# A Robotics Curriculum for Association Anoual to Support Moroccan Youth's STEM Education

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# ABSTRACT

Association Anoual, a non-governmental organization based in Kenitra, Morocco strives to make social change by supporting STEM based programs. The goal of this project was to develop a robotics program for youth, ages 12-15, to inspire and expose students to a project-based STEM education. We first researched robotics curricula and pedagogy in tandem with Moroccan STEM education. From our research an intensive seven-lesson program was developed, concluding in a final project presentation. The curriculum is described in detail in the lesson manual and the VEX robotics code and functions are explained in the technical manual.

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# EXECUTIVE SUMMARY


## Introduction

Students in Morocco are failing to receive sufficient STEM education in their youth resulting in a lack in both global and local competency. With a workforce that has an increasing demand for employees with a technical foundation and developed critical thinking, there is a pressing need to expand access and interest in STEM education for Moroccan students.

Non-governmental organizations have begun to address this issue by providing supplemental STEM education. One of these, Association Anoual, is aiming to empower youth with effective initiatives to enhance STEM education. The association currently conducts programs for youth to practice entrepreneurship, learn STEM and develop their leadership skills. Association Anoual offers a platform to host programs that can increase awareness of STEM skills.

## Goals and Objectives

The purpose of this project was to expose youth to robotics as a way to build their technical knowledge in STEM and their interpersonal skills. The program, named RobotiKids, was created for youth ages 12-15 and intended to have a long term impact. Our project goal was to leave Association Anoual with a curriculum that could be applied and expanded in the future. This project aims to use educational robotics as a platform to expose and pique interest in STEM skills.

## Methods

The objectives were addressed in our methodology through four main parts. We first developed a holistic understanding of robotics and the pedagogy that accompanies it. We then applied this information when we researched the Moroccan education system in our second objective. With these accumulated resources and guidance, an intensive seven-part robotics program was innovated. Once the program was finalized, it was piloted and assessed for recommendations and refining.

To accomplish our first objective, we interviewed experts and educators in the field of robotics in the WPI community with experience running similar youth robotics programs. We also conducted an exploratory analysis of the VEX resources and kits. To accomplish our second objective, we interviewed a parent of a middle school student and administered surveys to students. We also interviewed a mentor of a similar program within Association Anoual and NGOs and STEM educators with successful youth robotic programs. We used this to innovate a robotics curriculum from the resources we had at our disposal. The program was detailed in a lesson manual that followed a project-based learning style and provided an engaging curriculum that put student's critical thinking and interpersonal skill development at the forefront. To supplement this, a technical manual was developed to provide guidance on VEX  for the facilitator. Our final objective, the team organized logistical information to conduct a field evaluation which allowed for edits and recommendations.

## Findings and Discussion

Concluding each of our methods, we were able to compile an assortment of findings that helped to propel the project into three final deliverables.

Interviews with robotics experts created a compilation of information regarding a successful robotics curriculum and how to effectively teach young students. VEX resources in the IQ Kit and found online supplemented these points and guided our program construction. In tandem with this, interviewing people involved in the Moroccan education system gave valuable insight into the current state of education in Morocco. This included what areas needed bolstering, what tactics have been successful and what obstacles we would have to be aware of when constructing our own program.

From these sources, the team used the ideology of project-based learning to guide our curriculum construction. This would simultaneously engage the students, teach them technical skills and develop their soft skills. A seven lesson plan was outlined that incorporated the recommendations and research that was completed earlier. The lessons were then detailed with activities, teachings and discussions that put student learning and engagement at the forefront.

With the purpose of producing a robotics curriculum program for Association Anoual to implement on a full scale in the future, we created a detailed lesson manual and technical manual.

*Lesson Manual:*

The lesson manual was developed to operate as the main component of guidance for facilitating the Robotikids program. A seven lesson block that ended in a cumulative final project and presentation. Each lesson included activities and discussions as outlined in the lesson manual. The lessons were created in a manner that allows them to be customized to various instructor schedules. Lessons are versatile and although they are created around VEX IQ kits, they can be taught with other robotics kits.

*Technical Manual:*

Material used in the lessons that was directly relevant to VEX IQ robotics were compiled and explained through the technical manual. It also provides an explanation on how to use the online platform, coding examples, and insight into the hardware, all including detailed visuals. This resource is intended to provide more structure and clear instruction to the novice facilitator who may not be acquainted with VEX robotics.

## Recommendations

Based on the execution of our field evaluation we compiled a comprehensive document of recommendations for Association Anoual. The recommendations were derived from the developer's pilot, peers' evaluation, and a possible future mentor's evaluation. The recommendations illustrate a breakdown of the manuals, our recommendations for mentor training and facilitation of the program and recommendations for the final project. In order for the program to progress into a full-scale operation both benchmarking and assessment of student interest and knowledge is necessary. Templates of rubrics and surveys are also included in this document. Any other feedback was directly implemented into the program lesson manual or technical manual accordingly.

During our time in Rabat, we were able to deliver a customizable VEX robotics curriculum to Association Anoual. This includes a detailed lesson manual, technical manual, and recommendations document, which can be found in appendix H, I, and J. These three deliverables combined, will help create an engaging and impactful program called RobotiKids. With RobotiKids, we hope to see increased excitement in STEM education and youth development of associated skills.

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# CHAPTER 1: INTRODUCTION

Benjamin Franklin, a founding father who helped draft the Declaration of Independence for the United States of America, once said "Tell me and I forget, teach me and I may remember, involve me and I learn." Involving students in project-based science, technology, engineering, and math (STEM) education is a critical building block to the growth and advancement of a child's mind and future as it allows for the development of skills that are not cultivated in other fields of study. Differences in funding and curricula between public and private education systems lead to disparities in the thoroughness of STEM education (Toutate, 2021). Families of different socioeconomic backgrounds, who can afford private education are exposed to STEM practices, while other families, who can only afford to receive public education, do not receive this privilege. To address the growing educational divide, non-governmental organizations (NGOs) like Association Anoual are aiming to increase STEM capabilities and close the educational gap by creating programs for children. Association Anoual's mission aims to give everyone opportunities by empowering the future leaders through STEM and entrepreneurial programs. Association Anoual has instituted programs like Digigirlz in Morocco, which provides young women access to computer science opportunities, to increase competency and interest in STEM fields. To further Association Anoual's goal of closing the education gap between the rich and the poor, our research project provided a free-to-join extracurricular STEM robotics program for middle school students.

This research paper provides information on the current state of education in Morocco, the importance of STEM education, and effective ways to teach STEM. Our methods offer a detailed explanation of how we accomplished our end goal of helping Association Anoual to increase STEM competency regardless of the financial background of the student. Our methods progress through: 1) Semi-structured interviews and a literature review which will outline the best methods and pedagogy to engage middle school students in STEM, 2) Assembling a curriculum based on knowledge gained from the literature review that will engage students once implemented, 3) Piloting and reconstructing the curriculum which will give Association Anoual a deliverable to implement for the future.

By inspiring Moroccan youth with an engaging and informative robotics curriculum, it allowed students to learn like Benjamin Franklin.

# CHAPTER 2: BACKGROUND RESEARCH

## 2.1: Current State of Education in Morocco

Education is the gateway to empowering the future generations of the world. Youth education is crucial not only to the individual student, but to the progression and advancement of society. Middle school education is a vital stepping stone to prepare students for higher education and for a successful career (Diyen, 2004). However, despite the importance of education, Morocco falls short in their academic standings. Morocco ranks 121 out of 140 for the mean years of schooling, with an average of approximately 4.8 years (*The World Economic Forum*, 2019). The country also ranked 121 out of 140 in the 'critical thinking in teaching' section and 117 out of 140 in the 'skill sets of graduates' category (*The World Economic Forum, 2019*). A factor to Morocco's consistently low global rankings, is the difference in the number of students compared to the number of teachers. In 2019, the ratio of teachers to students was 1:27, where the global average was 1:18, this makes larger class sizes and less time for individual instruction (Berrada et al., 2022). Teachers that are assigned to large student audiences are prone to lecture-styled teachings that are less engaging with less teacher to student interactions. The current teacher shortage causes a lack of engaging course material, which diminishes the quality of the STEM instruction.

