM course. The three Overclock teams consisted of a wide range of students from minimal knowledge in VEX robotics to students who had two years of VEX experience. In an overall assessment, it was found that students who participated in the course with minimal knowledge of robots were able to perform significantly better than those who had more than three years of robotics and VEX competition experience but did not participate in the course. Students involved in the program had also shown significant improvement in confidence while they are engaged in public speaking, presentation, hands-on work, or robot competition. Future improvements to the course may include student exposure to additive and subtractive manufacturing, aerial robotics, and an increased variety of electronic devices, such as Arduino and Raspberry Pi. Students who enrolled this course not only learned the

knowledge and critical thinking strategies necessary to excel in the STEM field but are also facilitated with the skills necessary to pursue a career in engineering.

Introduction

I. VEX Competition

The VEX robotics competition matches are played on a 12 by 12-foot field with two alliance colors, red and blue. Each alliance color is composed of two teams forming a red alliance or blue alliance. The objective of the game is to obtain a higher score than the opposing alliance. Each new season features a unique stem challenge played with different scoring objects and methods. In the 2018~2019 VEX Turning Point challenge, there are eight Caps with colored sides, red on one side and blue on the other, placed around the field. Alliances aim to flip said caps, so that they show their alliance color, to score points for their teams while removing points from the opposing alliance. These caps can be low scored on the playing field tiles or high scored on the six posts around the field. In the field, there are also nine flags with three low flags that can be toggled by robots and six high flags that can only be toggled by being hit with the balls on the field. These flags also feature the two alliance colors and like the caps, teams aim to toggle the flags to their alliance colors in order to score points. At the center of the field, there are three platforms; one red platform for the red alliance, one blue platform for the blue alliance, and a center platform open to either alliance. To score points the alliance members must park on their alliance colors' platform or the center platform without being supported by other field components. The match begins with two caps in the red and blue low scored position, and four that start on balls in a non-scored position. Three flags on either side of the field are started scored in their respective alliance color while the three in the center remain in the neutral position. In total there are twenty balls that are either placed on the caps, underneath the caps, around the field, or given as preload. A single preload ball is given to each team at the beginning of the match and must be loaded into the robot or in contact with the robot before the start of the match.

II. Competition Matches

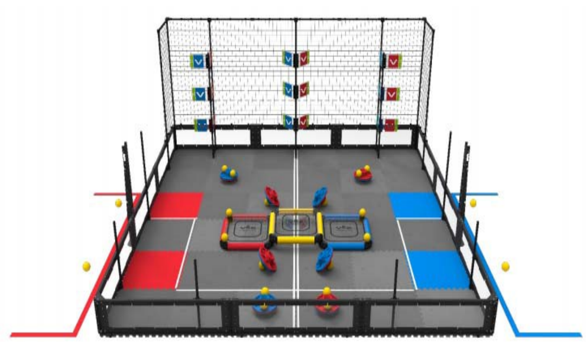
Figure I. Competition Field Layout

Each match is divided into two separate sections and totals a full two minutes. The matches consist of a 15 second autonomous period and a 1 minute 45 second driver control period. In the autonomous round, teams must use their programming skills to code their robot to toggle flags, flip caps, and park on their alliance platform autonomously. Autonomous programs must be written and uploaded prior to the start of each match. During the autonomous round, teams are not allowed to cross the two lines at the center of the field as seen in the figure. After an autonomous winner has been decided by the referees, the driver control period of the match begins. In the driver mode, teams must work together to obtain the higher score in the aforementioned time frame of 1 minute and 45 seconds. Once the time limit has been reached, the scores are calculated, and a winner is announced.

III. Qualifications and Eliminations

Each competition is divided into two sections, a qualification round and an elimination round. Qualification matches are randomly generated through the VEX Event Manager software where teams are matched with different teams to form alliances each match. After matches are completed and scored teams are ranked based on said scores. Rankings are decided based on three categories; win points, autonomous points, and strength of schedule points. Two-win points are awarded to each winning team, one point is awarded to tying teams, and no points for a loss. Four autonomous points are awarded to the teams that won the autonomous period and no points to the losing teams. Strength points are equivalent to the final score of the losing alliance. Strength points determine the difficulty of the opposing team. When deciding rankings, teams with higher win points rank higher. In the event of a tie in win points, autonomous points act as a tiebreaker. In the event of a tie in autonomous points, strength points act as a tiebreaker. At the end of the qualifying matches, the top 8 teams then choose their alliance partners for the elimination rounds. Once this is completed, teams participate in quarter finals, semifinals, and finals. The bracket for the elimination round is structured as follows, seed one versus seed eight, seed two versus seed seven, seed three versus seed six and seed four versus seed five.