A notable difference between the Moroccan education system and countries with the best ranked education systems is the lack of structure in Morocco's curricula. Within Morocco's educational curricula, lesson plans are not clear and syllabi fail to serve as guidelines and benchmarks. Students' creativity is not expanded on in many Arab states [1] because the educational systems fail to incorporate students' problem solving and critical thinking skills. It was also noted that a student's personal background and ideal learning environment are disregarded when determining a teaching style (Dagher et al., 2011). When a students' needs are not placed at the center of learning there is a disconnect between the lesson given by the instructor and students' engagement and retention of that lesson. Teachers in Morocco are understaffed and confined to teaching from a textbook catered to covering only the material needed for standardized testing (Dagher et al., 2011). The teachers are not trained with students' learning as the first priority causing them to gloss over what skills are the most essential to learn and how to effectively acquire these skills. Unfortunately, this means that students in Morocco

[1] Arab states are the 22 states that make up the Arab League as of 2022

do not receive an education with exposure to different learning techniques and related skills that students in other educationally advanced countries exhibit.

### *2.1.1 Morocco Education Enrollment*

In 2000, Morocco had just shy of 3.7 million students attending primary schools, which increased to 4.5 million students in 2020. During that same period, the middle school population grew from 1.5 million in 2000 and doubled to 3 million students(*The Statistics Portal*. Statista). The completion rate of middle school in Morocco is below 70%, which has led to a lack of basic skills (UNESCO, 2020). Some young students have minimal interest and capability to pursue higher education and work opportunities, due to a lack of STEM exposure in their education. Community members and government officials are working to fix the lack of interest and enrollment in education. This has caused a steady increase in the number of schools and higher education institutions, as Morocco has pushed to position itself for continual growth.

### *2.1.2 Public and Private School Education*

The teaching of STEM skills varies from public and private institutions in the Moroccan education system. NGOs are currently attempting to address the divide in STEM education by creating programs that close the gap between public and private curricula. Toutate in 2021 conducted a study where an exam tested students' capabilities in various categories. Within the math sector, 9% of public school students reached the satisfactory level compared to 49% of private school students. Around 8% of public school students were satisfactory in physics, chemistry, and life sciences compared to 42% of students in private school (Toutate, 2021). Additionally, Morocco is still faced with high subjective poverty levels and the issue arises even more in rural areas which means that private education is not a realistic option for many families (Gibson, 2019). In Morocco 6.8% of families in 2013 had at least one school-aged child not enrolled in education (*World Bank Report*). Even more surprising, 12.7% of families did not have a parent who completed primary education. If a family cannot fund a private education or does not prioritize education, their children are less likely to receive an education, let alone a quality education.

### *2.1.3 Lack of STEM Education*

STEM fields are not a priority in the Moroccan education system. STEM is best taught through critical thinking activities that encourage a non-traditional style of learning and are applicable to real life experiences (Chaudhary, 2019). The benefits of STEM are two-fold; they teach practical lessons on important curricula and can develop a student's interpersonal skills when taught non-traditionally. Arab countries spend a small amount of time learning STEM in school. Dagher and BouJaode (2011) stated the percentage of time spent learning science ranged from .3% - 13.3% of the student's education. There is a lack of quality science education due to outdated curricula, teaching methods, and lesson plans. In many Arab states there is an emphasis on theoretical science content and not on hands-on activities. There is also limited access to appropriate supplementary teaching tools and the internet, resulting in low quality science and technology education (Dagher et al., 2011). The current Moroccan education system is not exposing children to the best possible STEM education causing a lack of vital skills that make up a motivated and educationally well-rounded workforce.

### *2.1.4 Gender Differences in STEM*

In Morocco, there is a distinct difference between men and women in relation to education and careers. Girls of all socioeconomic groups have a disadvantage in the education system compared to boys, with the greatest disadvantage affecting girls from underprivileged families. According to the Global Competitiveness Report, for about every five salaried workers, only one will be a female (2019). The disparity between men's and women's education in Morocco parallels the disparity in the workforce, with women tending to go to school for fewer years than men. The difference also holds true for the STEM industry with women underrepresented. One of the reasons the difference exists is because young women report being less confident about their STEM abilities than men, which is why many of them choose not to continue their STEM education (Ardito et al., 2020). Even with attempts to improve the education system the percentage of females that continue on with STEM is consistently lower than males (Dagher et al., 2011). The gender differences in education, specifically STEM education, speak to the need to expose more women to STEM.

### *2.1.5 Economic Impacts*

Advancement in STEM fields is crucial for developing states as scientific and technological affluence is considered a necessity for economic and social development (Dagher et al., 2011). Policy makers around the world are attempting to entice students to enroll in STEM courses which will equip them with the skills needed for the modern workforce (Black et al., 2015). A well developed middle school education system can positively affect the nation's economy as well as students' development and success (Diyen, 2004). Building upon students' curiosity at a young age can have a tremendous effect on their personal and professional development, which can in turn benefit the country as a whole. A focused Moroccan education system can provide the workers needed to bolster Morocco's economy and society.

## 2.2: Middle School STEM Education

STEM education is vital for youth to expand their curiosity and explore their surroundings. Middle school is a crucial time to learn the foundations of science because this is where children develop and solidify cognitive aptitude and acquire long term skills.

A strong technical foundation in STEM fields prepares students for a plethora of future opportunities. Aside from the crucial hard knowledge that a student should acquire from a robust STEM education, the workforce also needs students who have sharpened their interpersonal skills that would contribute positively to the company. STEM based curricula have consistently proven to be the most impactful method to reach young minds and thus, lay the framework for the future (Kaçan, & Çelikler, D, 2017). There are two types of equally challenging and essential skills gained through STEM education, hard skills and soft skills. Hard skills would classify as knowledge or rigid lessons, for example, algebra or physics. Hard skills are systematic and often build upon each other. Interpersonal skills, or soft skills, are critical thinking, innovation, and collaboration which take a long time to develop into a usable state.

STEM can be daunting and difficult for young students, which makes them less likely to continue with STEM and hinders the amount of skills that students can draw from their courses. Starting STEM earlier in students' education allows for skills to be developed deeper which ensures a stronger foundation and can impact one's success in the workplace (Berry & Rogers, 2016). Students exposed to STEM learn about the benefits that it can have outside of the classroom, and its contribution to quality of life. A study completed on 60 sixth graders showed there was an increased interest in STEM and the students had a more positive outlook on careers after completing a five day afterschool STEM program (Baran et al., 2019). Establishing an aptitude for STEM in youth has been shown to impact middle school students' perspectives, increase their confidence and encourage them to continue taking STEM classes throughout their academic career.

One particular subject that teaches STEM holistically is robotics. A study showed that when a robotics curriculum was implemented on middle school students, the students expressed a desire for more STEM classes (Grubbs, 2013). After completion of the curriculum there were comments from teachers on the improvement of the students' critical thinking skills in their individual classes; the students' collaboration and communication with peers was also greatly improved since the implementation (Grubbs, 2013). This helps to cement the idea that robotics is an ideal subject to teach STEM to middle school students.

### *2.2.1 Non Governmental Organizations*

STEM is not taught in depth or in an effective manner in government-run Moroccan schools, leaving the question of who should engage students in STEM topics in Morocco? The answer is NGOs, which are taking action in Morocco to face important issues such as helping students access STEM and entrepreneurial skills.

## 2.3: Teaching STEM Through Project-Based Learning

Project-based learning style provides students with hands-on experience that builds both hard and soft skills. Project-/problem-based learning (PBL) is a teaching method that allows students to gain knowledge and valuable skills from working both individually and collectively on an authentic, engaging, and challenging question, project, or problem at a level that is far more efficient than other teaching styles (*What is PBL?*). Soft skills, even within STEM fields which encompass interpersonal skills more, do not get developed to the utmost potential when it is taught without student interaction and without showing its relevance. PBL provides hands-on opportunities to learn concepts and valuable skills through activities outside of traditional assignments and lectures.

When students are presented with projects that involve teamwork, leadership, presenting, and time management, they are pushed to think creatively and beyond technical understandings (Brown et al., 2009). Project-based education enables students to share their efforts with others in their classroom or community. Critical thinking is a skill that provides new viewpoints and challenges previous ideas; this can lead to new concepts, companies and inventions. Innovation goes hand in hand with critical thinking since it encourages free thinking and new ideas (Ntemngwa & Oliver, 2018). Furthermore, collaboration is known as one of the most desired traits in potential hires for companies around the world because they are aware that “great discoveries and improvements invariably involve the cooperation of many minds” (Alexander Graham Bell). Using project-based learning as a teaching method to develop soft skills is effective and influential on a student’s ability to practice those skills outside of the classroom

Students benefit from PBL because there is no hierarchy of topics, allowing all related topics to be drawn upon and developed as they emerge (Hung et al., 2007). PBL is relevant to the real world in many jobs, such as a scientist doing an experiment in a lab or an architect designing a building, which use PBL skills (Krajcik & Blumenfeld, 2005). PBL has also been seen to assist in testing skills and reaching standards set forth by educational institutions and states (Massa, 2008). The knowledge that is gained during project-based learning accounts for many of the skills needed to continue in STEM areas of study.

Project-based learning is divided into four steps: 1) Identify the problem or opportunity, 2) Devise a plan for solving the problem, 3) Implement/evaluate the plan, and 4) Communicate the plan/solution (Euefueno, 2019). Students increase their problem solving ability when they identify the problem they have been tasked with. When students implement the devised plan they practice behavioral and teamwork skills to produce a product. With a finished product, students are able to communicate what they have accomplished to others. Students who learn via project-based learning are able to take real world skills learned, such as communication, responsibility, problem solving, and behavioral skills, and apply those soft skills to jobs and or everyday life (Euefueno, 2019). Students have the ability of expanding upon ‘the four Cs’, Critical Thinking, Creativity, Communication, and Collaboration Skills, when exposed to PBL (Vogler et al., 2017). Interdisciplinary work, a hallmark of PBL, was practiced in a recent study where students participated in a hard skill job but were tasked with challenging soft skill problems, such as communicating with a client during a conflict (Vogler et al., 2017). The study showed that students had to adapt and increase their soft skills after the design and implementation of their program. The students’ ability to communicate, manage their time, and show initiative and curiosity all increased after implementation (Tadjer et al., 2020). Students improve their technical skills and their perception of their own skills, not only in their field of study, but in their life-long skill set which are valuable to the workforce.

Integrated STEM learning is a common term used alongside project-based learning; it is the process of making connections between concepts in STEM so the field is seen as a whole, rather than individual subjects (*What is integrative learning?*). Integrated STEM (ISTEM) is a student-focused learning environment which has a direct effect on how students engage with their class and the processing of the information (Struyf et al, 2019). It can have a large effect on students' success because it combines individually daunting subjects into one cohesive subject; this is less daunting because it makes the subjects more relatable and real world applicable. Integrated learning, using PBL, has been found to be an effective way to engage students and encourage a lifelong interest in STEM. Students should be a part of the lesson plan in order to tailor to their learning style, this also improves the educators' ability to observe what style of learning their students are most receptive to and adjust their methods accordingly (Nygaard et al., 2006). Successful integrated learning curricula focuses on giving students the best learning and retention of the lesson and complementary skills. The success of the program is displayed in how the student grasps the material and can apply it, not how it is regurgitated in a test format that is not applicable to real life situations nor is retained long term.

## 2.4: Robotics Education

Robotics is one of the best ways to teach and engage students in STEM. Robotics is a form of integrated learning (Yang et al., 2019). Robotics is particularly effective because the PBL that is intertwined in robotics makes it easy for young students to get involved and build a foundation. Robotics incorporates many important disciplines that help students understand STEM topics and provide opportunities for hands-on practice. For young students programming can be difficult, but in many educational robotics platforms it can be taught fundamentally by using "drag and drop" code. This means that the robot can be programmed quickly which can help students see quick results, making the subject instantly rewarding. The STEM proficiency that can be gained from robotics is especially important if Morocco hopes to continue progressing towards the STEM proficiency that some of the most wealthy countries have. Furthermore, aside from computer science, robotics facilitates other STEM hard skills such as physics, material science and math. Using robotics as a form of project-based learning can be an effective tool to combat STEM hesitancy for middle school students and can make them more likely to pursue STEM in the future (Berry & Rogers, 2016). Robotics turns STEM, a daunting field for young children, into a fun project for students that incorporate many different subjects of STEM into one digestible topic helping to promote continued interest in STEM.

Introductory robotics incorporates hands-on projects, which is a great way to teach young students (Ntemngwa & Oliver, 2018). When students are tasked with projects, like building a robot, they learn first hand how to use lessons previously taught to solve real world problems. Projects prompt students to learn how to break down complex subjects; they open up routes for students to build and explore the subjects at their own pace. Robotics is also a field that requires development of soft skills namely, problem-solving and critical thinking. It creates an environment where complex problems must be broken down logically and this improves soft skills and creates room for experimental mistakes to be made and learned from. By working in teams and exposure to other students' ideas, students subconsciously work on their soft skills that are needed for higher education and all STEM industries.

Worldwide, there has been a steady introduction and integration of robotics into modern society. Competitions and programs aimed at increasing STEM interest through robotics continue to gain attention and are a major driver for increasing youth engagement. Competitions allow students to take part in a complicated project, become acquainted with hard and soft skills, and learn how to work with different people effectively.

VEX is a company founded with the vision to create tools that educators and mentors will use to form the students today into problem-solving leaders of tomorrow. The company believes in hands-on learning to build and solve problems using innovative technology. VEX robotics has over 20,000 competing teams in over fifty countries and has impacted over a million students, making them a reliable and robust platform. VEX has branched out and developed strong relationships with schools in Africa. VEX offers a robotics kit, shown in Figure 1 on the right, targeted at middle school students, called VEX IQ. VEX IQ was designed for children aged 8-14, so they would gain experience in robotics through simple instructions.

Figure 1: VEX IQ Kit

The VEX IQ kit is limited in constructional parts, with many resources for educators and students to learn more. VEX IQ kits are capable of performing complex and engaging tasks that are necessary to keep students interested and give them an actual idea of what robotics is capable of doing for students and communities if they continue studying this field.

# CHAPTER 3: METHODS

This section details the methodology proposed to provide access to robotics education for middle school students through a supplementary program administered by Association Anoual. The methods chosen were developed to meet the following project objectives.

### Objectives

1. Review robotics education and pedagogy
2. Research Moroccan STEM education
3. Innovate previous VEX robotics curricula
4. Pilot and assess the robotics curriculum

### 3.1: Review Robotics Education and Pedagogy

Objective one was to review existing robotics education and successful pedagogical approaches to innovate, pilot, and assess a supplemental robotics curriculum in Morocco, the list of reviewed curriculum can be found in Appendix A.

VEX curricula was researched to assist the team in gaining an understanding of robotics curriculum structure. VEX curricula and previous programs were consulted and reviewed to determine key components of robotics education.

To develop an understanding of robotics education, semi-structured interviews were held with experienced curricula developers and experts in robotics teaching. The transcripts of these interviews can be found Appendix B and Appendix C.

### 3.2: Research Moroccan STEM Education

Objective two was to research Moroccan STEM education to understand where and how a robotic curriculum, similar to those reviewed in objective one, would fit within the current state of Moroccan STEM education.

To accomplish this goal semi-structured interviews were held with stakeholders of the Moroccan education system: a Moroccan student mentor, a parent and child immersed in the Moroccan education system, a STEM educator in Moroccan public schools, a STEM focused after school academy in Morocco. In addition, the team interviewed members of Association

Anoual to gain insights on their previous related program, DigiGirlz. The transcripts of these interviews can be found in Appendix D, E, F, G and H.

### 3.3: Innovate Previous VEX Robotics Curricula

To achieve our objective of innovating previous VEX curriculum, the team assembled a robotics program encompassing the use of VEX IQ robotics kits.

Based on the information found in objective one the team decided the duration, engagement style, method of teaching, necessary topics to cover, location set up, and number of students and mentors. The team compiled the structure of the curriculum collaboratively based on the analysis of results found in objective one. The curriculum was created around ten VEX IQ robotics kits which were donated on behalf of the REC Foundation (Robotics Education and Competition Foundation). The team used an online virtual robotics simulator, VEX VR, and a computer application, VEXcode IQ, to take advantage of simulated actions of a robot so students could learn the basics of coding. The program was designed to conclude with a final challenging problem in which teams would demonstrate and present their robot.The lesson manual can be found in Appendix I. The technical manual can be found in Appendix J.

### 3.4: Pilot and Assess of the Robotics Curriculum

With the curriculum assembled a marketing infographic, student interest application, and mentor interest application was created. Copies of these can be found in Appendix K, L, and M.

A contingency was developed: were a location, day, time, and participants obtained? Was the marketing infographic, student interest form and mentor application distributed? If the answers to ***both*** these questions were yes, the team would have followed the methods outlined in Appendix N (student pilot), otherwise, as indicated in Figure 2, we would proceed with the field evaluation as described below. The team proceeded with the following outlined method.