IV. Alliance Selection

As previously mentioned, at the end of the qualifying matches the top 8 ranking teams must select their alliance partners for the finals. Selection begins with the first ranked seed and they can choose any team they want including those in the top eight. If a team in the top eight is chosen, for example seed 6, the teams below shift up in rank and seed 9 joins the elimination ranks. Teams chosen by a higher-ranking team can reject being chosen, however if they do so they are no longer able to be chosen by other higher ranked teams. Instead, refusing teams must choose a team ranked lower than them as their alliance partner or risk being kicked from eliminations.

V. Skills Challenge

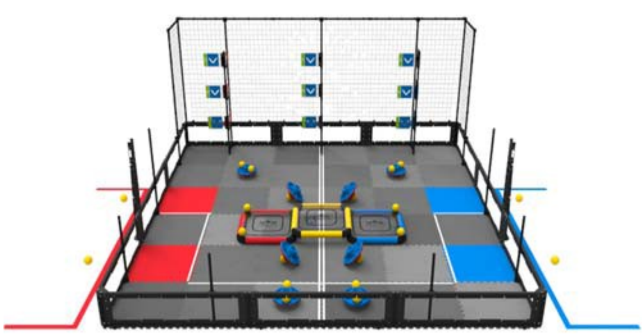

Figure II. Skills Challenge Field Layout

The VEX Robotics Challenge is not solely built on the Competition Matches, but instead also includes a section called Robot Skills. The Robot Skills challenge requires teams to compete in 60-second-long matches where they attempt to score as many points as possible. The field is set up in a manner similar to Competition matches, with slight changes, as seen in the figure to the left. All scoring objects are scored against the team and they must turn the objects to their color in order to score points. The Robot Skills challenge is completed by individual teams alone, not in an alliance. These matches consist of Programming Skills and Driving Skills. Programming Skills matches require the robot to operate and score autonomously much like the Autonomous Period of competitive matches. Driver Skills matches are completely driver controlled similar to the Driver Period of competitive matches. For Robot Skills rankings the teams highest scores for both their Driver Skills and Programming Skills are combined. The Robot Skills challenge is completely optional, and teams can choose to not participate, however teams who choose to participate and then do well can qualify for States and Worlds without winning the Competition Matches.

VI. Competition Path

VEX Competitions are divided across level and region with examples such as; Regional Qualifiers, States Championship and Worlds Championship. At the high school and middle school level, the end goal is to qualify for the Worlds Competition. To do so, teams begin at the regional level, competing at various Regional Qualifiers in hopes of qualifying for the State Championship. At these competitions there are multiple methods to qualify for States which include, Tournament Champions, Tournament Finalists, Robot Skills Champions, Design Award, and Excellence Award. At smaller Regional Qualifiers some awards, including Tournament Finalists, Robot Skills Champions, and Design Award may not qualify teams to go to State Championship. For some of these awards judges follow preset criteria to see which teams qualify. The Design Award is awarded to a team that has a well put together engineering notebook, can explain the design of their robot clearly, demonstrates use of time and resources, and exemplifies professionalism and teamwork. The Excellence Award is awarded to a team that had strong qualifications for other judged awards, has a high Qualification ranking, high skills ranking, and a strong engineering notebook. Once qualified for the State Championship teams must also win the above listed awards at the State Championship in order to qualify for the World Championship. Teams are also able to qualify for Worlds through a World Robot Skills Ranking. Robot Skills scores are recorded from each individual competition and submitted to the Worlds Robot Skills Rankings. The top 10 team who were not able to qualify to Worlds through other methods are able to qualify through Skills.

VII. Our Role

Given the STEM engineering challenge provided by VEX, many teams lack the knowledge, experience, or resources necessary to efficiently and effectively compete. In creating a one-year training program, current teams can receive the necessary knowledge and skills necessary to improve their world rankings and maximize on the STEM experience gained through being a part of the annual competition. The training program is divided into four different sections depending on the schedule of the VEX robotics competition. We aim to target all aspects of the VEX competitive experience to develop a well-rounded world-class team. Furthermore, the aims to improve and prepare students who are interested in pursuing a career in engineering for college. [5]

STEM Training Schedule

The training program was divided into four separate sections based on the VEX competition season. Through the schedule, students were able to continue learning and gaining experience that they applied during the competition season.

I. Initial Training Program

The initial program is an after-school program introducing students to technology and basic engineering principles. Education researches have shown that an early introduction to engineering concept and design prepares students for a career in engineering. The purpose of this section of the program is to introduce engineering principles and critical thinking. As the students develop critical thinking skills, they become able to develop ideas for the VEX competition robots for the upcoming year.

Class	Topic
0	Orientation of the STEM Program (Attendance Mandatory)
1	Introduction to Computer Aided Design Part I
2	Introduction to Computer Aided Design Part 2
3	Introduction to 3D printing, printing process, maintenance, and 3D print finishing process
4	Introduction to Drones and Drone Components/Introduction to Tello Drones
5	Introduction to Autonomous Programming with Scratch
6	Hands-on Soldering, Drone building, and Drone Tuning
7	Drone flight safety, Drone flight controls, and training.
8	Midterm Examination
9	Introduction to Robots and Basic Robot Mechanics
10	Introduction to Robot design, VEX Components, and CAD Assembly
11	Introduction to the VEX Clawbot and building the VEX Clawbot.
12	Introduction to public speaking, technical writing, and interview skills Final Examination
13	Overclock Summer Training Program Orientation (Invite Only)

Figure III. Initial Training Program Semester Syllabus

The initial start of the program began with an introduction to Computer Aided Design (CAD). The CAD classes consist of an introduction to creating self-designed parts, modification of existing Solidworks components, and CAD assembly. The purpose of introducing Cad design at the start of the program is to provide students with an introduction to design and start developing their critical thinking and problem-solving skills. In the continuation of the course, 3D printing is introduced giving students the ability to physically produce their CAD designs. By giving students the knowledge of additive manufacturing, students can understand the manufacturing process in engineering and the existence of a solution to

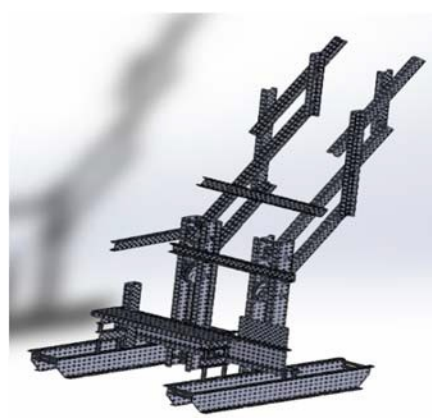

Figure IV. Student CAD Rendering

every problem they encounter while working on the VEX robotics competition. On the right is a CAD rendering of the students' robot design based on their previous year's competition robot.

Figure V. DJI Tello EDU

In the next few lectures of the semester, an introduction to drones provides students with an introduction to technological advancement in robotics. The DJI Tello EDU drone comes equipped with a 720P HD Transmission, 5 Megapixel camera, precise hovering capability, swarm robotics capability, and a 13-minute battery flight time. The drone is capable of autonomous programming using Scratch, Python, and Swift programming languages and a library of advanced commands and data interfaces. With Scratch programming, students can easily begin to understand the concepts of programming and implementation in electronics. Using this method of introducing students to programming provides a more effective approach to helping students understand the basics of implemented coding. In this section of the course students are given an understanding about how the different electronic components of a drone work individually and as a system.

Finally, being that this program is the first section of the training program for a VEX robotics competition team, students are introduced to robotics and the basics of robotics applications. Students were first introduced to the VEX Clawbot which provided a foundation of understanding the different components of a robot. The VEX Clawbot is a commonly used VEX robot in classroom settings for STEM education and provides a means of beginning a career in the VEX robotics competition. Following the manual, students performed several basic exercises in autonomous programming such as moving forward, backwards, and turning. The purpose of this section was to provide an introduction into VEX robotics and allow the coach to evaluate student performance when working with VEX robotics. This evaluation will be later used to restructure and improve the next semester of the training program.