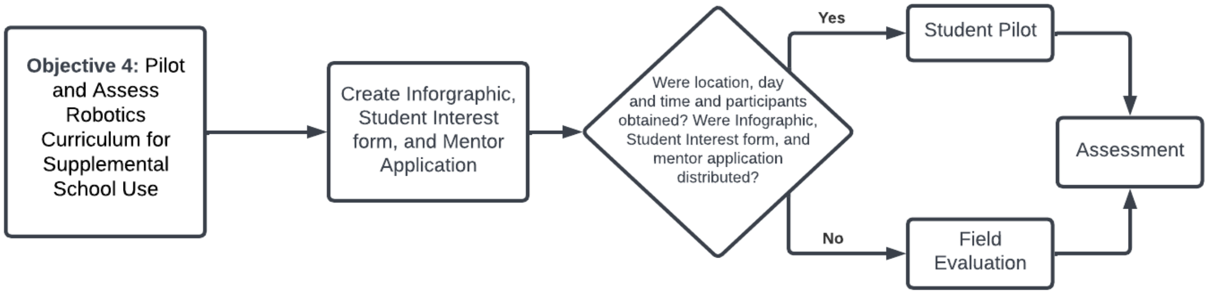


**Figure 2: Decision Flowchart for Pilot Method**

### *3.4.1 Field Evaluation*

The team distributed the lesson manual and technical manual to a Moroccan student mentor, an experienced robotics curriculum developer, peers, advisors, and a computer science student. The team created two evaluations surveys, which can be found in Appendix O and P, which gave the feedback on the content and ease of facilitation.

The members of the team carried out the program amongst themselves. Each member taught a lesson that they did not outline, to identify issues that arise when facilitating. Seen in Table 1, each member taught a lesson they did not write; all other members participated in the lesson.

| Lesson Title | Author | Facilitator | Participants |
| --- | --- | --- | --- |
| Lesson 1: Introduction to Course | Erin Gowaski | Nate Kumar | Erin Gowaski, Hannah Jaworski, Josh Palmer |
| Lesson 2: Introduction to Programming | Hannah Jaworski | Erin Gowaski | Hannah Jaworski, Nate Kumar, Josh Palmer |
| Lesson 3: Movement and Turning | Hannah Jaworski | Josh Palmer | Erin Gowaski, Hannah Jaworski, Nate Kumar |
| Lesson 4: Sensors | Josh Palmer | Hannah Jaworski | Erin Gowaski, Nate Kumar, Josh Palmer |
| Lesson 5: Arms and Joints | Nate Kumar | Erin Gowaski | Hannah Jaworski, Nate Kumar, Josh Palmer |
| Lesson 6: Project Introduction | Erin Gowaski | Josh Palmer | Erin Gowaski, Hannah Jaworski, Nate Kumar |
| Lesson 7: Project Presentation | Erin Gowaski | Hannah Jaworski | Erin Gowaski, Nate Kumar, Josh Palmer |

**Table 1: Distribution of Facilitation**

A further discussion with the Moroccan student mentor was held to review facilitation and to get more in depth comments on the content of both manuals. A copy of this can be found in Appendix Q.

A reflection was done with the sponsor to review the steps taken to see the project to completion. This reflection was to assist in compiling recommendations for potential implementations. A copy of this can be found in Appendix R.

### *3.4.2 Assessment*

An assessment of the data and documentation collected during the professional evaluations was completed to prepare recommendations for Association Anoual.

The outlined curriculum from objective three was reassessed and refined to implement changes found from the developer program pilot and reflection.

# CHAPTER 4: RESULTS

The following results section is organized by the project's objectives utilizing the methods found in section three.

## 4.1: Results: Review Robotics Education and Pedagogy

We obtained results from objective one prior to our arrival in Morocco, when we were still on campus at Worcester Polytechnic Institute (WPI). Interviews with two WPI robotics professors uncovered important topics in robotics education and pedagogy. These results came from WPI professors and VEX Robotics resources and were aimed at giving us a better understanding of robotics education. Namely, what is needed to teach it correctly, the best ways to engage students, and what the most important sub-topics are.

The first interviewee was a WPI professor who was involved with starting the robotics program at WPI. We chose to interview this professor multiple times because of their experience with robotics, specifically involving education for children aged around 12-15. This professor helped give us an understanding of important elements to teach in the lessons and tips for teaching younger students. It was made clear that children have trouble focusing, which makes it especially important to ensure the curriculum is engaging and includes numerous breaks that are not associated with STEM. For example, students could play soccer outside for their break. This was shown to help to refocus their minds and keep students interested in their projects, and that makes the students able to engage in the course and develop the intended soft skills. The team found that educators communicate with students differently depending on the age group they are working with. Younger students, like those involved in our program, perform better if there is mainly physical engagement with supplementary auditory engagement. For example, the students should mainly be doing activities with the robot and working on coding, with small segments of lecture to help guide them in the right direction. This WPI professor helped us to provide a good guideline for what components of the curriculum are the most essential to have fully elaborated on. A copy of this interview can be found in Appendix B.

The second interviewee, another robotics educator at WPI, helped to add onto the details highlighted above. The interviewee highlighted two key elements to a robotics curriculum, working group size and a teachers guide. It is important to have a small number of students in the working groups so that every student is constantly working and gets access to the robot and also to the coding platform. Two is an ideal number because it encourages collaboration and requires that students solve problems between themselves rather than having a third student who can easily break the tie. This helps students with their communication skills as well. From this important point, it was encouraged that the team look into a teacher's guide to ensure key elements like this were not overlooked. The teacher's guide is essential for this course because it would allow for a smooth transition of the material to our sponsor without a critical loss of information or teaching style during reimplementation by Association Anoual. Both of these ideas proved to be critical to the advancement of our course as it developed. A copy of this interview can be found in Appendix C

Lastly, we studied the donated VEX IQ robotics kits and VEX open source course material. We looked at the VEX IQ robot kits that were donated to this program as they would be the main vector for teaching in this course. The team found that the robot kits were very capable and diverse in what they could construct and what they could accomplish. The students also would have access to the VEX Virtual Robot. This allowed the students to work on their coding abilities and also work on complicated tasks with the robot without having to set them up in the real world. Similarly, the VEX open source course material helped us to learn what needed to be taught and possible ways to teach it using the VEX IQ robot and the VR platform. This allowed the team to be more creative with the course and determine activities and tasks that would consistently engage students. The list of these resources can be found in Appendix A.

### 4.2: Results: Research Moroccan STEM Education

The team conducted interviews while in Morocco that were focussed on understanding the Moroccan education system so we could properly implement the robotics program into Moroccan context.

The first interview conducted in Morocco was with a parent whose child is in the age range of 12-15 years old. This parent had expressed concern that their daughter was not able to enroll in an extracurricular STEM program despite their efforts to enroll their daughter in one. We learned that their daughter's school was not providing sufficient STEM education and that many of the extracurricular programs were costly. From this interview we gained information on what type of program they wish their daughter enrolled in, how long the programs typically run for, and what content and skills the students are supposed to gain from these courses. The parent was also an excellent resource because they connected us with Moroccan STEM educators.

We interviewed a number of different people involved with NGOs that focus on providing access to STEM. The first interview in this category was with our sponsor Association Anoual, they helped to provide us with an understanding of their previous program, Digigirlz. This allowed us to understand how they run programs, what they focus on teaching, and what age groups they work with. Despite the age ranges being different from what we were planning on working with, and that their student demographic was only young women, we were still able to extrapolate similarities between the program we were creating and their program that already exists. The team conducted an interview with an educator at a STEM focussed after school academy. The STEM focussed after school academy has a program similar to the course we wanted to provide so there were many direct takeaways on how to start drafting the program and what to focus on. We found that their curriculum, that they use for 12-15 year old students, is similar to what we were thinking for our course. This helped to assure us that we were moving in the correct direction and the implementation into the Moroccan education system would work as intended. A third interview was with a Moroccan robotics educator. The most unique takeaway from this interview was the information on timing for Ramadan. For example, we learned that students do not require shorter lessons or more breaks during Ramadan. We did not have any experience with Ramadan as non-Muslims so this was very helpful for us to learn about. Lastly, the team conducted an interview with a super mentor, a person who oversees and assists other mentors, for the Digigirlz program. The mentor offered unique insight on how she prepared to facilitate a similar robotics program on her own, the tactics she uses when working with students and other advice for our creation of RobotiKids.  The transcripts of these interviews can be found in Appendix D, E, F, G and H.

All of the information from this section helped our team to fit what we learned from the results of objective one into a Moroccan context.

### 4.3: Results: Innovate Previous Vex Robotics Curricula

We designed our curriculum to be seven lessons. Lesson one includes an introduction course where students learn the basics of robotics and construct the base bot that will be used throughout the program. Lesson two includes the basics of block coding and conditional statements. Lesson three, four and five include technical lessons where students learn the fundamentals of movement, sensors and arms. The final two lessons include a project where the students use their creativity to solve a simulated real world problem. A crucial component of the final lesson includes a presentation for the students to demonstrate their work to the peers and mentors. We developed a detailed lesson plan and technical manual for Association Anoual which will assist with the sustainability of this program.

*Lesson Manual*

The lesson manual provides detailed summaries and objectives of the sections taught in each lesson. Each lesson begins and ends with discussion questions to promote class engagement with interactive activities throughout. There is also a demonstration in each lesson to encourage students to visualize what a finalized robot could look like. Finally, the lesson manual includes the recommendations, purpose, and duration of each activity. The full lesson manual can be seen in Appendix I.

*Technical Manual*

As a result of the extensive literature review and interviews a technical manual was created that includes step-by-step instructions for the coding aspect of our curriculum. The intended use is for the instructor to show students the examples of VEX code provided before they design their own code for the robot. The full technical manual can be seen in Appendix J.

## 4.4: Results: Pilot and Assess Robotics Curriculum

Our final objective includes testing the curriculum in order to make improvements and observations before handing our program to Association Anoual. Based upon Figure 2, we went forward with conducting a field evaluation. We began with a walk through of the lessons amongst the team. The field evaluation included testing the curriculum amongst ourselves and with our peers. We also sent the technical manual and lesson manual to a mentor at Association Anoual, who has the possibility of participating in this program in the future. To conclude our field evaluation, we gained insight from a robotics expert, who has previous experience creating curriculums and teaching students of various ages. Each of these participants in our field evaluation provided great insight to make our curriculum reach its fullest potential. Each of the evaluators of our program filled out a survey for both manuals that asked them to summarize any recommendations they had to make the program more complete. The results of the survey can be found in Table 2 below. The completion of the survey provided ways to improve our curriculum, however, we have created a rubric that can be found in Appendix S, that will ensure constant improvement of the program by gaining feedback from students and mentors.

To make sure our individual lesson plans and technical manual are coherent to future teachers of this program, we each taught a lesson that we did not design, see Table 1 for distribution of facilitation. From this we were able to determine what areas of our curriculum needed more explanation. Also, because this was our first test, we were able to restructure the timing of how long each activity will take as well as implementing more breaks when we previously thought they were not necessary. By running through the curriculum ourselves, we were able to make crucial edits on the timing and description of the activities to make our lesson plan more complete.

**Table 2: Survey Results**

| | Lesson Manual | | Technical Guide | |
|---|---|---|---|---|
| | Mean | Std | Mean | Std |
| Overall Opinion | 8.86 | 1.12 | 8 | 2.61 |
| Understandability | 9 | 1.07 | 8.80 | 1.60 |
| Engagement | 9 | 1.31 | 9 | 0.63 |
| Difficulty | 7 | 2.38 | 6.40 | 2.94 |

Std = Standard Deviation
7 Responses in the lesson manual
5 Responses in the technical guide

We received feedback from seven university students, representing many different majors. The non-robotics majors were essential to this evaluation because they had no background in the course topics and the information they were presented with was new to them. All of the non-robotics majors had positive opinions on the course documents and expressed that they thought it would be engaging, accomplishable, and informative. The students majoring in robotics reported they thought the course may be difficult for middle school students and take up more time than originally intended, but they agreed that it was engaging and informative. Overall, the peers' feedback left us with positive feedback on the readability, understanding and content of the manuals. The peer evaluation gave our team another perspective on how the course would function when given to students.

A review with a super mentor at Association Anoual provided feedback in order to improve our curriculum. A major finding was to incorporate longer than ten minute breaks. For this reason, we had to alter the timing of the activities. Another important detail that was mentioned was to make sure that the mentors have significant knowledge of VEX before the curriculum is taught. This means that the instructor would have to hold a briefing with all of the mentors to introduce them to the technical manual and lesson manual to make sure that it is properly translated in Arabic, if necessary. The instructor would also have to make sure that the mentors understand the contents of the material. Specifically, it is important for the mentor to understand the technical manual as it gives explanations to interactive activities. Mentors should discuss any part of the technical manual that they do not understand with the instructor, before the start of the program. The super mentor also mentioned that the curriculum should explain some of the difficult topics, such as loops, in a quick and efficient manner. This topic can be difficult for students of this age to understand, making student engagement a concern. To solve this problem, we incorporated a longer break and made sure to involve interactive activities. We also made sure that the loops section was short in length, yet efficient.

# CHAPTER 5: RECOMMENDATIONS AND CONCLUSION

The following are our five recommendations followed by a brief discussion. The recommendations relate to the use of support material, mentor training, final project suggestions, benchmarking success and future assessments, and the expansion of RobotiKids.

## 5.1: Recommended Use of Supportive Material

We recommend using the provided Technical Manual and Lesson Manual when facilitating this program. The recommended guidelines for how to use these supportive materials is outlined in the following section.

### *Lesson Manual*

A detailed lesson manual was developed to operate as the main component of guidance for facilitating the RobotiKids program. It was organized into seven main lesson plans: an introductory lesson, four technical lessons with the topics of coding, movement and turning, sensors, arms and joints and then two lessons delegated to the project explanation and demonstration. The lessons are created in a manner that allows them to be stacked or spread out that best suits the teacher's ideal lesson layout. The lessons are versatile and although they are created around VEX IQ kits, they can be taught with other robotics kits and deliver the same lesson and skills. The lesson manual is equipped with an outline of a recommended order of lessons, discussion and activities. Further detailed information is included that explains activities, provides discussion points, additional resources, recommendations and lesson material.

### *Technical Manual*

Supplemental material that is directly relevant to VEX IQ robotics was compiled and explained in the technical manual. It provides an explanation on how to use the online platforms, coding examples, and insight into the hardware. There are examples of the robots that can be constructed as well. This resource is intended to provide more structure and clear instruction to the facilitator with VEX robotics. It is expected to be used in tandem with the lesson manual because the lessons align and correlate.

Examples covered in the Lesson Manual and the Technical Manual are not exhaustive; there are extensive other possibilities that are available through the platform and with exploration of the robot. We recommend becoming as familiar with VEX as possible which will assist with implementing, facilitating, and building RobotiKids.

### 5.2: Recommended Mentor Training Program

We recommend having a mentor training program that prepares mentors to assist in facilitating the RobotiKids Program.

It would be highly beneficial to have at least one main facilitator of RobotiKids that is well-versed in VEX and the program. All mentors should be comfortable with pertinent STEM fields (especially coding) prior to assisting facilitating this program. We predict that it would be best if mentors could return for multiple iterations of the program, so they become more acquainted and also can help train new mentors that may not be as familiar with VEX. We have created a form to gauge a mentor's willingness to participate in the running of this program. This form can be found in Appendix N.  The lesson manual and technical manual should be administered to the mentors beforehand and they should review all the material and become acquainted with the online platform, code and robotic functions. After reviewing the material individually, a session should be held with all participating mentors to debrief any questions and also train how to work with middle school children. This training program should prepare them for how to efficiently work with students and support them properly along with problem solving techniques. Given Association Anoual has conducted many youth programs, we had envisioned a bootcamp that operated similarly to one that already exists, particularly one like Digigirlz. Mentors should be there for guidance and know how to complete all of the tasks but not take over for the students or become another member of the student team. We recommend having a ratio of one mentor per two or three students.

### 5.3: Recommended Final Culmination Project Guidance

We recommend implementing and continuing to develop a final project as a culmination of the RobotiKids program.

The final project and presentation is a critical component of RobotiKids. It is the motivation for the other lessons to lead up to a project where the students can demonstrate their knowledge and practice working on a team. Ideally, the project is worked on in a team; the team will have planned, built and executed both the code and construction of a robot to complete a task framed in the form of a real life problem. The final project should include a presentation or pitch that allows them to explain their ideas and methods that will tie in entrepreneurship and interpersonal elements.