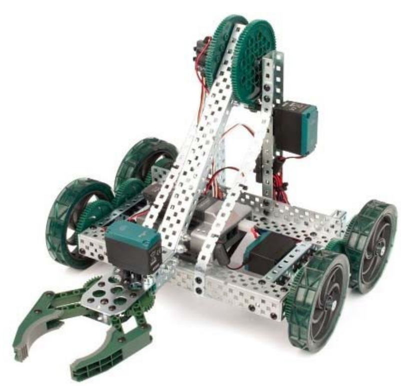

Figure VI. VEX Robotics Clawbot

II. Summer Training Program.

The summer is the most crucial portion of the training program as students did not need to attend school. As a result, the summer schedule consisted of three-hour classes on Monday, Wednesday, and Friday. On the days without class scheduled, students are required to come, and finish assigned homework and class work. In doing so, it creates a professional work ethic giving students a responsibility in remaining active and communicating with their team. In general, the summer training was divided into the mechanical, electrical, programming, and teamwork components of the VEX competition.

Week	Meeting	Scheduled Topics
1	1	Introduction to the new VEX Competition Challenge and Analysis.
	2	Introduction to drivetrain types and their optimization.
	3	Drivetrain analysis and building different drivetrain types.
2	4	Introduction to lifts and their pros and cons.
	5	The building of lifts and analysis of efficiency.
	6	Review of VEX interview process and interview skills.
3	7	Design of end manipulators and their degrees of freedom
	8	Designing and working with acrylic and plastics.
	9	Midterm Examination
4	10	Introduction to VEX sensors and measurements.
	11	Introduction to VEX EasyC programming and logic operators.
	12	Introduction to function calls with passed parameters.
5	13	Introduction to the VEX joystick and programming remote control.
	14	VEX competition path planning methods and analysis
	15	VEX 2018~2019 Competition Field Set up and midterm 2 examination.
6	16	Public speaking and presentation skills workshop
	17	VEX team roles, team structure, and organization.
	18	Practice presentations of their current group robot progress.
7	19	Mathematics required in the VEX competition.
	20	Group assignment and proposal of final project
	21	Final project development
8	22	Final cumulative examination and final project development
	23	Final project presentation and peer evaluations
	24	Overclock team assignment and orientation.

Figure VII. Summer Training Program Syllabus

As seen in the figure above, the first section of the summer program is the new VEX competition challenge analysis followed by the mechanical design of the three key components of a robot; the drivetrain, the lift structure, and the end manipulator. Students are given examples of previously used designs by teams participating in the VEX competition and group discussion is used to analyze their efficiency and effectiveness for this year's challenge. Mathematical explanations were included giving students an understanding of the theory used to create these designs. Students were then divided into groups of three and assigned a mechanical structure type to replicate. At the end of the mechanical segment of the course, students were then given a midterm examination covering the different mechanical designs and the purpose of different VEX components.

Following the mechanical segment of the course is an introduction to sensors and measurements. This covered the function and applications of the ultrasonic, bump, encoder, Inertial Measurement Unit (IMU), and line tracking sensors. In the same week, students were then introduced to VEX EasyC programming, implementation of sensors, and creating function calls with passed parameters. The programming segment of the course concluded with the introduction to the VEX joystick and mapping the different controls necessary for the driver to control the robot. At the end of this segment, a second cumulative examination was administered to understand if students retained the information from the lectures. After the examination, students were tasked with the assembly of the 2018~2019 VEX Competition field in preparation for the competition season.

In the third segment of the course, students were given workshops and training to improve their presentation and public speaking skills. In the first lecture of this segment, students were introduced to the different types of public speaking and structuring an organized flow in developing their presentations. The groups were then tasked with creating a presentation explaining their assigned robot designs and the pros and cons of their designs. In doing so, students can practice their public speaking skills for the future competitions.

III. Pre-Competition Season

This segment of the training program consisted mainly of hands on work in preparing for the VEX tournaments that the teams were registered for. Being that this segment of the course is at the start of the academic school year, attendance was divided into two categories. During the weekdays and Sunday, students will meet with their team at the afterschool location to work on their competition robots. On Saturday, classes are held for 3 hours which covers a half hour meeting update with the coach, one-hour lecture, and students would continue working on their robots for the remainder of the day.

Figure VIII. Students Working on Field

Due to the amount of work and time necessary to build, program, test, and practice with their robots, class lectures were kept to a minimal. The lectures consisted of English grammar, technical writing, public speaking, and presentation practice. During class lectures, students also worked on documenting their design process in the engineering notebook. In this period, students are given the opportunity to test multiple designs as well as completely change their robots if necessary, to more efficiently and effectively complete the competition objectives. During this pre-competition season, a partnership was developed with the Vaughn College VEX robotics team (VCAT). This partnership consisted of friendly competition matches between the Overclock teams and the VCAT teams. Through these matches, students were able to test their robot designs and make improvements in preparation for their competition season.


Figure IX. Students Mock Competition Interview and Presentation at Vaughn College

IV. Competition Season

During the competition season, students continue working with their teams, assigning roles to each member of the team. In the teams, the roles consist of builders, programmers, driver, and notebook team. The builders and drivers work to build the imagined robot design and modify the different components of the robot. On a team of 10 students, six students are usually assigned to the task of building the different components of the robot. Two students of each team are assigned the roles of creating the paths for autonomous match and skills. The programming students will then implement and test the programs as the builders make final adjustments to the robot. The two notebook team members work to ensure that all members of the team complete entry logs for the work they do every day as well as make modifications to the CAD files and design cosmetic 3D printed pieces for the robot.

During this season, there are no classes on Saturdays and learning is done on a meeting basis. Each team meets with the coaches to discuss new designs and concepts they do not understand are further explained in detail. By providing a more freedom-based class schedule during the competition season, students have shown more willingness to focus on the different concepts and designs they do not understand and work together in teaching each other new information. Through peer tutoring, students can create a better work ethic of learning and performing research when not at the school. In figure X, we see the finalized robots for the competition season that the students have developed with minimal support from the coaches. The minimal support method of teaching develops in students a work ethic of self-responsibility, peer to peer evaluations, and team building.

Figure X. Final competition robots designed by each team.

In the figure shown above, the left figure displays the 16099A robot complete with a 180 degree rotating claw that is able to grab caps as well as load balls into the intake at the top of the robot. The intake would feed the balls into a linear puncher that is used to toggle the high flags, allowing the team to score points. In the right side in figure X, 16099B decided to use a flywheel to launch balls at the field flags. The team utilizes the rotating intake with rubber bands to push caps over to their alliance colors. On the rear of the robot, two bars are connected to a motor allow for them to also utilize the back side of the robot to flip caps as well. In the center figure, the blue alliance parked robot is 16099M's linear puncher robot. The team decided to use the effectiveness of the 16099A linear puncher with the 16099B's method of using the intake to flip caps to effectively complete the competition challenge.

Competition Outcomes

I. Current Season Outcomes

The competition season consists of several tournament matches that teams must win specified awards to qualify for the State Championship. These awards include Design award, Excellence Award, and Tournament Champions. The design award is awarded to a team that has demonstrated an organized and professional approach to the design process, project and time management, and team organization. The Excellence Award is the highest award presented in the VEX competition and given to a team that exemplifies overall excellence in creating a high quality VEX robotics program. In both awards, teams must also submit an engineering notebook that shows the entire design process, the team strategy, personnel, time, and resource management. Furthermore, students must separately meet with judges for a 10-minute interview where they present their robot for the competition and explain their strategies for meeting the challenges set forth by the VEX competition. The tournament champions award is given to the alliance team that wins the finals matches at the tournament. Finally, the skills champions award is given to a team that holds the highest-ranking skills challenge score at the competition.