We recommend not limiting the program to a single final project but rather have it change with each iteration. This will help to identify areas of the lessons that need improvement and also drive the program in the entrepreneurial front by addressing multiple possible real-life problems.

*Example Problem:*

A recommended problem can be framed as a beach clean-up and removal of trash. This includes having an arena setup with different types of trash of different color, objects to avoid and walls that obstruct. Trash should be picked up and removed accordingly. Variations are welcomed and can alter the difficulty of the project. Students should execute this by creating a robot with code and test out its functionality. It can be made into a competition with different parameters, like what robot can remove the most trash or do it the quickest. The preparation process should include mapping a plan with the engineering design process to address the problem. The presentation portion should include preparing a presentation to showcase their process and decisions and pitch what their robot is capable of.

*Timing:*

After conducting our field evaluation, we concluded that a full scale completion of the robot and code would require multiple days of work. The construction of the code and robot with a series of tests to ensure it works properly would not be feasible in the allotted time of the original lesson plan. This, in addition to preparing their pitch, would be a time consuming process and require extensive guidance from mentors. If a full scale final project with a fully operational robot and code, was to be implemented, two to three days of build time will be necessary. We recommend striving for this in future iterations of RobotiKids as it would leave a profound impact on the youth. This can be done by adding work days in between lessons 6 and 7.

If more work days are not feasible at the time, one solution could be to scale back the presented problem. For example, using the color sensor is one of the most time-consuming and difficult tasks so this element could be removed and replaced with line-following instead. Here, students would code their robot to follow a line and identify trash that was placed on it, this would eliminate the need of a search pattern and other more difficult coding. Another option that would work with the original seven-lesson plan is to shift to take on a more entrepreneurial standpoint. The project could be presented as if it were to be executed, but instead, have the students focus on the process they would go through if they were to create a functional robot. This includes mapping out their engineering design process, highlighting what key features from the lessons that they would include, how they would do this, why, and an explanation of why their robot is the best. It should be framed as a startup that is pitching to their investor. This version of the final project would be able to run in the time frame of the original lesson plan. Given Association Anoual's passion for entrepreneurship, this was recommended to implement tactics and strategies from other programs to instill the importance of entrepreneurship into their lives and continue to grow in these areas.

Essential elements need to be considered and outlined before executing the entire lesson plan including having a predetermined set of standards. These can be changed iteration to iteration, but a well defined project will make a difference in the outcome. Ensure to specify exactly how to handle practice times, where field elements will be placed, allowed human interaction zones, when the official runs will begin and how many trials are allowed. These are not exhaustive limitations and standards, but rather guiding parameters to consider.

Regardless of the chosen final project, it is incredibly important that the students feel successful in their final project demo. Given that they have put in an abundant amount of time and faced challenges, this should be a rewarding experience that encourages them to pursue STEM further.

## 5.4: Recommended Success Benchmarking and Future Program Assessments

We recommend implementing consistent benchmarking and assessment tactics into the curriculum to assess student and program success. This will result in recommendation and adjustments to compile and be added to the program for future assessments.

To continue to improve the program and work towards expanding, it is important to benchmark success and continue to note where changes should be implemented by taking record of what works and doesn't work. We recommend having both students and mentors fill out a survey before and after the program. This survey should include their perception of robotics and STEM fields but also ask for opinions on the program. In addition to taking record of these feedback surveys, we recommend holding both mentee and mentor focus groups and recording opinions and feedback through these semi-structured meetings. These should be hosted to see from another perspective what went well, what didn't and areas of improvement. In the beginning stages of the program, it would be beneficial to record observations in real time and have mentors do the same, so successes and struggles can be noted and adjusted accordingly. The team predicts that having a structured written format in addition to the notes taken from the surveys, focus groups and observations would be helpful. A rubric would offer a standard to guide with and can be used to assess student success. A similar rubric can also be formatted to gather data on students' feelings towards the program to supplement the pre and post program survey. A template of can be found in Appendix S. We recommend this rubric would be beneficial to use at the end of the program to assess the student's progress and outcome after completing the program.

### 5.5: Recommended Steps for Expanding RobotiKids

We recommend striving to continue to advance RobotiKids and aim to expand with each iteration so that more students can be impacted.

The seven-lesson plan format that was constructed and tested by the team was organized with the intention that it would be versatile to the teacher and easily implemented into a variety of forms. We envisioned that this would help Association Anoual implement RobotiKids in a form that was most conducive to their desired structure. Since it is in early stages and developed into this format, we recommend deciding and creating a standard for RobotiKids, whether it be an after school program, a summer camp, an implementation of lessons delivered to schools or extended into a long term program. This will help to solidify the program and ensure it has a solid foundation and vision going forward. Additionally, we highly recommend the use of VEX IQ kits for the most seamless operation of this program. If it were to expand, it would be necessary that participating students have access to kits so investing in more kits or creating a schedule that allows students the most access to the kits is essential. We hope RobotiKids will become an engaging program that is impactful to the youth. Promotion on social media and advertising would be greatly beneficial to the program's growth in the future. Lastly, we recommend providing ways for students to continue to code and get involved in STEM education and robotics through other programs like available robotics competitions. This will help to promote RobotiKids and leave a profound impact on the students.

### 5.6: Conclusion Statement

We believe this program will leave students excited and encouraged by what they have accomplished. The program represents some of the most engaging and critical topics in robotics. The small successes that students see, the team is hopeful, will encourage them to seek STEM opportunities in the future. We believe that after completing RobotiKids, students will have unknowingly developed their soft skills, like teamwork, critical thinking and problem-solving that they can use as a foundation to continue to improve these skills. We are confident in the RobotiKids program's ability to make a difference in student's lives with the delivery of important technical STEM education through engaging project-based learning.

The team wants to express how thankful we are to have been able to work on this project and for the support and encouragement of Association Anoual throughout the entire process. We hope this program will be able to reach and impact students in Morocco and ignite their interest in STEM.

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# Appendix A: Reviewed Robotic Sources

- VEX IQ - https://www.vexrobotics.com/iq
- Digigirlz Curriculum schedule
- Advanced JCR Sample Schedule - From Robotics Faculty
- VEX IQ Robotics Education Guide - https://www.vexrobotics.com/iq-education-guide.html
- VEX IQ STEM Labs - https://education.vex.com/stemlabs/iq?lng=en
- Robot Lab Curriculum- https://www.robotlab.com/blog/designing-a-robotics-class-for-middle-students
- VEX IQ Demo Videos - https://www.youtube.com/playlist?list=PLvvcc7S26YEgp60fNJwh64aj9ywiZ79Ta
- Robotics Education Competition (REC) - https://www.roboticseducation.org/educational-resources/robotics-curriculum

# Appendix B: Interview with Robotics Staff

**Location:** Worcester Polytechnic Institute
**Time:** February 24, 2022 11:00 AM EST
**Interviewee:** WPI Robotics Staff Member

**Preamble**
We are a group of students from Worcester Polytechnic Institute in Worcester, Massachusetts in the United States of America and we are working with Souhail Stitou and Association Anoual to create a middle school robotics curriculum aimed at increasing youth access and interest in STEM fields and developing their soft skills. Currently, we are interviewing people to gain a better understanding of how to most effectively teach robotics and implement a program in Morocco. This will also help us to determine how to construct our own curriculum and offer recommendations. Your participation in this interview is completely voluntary and you may withdraw at any time. You are not required to answer any of the following questions. Please remember that your answers will remain anonymous. No names or other identifying information will appear on the questionnaires or in any of the project reports or publications.