Date	Competition Location	Ranking		Awards Received
December 15, 2018	Roslyn High School	16099A	3	Tournament Champions Robot Skills Champions
		16099B	5	
January 6, 2019	Farmingdale High School	16099A	5	Tournament Finalists
		16099B	6	
		16099M	28	
January 12, 2019	Adelphi University	16099A	3	Tournament Champions
		16099B	1	
		16099M	25	
February 2, 2019	Freeport High School	16099A	4	Tournament Finalists (x2) Design Award Robot Skills Champion
		16099B	2	
		16099M	7	
February 9, 2019	Vaughn College	16099A	4	Excellence Award Innovate Award Robot Skills Champion
		16099B	3	
		16099M	8	
March 2, 2019	East Rockaway Southern NY State Championship	16099A	12	Tournament Champions (x2) Robot Skills Champion
		16099B	2	
		16099M	29	

Figure XI. Overclock Competition Schedule and Outcomes

The figure above shows the overall results of the competitions attended by Overclock at different stages of training. The rankings provided were the rankings at the end of the qualifier matches at the beginning of the tournament. The first competition of the Overclock season was Roslyn High School, where only the high school teams (16099A and 16099B) competed. At the final match, 16099A was able to win achieving them Tournament Champions, giving them an invitation to the state championship. At the Farmingdale competition, the team, 16099M competed for their very first time. Being a completely new team with no veteran members, the purpose of this competition was to introduce them to an actual tournament. Although the team ranking was not very high, the middle school team was able to successfully complete the day with a final ranking of 28. At the competition, 16099B was able to reach the final match where they received the award, Tournament finalist.

Figure XII. Roslyn High School awards and group picture

At the tournament in Adelphi University, the middle school team (16099M) was able to improve their rankings from the previous competition. The team 16099B was able remain rank 1 through all the qualifier match and won the final match, making them the tournament champions of the day. Being tournament champions, the team 16099B was able to receive an invitation to the State championship. Finally, the team 16099A was unable to win the finals match against 16099B due to a motor failure during the match.

During the Freeport High School Tournament, as seen in the figure above. The three Overclock teams successfully remained in the top 10 in a tournament of more than 30 teams participating. The team 16099A received the Design and Robot Skills Champion awards. The second high school team, 16099B, unfortunately was not able to win the final match, but was awarded with the Tournament finalist with their alliance member being 16099M. However, this was the most crucial portion of our research as the ranking for all three teams remained within the top 10 throughout the day. This included matches in which Overclock teams were on opposite alliances. Furthermore, the teams 16099A and 16099M through perfecting their skills challenge autonomous and driver points, were able to reach rank 1 in the New York State rankings. Since 16099A was already qualified for the State Championship, the invitation was rolled over to the second team which was 16099M. Thus, qualifying the middle school team for the State Championships as well due to their skills ranking at Freeport High School Qualifier Tournament.

Figure XIII. Freeport High School Tournament awards and group picture.

At the Vaughn College tournament, all three teams were already qualified for the state championship. As a result, the teams decided to use the tournament as a practice match to test new alterations to their robots and autonomous programming. All three teams maintained in the top 10 ranks during the qualification matches and were able to successfully make it into the finals match in a tournament of 60 teams. This was a major difference to previous tournaments as this competition had the largest number of teams participating.

The State Championship was hosted on March 2, 2019 and consisted of 44 teams. At the competition, the teams decided that each team would focus on a different method of receiving a qualification for the World Championship. It was announced that only High School Excellence Award, Design Award, Tournament Finalists, Tournament Champions, Middle School Excellence, and Robot Skills Champion will qualify. Since 16099A still held rank 1 in the New York for the skills challenge, the team decided that they will place most of their focus on the Robot Skills Challenge of the day. Given that 16099B's was more effective for competition, the team decided with team 16099A that they will focus on the main tournament and select 16099A during the finals alliance selection. The middle school team 16099M decided that it would be difficult to make it to the finals match competing against high school students, decided that they will focus mainly on receiving the middle school excellence award and design award. However, during finals selection, it was announced that the middle school excellence award was cancelled due to insufficient middle school team participation. In the finals match, teams 16099A and 16099B were able to successfully win all matches giving them the Tournament Champions award. As a result, teams 16099A and 16099B were able to successfully qualify for the World Championship.

Figure XIV. East Rockaway Southern NY State Championship

The competition outcomes have shown that by providing the students with the proper resources and training, there can be a drastic improvement to their performance. Due to a lack of middle school teams in New York, the team 16099M competed against high school students in all tournaments they attended. In competing against high school teams, 16099M was able to achieve a high ranking throughout the day at Freeport with drastic improvements from previous tournaments by being provided proper resources and knowledge in VEX robot design. In previous seasons, the Overclock 16099A and 16099B team performance ranked in the 10 to 20 range during competition and as a result were not able to make it past the State Championship.

II. Competition Outcomes of Previous Year

The Overclock 16099 team in previous years consisted of two high school teams with a total of four members on each team. Given that the team was created in partnership and under the same administration as a team that has existed for five years. However, students of the Overclock team did not receive the proper guidance and were given zero training in the development of competition robots. As a result, teams were unable to receive judge awards due to a lack of an engineering notebook and basic comprehension of engineering principles. As a result, teams 16099A and 16099B relied solely on tournament and skills challenge to qualify for the state championship.

Date	Competition Location	Ranking		Awards Received
January 7, 2018	Farmingdale High School	16099A	3	Tournament Finalist Robot Skills Champions
		16099B	5	
January 13, 2018	Vaughn College	16099A	4	Tournament Champions Robot Skills Champions
		16099B	14	
February 3, 2018	Freeport High School	16099A	1	
		16099B	4	
March 4, 2018	Harvey School Southern NY State Championship	16099A	18	Robot Skills Champions
		16099B	6	

Figure XV. 2017~2018 Competition Results

Furthermore, as seen in figure XV, the team rankings were very inconsistent, and many times placed outside of the top 10 in rankings. As seen in the awards received, section of the figure, the due to the lack of previous engineering knowledge and lack of an engineering notebook, teams were only able to receive awards that did not factor judge interviews and the design process documentation. Furthermore, the two high school teams were unable to qualify at the state championship for the world championship. In comparison, the training program has benefitted students with increasing teamwork, organization, and knowledge in engineering education.

Program Outcomes

In the program, the goal is not only to improve the competition outcomes of the team but increase the different skills and assets students can use in the future as well. This includes their presentation, communication, teamwork, and public speaking skills. At the beginning of the program when students first started the training program, it was evident that public speaking and presentation skills were very low. Students constantly struggled in completing full sentences while maintaining a professional posture. Furthermore, students were unable to make eye contact with the audience and often spoke in very low voices. To overcome this lack of self-confidence in public speaking and increase their voices to an audible level, students were constantly asked to present their work at Vaughn College. At Vaughn College, students and faculty were asked to rate their presentations and provide feedback directly to students individually. Furthermore, speech classes and constant revisions were done to presentations giving students the ability to understand the concepts of technical writing, improving the way they can explain their design process.

As the training program ends, it is seen that students can speak and present confidently at an audible level while maintaining a professional posture. Students have decreased the amount of stuttering and freezes during presentation and understand the importance of creating an organized group presentation speech. Recently, students were given an anonymous survey about their experience and how they feel about their improvements. The survey questions are listed as follows:

1. The program has taught me about robotics and the different designs and applications available.
2. I know how to build the drivetrain, lifts, and end manipulators taught in class confidently on my own.
3. I have learned to program the robot for autonomous and driver control in a competition.
4. I understand the different sensors available in VEX robotics and how to use them effectively.
5. The program has taught me how to write technical papers and presentation speeches.
6. I can confidently give a presentation and my public speaking has truly improved.
7. I feel confident when attending a competition that my team will perform well.
8. I truly believe that the team has improved drastically from previous years.

In the end results more than 90% of students checked that they strongly agree/agree for each of the questions. Several students however selected neutral with the explanation that they believed that there were certain topics in the program that were difficult for them to follow along. However, they believed that if given more time, they would be able to understand the material.

Conclusion

Although the program has shown to effectively improve the competition outcomes and rankings of the VEX robotics team, there are still several future improvements. One improvement that will be made is to increase the meeting times per week allowing students to have more time to understand the material. Another improvement is that outside of summer vacation, the schedule will increase more meeting days for students to be able to work on their robots as well as continue learning new material and engineering concepts. By increasing the number of classes, a week, students will be able to extend their learning beyond that of only VEX robotics. Although VEX robotics provides a STEM engineering challenge, it is still unable to also truly provide all aspects of STEM education. Through the program however, it was seen that students, especially veteran team members, have shown drastic improvement during competition season and all students of the team are able to aid in each other's roles and tasks. Furthermore, students have shown significant improvement in communication, teamwork, public speaking, and presentation skills. Due to the focus on VEX Robotics Competition, the course development differs highly from many different STEAM programs in that it focuses mainly on the field of mechatronics and robotics engineering.

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