**How do you keep students interested in robotics?**

*They suggested that in order to keep students engaged show a game on the first day so they can see what they can accomplish. Make sure that there is a challenge or point system or game that encompasses all the skills they have learned.*

**What are the most important things you can teach someone who is new to robotics?**

*Getting students excited about engineering and letting them have 'wins' allows students to have experiences that result in success. FIRST robotics competition is all about inspiration; education is not the goal rather inspiring students to be involved. Students should first learn how to approach the problem and then solve it not get immediate success.*

**What do you know about working with the VEX IQ robot kits?**

*The VEX IQ kits are very good with the mechanical design, and they are tool-less so they snap together which is helpful with students. The kits are good at teaching about mechanisms. The kits can utilize a mix of programming and mechanical knowledge, which give a more rounded view on robotics. They mentioned a simulator for the robots which simulates similar variation of programming that can be used on the VEX IQ robots.*

**Do you have any suggestions on the formatting and content of an introductory robotics program for middle schoolers?**

*They suggested a variety of ideas that they found beneficial in their implementation of curricula.*

- *The first thing they should do is build a base robot so everyone gains experience. when you do programming languages, they do it on the base robot and everyone has the same base.*
- *Make some guide for teacher with lesson ideology and rationale to look back on*

- *Have things that can elaborate on so that students are not sitting around, middle schoolers do not sit quietly*
- *Short lessons with demonstration then play with robots to combat short attention span*
- *Drive, turn, do stuff with sensor, build a arm - should each be a model or lesson*
- *After each lesson note what worked and what didn't work to update the lesson so teachers will know this*

# Appendix C: Interview with Robotics Expert

**Location:** Rabat, Morocco
**Time:** March 30, 2022 11:30 AM GMT
**Interviewee:** WPI Robotics Staff Member

**Preamble**
We are a group of students from Worcester Polytechnic Institute in Worcester, Massachusetts in the United States of America and we are working with Souhail Stitou and Association Anoual to create a middle school robotics curriculum aimed at increasing youth access and interest in STEM fields and developing their soft skills. Currently, we are interviewing people to gain a better understanding of how to most effectively teach robotics and implement a program in Morocco. This will also help us to determine how to construct our own curriculum and offer recommendations. Your participation in this interview is completely voluntary and you may withdraw at any time. You are not required to answer any of the following questions. Please remember that your answers will remain anonymous. No names or other identifying information will appear on the questionnaires or in any of the project reports or publication

To start our meeting, the team showed the lesson plan outline and explained the direction of the project at the time.

**Do you have supplemental resources for our lesson plan?**
*The base of the outline is good, they note that the breakdown of each individual lesson would likely not have equal timing, especially for the pilot. Enough needs to be taught with basic pedagogy to complete the final task. They suggested a sumo game for the end game. The end should leave them interested in robotics enough to look for more. They recommend that the first session should not be too academic focused. They recommend that hands-on experience is what makes the curriculum engaging. They highly recommend using videos of robots incorporated into the curriculum. This will help to keep the students' attention. They also note that it is important to keep in mind the program will likely be coed and to keep this in mind when making situational team making.*

**Is there any general advice you would offer for running a program?**
*They suggest a 40 min time frame for attention span for middle schoolers before changing it up. They recommend having lessons increment up and incorporate both code and mechanical aspects. This will also allow other technical skills to be snuck in like basic algebra. Two people per kit is good. They suggest success oriented completion.*

**Do you have any insight on VEX robotics or robotics curriculum?**
*The robots need to have sensors, not just be remote controlled, this is the defining factor of robots. In order to drive you need to learn how to code. There are a lot of available projects that can give insight into final project ideas. VEX and FLL offer step-by-step publish camp guides.*

*These are open source with curriculum instructions. They gave an example of how to make conversations about parts engaging. A dialogue about sensors could relate the sensors back to human functions in the form of how you sense, then how you compute and learn, then how you act then relate it back to the physical world. Ending with a robot can do exactly what you do. Make sure that there is plenty of time designated to building the robot. They recommend that after the conclusion of the lesson, assemble or fix the robot regardless of what stage they left off at. Also don't allow students access to all parts, only what is necessary.*

# Appendix D: Interview with Moroccan Student Mentor

**Location:** Zoom Video Call
**Time:** March 31, 2022 14:00 GMT
**Interviewee:** Moroccan Student Mentor

**Preamble**
We are a group of students from Worcester Polytechnic Institute in Worcester, Massachusetts in the United States of America and we are working with Souhail Stitou and Association Anoual to create a middle school robotics curriculum aimed at increasing youth access and interest in STEM fields and developing their soft skills. Currently, we are interviewing people to gain a better understanding of how to most effectively teach robotics and implement a program in Morocco. This will also help us to determine how to construct our own curriculum and offer recommendations. Your participation in this interview is completely voluntary and you may withdraw at any time. You are not required to answer any of the following questions. Please remember that your answers will remain anonymous. No names or other identifying information will appear on the questionnaires or in any of the project reports or publications.

1. **Can you talk about your experience with DigiGirlz?**
   *Tried to find technological solutions to community needs. Social entrepreneurship. They did not get to do a lot of workshops because of the timeline.*
   a. **How did you get involved?**
      *Saw it on social media and was involved with volunteering with the US embassy.*
   b. **What are your responsibilities in the program**
      *They work with different teams, guides and helps mentees - but mentees want to be independent. The mentor puts on workshops for the fellow mentors and mentees*
   c. **How do students typically interact with the mentors (mentor to student ratio)**
      *They are excited and they want to do stuff right away…they have great ideas! DigiGirlz did not do a lot of robotic workshops, their main focus was on arduino and the development of their projects. In university program each mentor had a group of 5-7 students*

2. **How were the mentors taught the curriculum in DigiGirlz?**
   *DigiGirlz taught the mentors about social interaction, entrepreneurship, and how to come up with project ideas.*
   a. **Did you come up with the arduino lesson yourself?**
      *They get curriculum ideas from youtube and books online. The curriculum and programs that the mentor's club participates in assembles the lessons from outside resources.*

3. **Do you feel like the mentors needed training for digigirlz? Were you prepared for the social and interactive aspects of the curriculum?**
   *Mentors spent a lot of time in training [in both programs the mentor is a part of]. The bootcamp makes sure they have all the tools and knowledge that they need in order to teach and guide mentees in the program*
   a. **Were there language barriers? What language did most students speak?**
      *Darija, English and French are the most spoken languages used. English and darija were common in the digigirlz program. At the mentor's university, French and Darija are the two main languages spoken. They mentioned that it will be challenging to find someone who can speak french and english fluently.*
4. **How many students are in your club at your university? And what majors?**
   *There are 80 students in the mentor's university club, mostly electrical, but software and mechatronics are frequent majors. * There are 2 years of pre-reqs, then major is declared in 3rd year. Robotics engineers are not really a thing in college. In electrical you can select two fields. One of which was similar to robotics.*
5. **What was the hardest part/challenges of the digigirlz program?**
   *COVID was a big problem - no in person meetings*
   *Secondary school students have final exam (may/june) that may conflict*
6. **How can we avoid mistakes or wasting time when developing and implementing our curriculum? Do you have suggestions on where to implement ?**
   *The mentor suggested to the team to: try to connect with parents, it is extremely important that they are invested in their student's education. Rabat will be the best play for the team's program, but public schools will be hard; private schools will be easier to contact.*
7. **Were there any other students within her university club that have participated in the digigirlz mentorship program before?**
   *There are 5 other students in the mentor's university program that have participated in the digigirlz mentorship program before.*

**The mentor also noted that the program would be taking place during ramadan. As a student they suggested the following things:**

*10 oclock is a good time to start teaching*
*1:30 hours for meeting*

# Appendix E: Interview with Parent of Middle School Student

**Location:** WhatsApp Video Call
**Time:** March 29, 2022 10:00 AM GMT
**Interviewee:** Parent of Middle School Student

**Preamble**
We are a group of students from Worcester Polytechnic Institute in Worcester, Massachusetts in the United States of America and we are working with Souhail Stitou and Association Anoual to create a middle school robotics curriculum aimed at increasing youth access and interest in STEM fields and developing their soft skills. Currently, we are interviewing people to gain a better understanding of how to most effectively teach robotics and implement a program in Morocco. This will also help us to determine how to construct our own curriculum and offer recommendations. Your participation in this interview is completely voluntary and you may withdraw at any time. You are not required to answer any of the following questions. Please remember that your answers will remain anonymous. No names or other identifying information will appear on the questionnaires or in any of the project reports or publications.

**How difficult has it been to find a STEM program for your daughter?**

*They had enrolled their children in a Moroccan based school, however it turned to a French school. They mentioned that the French school did have a 3D printer in some more restricted classrooms, however it was not easily accessible or often used.*

**Are robotics curriculums hard to find for children? do they cost money? What are the hours of the program? Is it a summer program or after school program and how long does the whole program run for?**

*The programs that the parent looked into included LEGO education and coding based camps. The parent chose to select an app for coding however the parent desired something that was more hands on and engaging. Their goal in involving her children in a program that was based in STEM and hands-on learning was to encourage their creativity. The programs that they did look at cost money to participate in.*

**Do you feel like your child has had sufficient stem education in their current schooling, what has it been composed of? How is her current STEM education being taught? Do you think your daughter feels confident and interested in STEM fields after receiving education in STEM?**

*They spoke to the fact that STEM is not part of the curriculum at school. The 7 year old daughter does not get exposure to STEM in class. Their daughter who is in 6th grade does receive some exposure, but the daughter attends a private French school in Rabat. The parent informed the group that there are no computer labs and if there is "technology" it is rare and the program is under developed for students to use to full capacity.*

*The parent told the team that the lessons taught in class are: Physics, math, arabic, islamic education, a couple others, sports, french*

**Would you be willing for us to interview your daughter, to ask about her experience in STEM? Questions would include:**

1. **Do you go to a public or private school**
2. **What is your favorite subject?**
3. **Do you have an interest in science and math?**
4. **Do you learn a lot about science and math in school?**
5. **What do you want to be when you grow up?**

*They verbally consented to this and the questions were sent to the parent and others following the interview.*

***They informed the group at the end of the interview that the parent has contacts that could get the team incontact with if they wish. Those contacts would be: a Moroccan school board member, a STEM teacher at a Moroccan private French school, and an educator who works with public school students on STEM initiatives.***

# Appendix F: Interview with STEM Educator

**Location:** Zoom Video Call
**Time:** April 7, 2022 11:00 AM GMT
**Interviewee:** STEM Educator

**Preamble**
We are a group of students from Worcester Polytechnic Institute in Worcester, Massachusetts in the United States of America and we are working with Souhail Stitou and Association Anoual to create a middle school robotics curriculum aimed at increasing youth access and interest in STEM fields and developing their soft skills. Currently, we are interviewing people to gain a better understanding of how to most effectively teach robotics and implement a program in Morocco. This will also help us to determine how to construct our own curriculum and offer recommendations. Your participation in this interview is completely voluntary and you may withdraw at any time. You are not required to answer any of the following questions. Please remember that your answers will remain anonymous. No names or other identifying information will appear on the questionnaires or in any of the project reports or publications.

**Can you explain in depth what your program and involvement does with the education community?**

> *They said that students need to learn soft and life skills. Their program partners with other companies like CIEE, and works with 42 schools. The kids want to play so they play and learn logic for algorithms. They do projects that relate to a problem in the community and teach them teamwork*
> *They mentioned that the program that they run concludes in a competition that has to exhibit 5 core values - teamwork, language, original ideas etc,... and they have to score points in competition based on those 5 core values.*

**Is there a lack of robotics or STEM in general taught in school?**

> *They mentioned that in general there is a lack of soft skills being taught.*

**How many students are in your program?**

> *The program works with 42 schools. There are three stages of school systems: private school, youth centers, and public schools.*

**What was the hardest part/challenges of the program?**

> *They said that there isn't STEM in schools or in professional work spaces. This can make it difficult to show students the opportunities that lie ahead.*

**How can we avoid mistakes or wasting time when developing and implementing our curriculum? Do you have suggestions**

*always be giving the kids something to do, they can listen and take in information even if they aren't paying attention. Don't spend a lot of time speaking to them. Make it fun and engaging - make things move and light up. Always keep them involved, have them help make lunch clean up (good life skills), they give them a lot of entrepreneurship skills as well as just the technical ones.*
*They invited the team to go and visit to elaborate on the program. They told the team that you have to be able to adapt to change and learn from experiences.*

# Appendix G: Interview with Educator at a STEM Focused After School Academy

**Location:** Zoom Video Call
**Time:** April 7, 2022 10:00 AM EST
**Interviewee:** Educator at STEM Focused After School Academy

**Preamble**
We are a group of students from Worcester Polytechnic Institute in Worcester, Massachusetts in the United States of America and we are working with Souhail Stitou and Association Anoual to create a middle school robotics curriculum aimed at increasing youth access and interest in STEM fields and developing their soft skills. Currently, we are interviewing people to gain a better understanding of how to most effectively teach robotics and implement a program in Morocco. This will also help us to determine how to construct our own curriculum and offer recommendations. Your participation in this interview is completely voluntary and you may withdraw at any time. You are not required to answer any of the following questions. Please remember that your answers will remain anonymous. No names or other identifying information will appear on the questionnaires or in any of the project reports or publications.

**When and how did you start your program?**

*They mainly partake in the "learning for play" approach. They invite kids to come over, play, and discover stem approach, stems, mechanics, physics. The program is highly hands-on as students come to play and if they happen to learn from the discovery that is a plus. They have some franchises, so they have their own curriculum, academy in RDC and kungo. The company follows the lego education curriculum.*

**Can you outline your robotics program, training process, curriculum, timeline, success measurement and sustainability?**

**Are there open access resources that you used to help guide and refine your robotics program?**

*They explained that students begin with basic projects that are directly from the lego education projects because Lego has provided tutorials. They also elaborated on the idea of having a "facilitator" as they dont view the instructor as a teacher, because the students are teaching themselves and guide the projects as the students see fit.*
*Fatima went on to explain that: a 6 year old starts with tutorial activities then guided projects and then activities and then continues to challenges that Lego has produced. After 10 + sessions the facilitator begins to introduce bigger projects that have a teachers guide so the facilitator can guide the student through any challenges that may arise. They build legos and robots that are designed about nother subject i.e. tiger*

*They mentioned one thing about their curriculum: there are very few slides, and mostly hands on. The slides are there to progress the students from challenge to challenge, not to teach.*

**What competitions do you see success in? And why do you think you see success in those competitions/programs? If a student enters a program as a 6 year old, are they able to come back and participate as a 7 year old?**

*They outlined the program with: 3 month session depending on the age of the student. The team works with those kids catered to that age, mainly working with 3 age brackets, 6-9, 9-12, 12-16. All kids do the same solution and build the same base for their age group. The projects develop faster based on age and depending on where they are on the understanding of material spectrum, the programs are designed to cater to a student's learning capabilities. Everyone in the age group will do the same activity, what makes it unique is the timing of each student's completion. Everyone does the same objective and project but instructors give more specific instructions based on challenge level.*

- *Speed, robot look, coding etc*
- *Adaptability based on skills*
- *Must be touched on based on facilitator training*

*FLL Competition, they organize teams all over the world. From villages and public schools. The FLL team wants to talk to kids on their progress and aspirations, not to parents.*

**They then introduced the team to the SPIKE platform and general Lego League related materials the following is what was reviewed.**

*Link to Lego education: https://education.lego.com/en-us/lessons*

*Spike platform: https://education.lego.com/en-us/downloads/spike-app/software*

*Three categories offered within the FLL and their partnership*

- *Fll discover: ages 4-6 expo of their work. Build a robot and level it up, and judges cme and ask questions students have to answer on their robot and how they see the robot working*
- *Fll explore: ages 6-10 expo where students get to show work, innovative part, and robot has to have one automatic device based on robotics*
- *Fll challenge: ages 9-16 work for qualifiers, work on robot game, identify a problem and find the solution, core values*

***NOTE: LEGO education, their academy, and LEGO league are in a 3 way partnership with each other. The materials that are provided are sourced directly from LEGO, the program does not create a curriculum that is transferable outside of the use of FLL/LEGO education.***

## Appendix H: Interview with Operations Manager of Association Anoual

**Location:** CIEE Office, Rabat, Morocco
**Time:** March 30, 2022 10:00 AM GMT
**Interviewee:** Operations Manager of Association Anoual

**Preamble**
We are a group of students from Worcester Polytechnic Institute in Worcester, Massachusetts in the United States of America and we are working with Souhail Stitou and Association Anoual to create a middle school robotics curriculum aimed at increasing youth access and interest in STEM fields and developing their soft skills. Currently, we are interviewing people to gain a better understanding of how to most effectively teach robotics and implement a program in Morocco. This will also help us to determine how to construct our own curriculum and offer recommendations. Your participation in this interview is completely voluntary and you may withdraw at any time. You are not required to answer any of the following questions. Please remember that your answers will remain anonymous. No names or other identifying information will appear on the questionnaires or in any of the project reports or publications.

**What do you do as a board member and operations manager for Association Anoual?**

*They are the financial officer and project manager at Association Anoual.*

What are your day to day responsibilities?

They oversee all projects on the backend. They followed up with all current working and active projects.

**Can you provide a brief overview of how Digigirlz operates?**

The goal was to recreate the DigiGirl program that happens around the world. The goal was aimed at 15-18 year old female students to give these students a entrepreneurship introduction through coding projects

- More specifically, what is the timeline (number of hours per day, what days, etc)?
  *DigiGirlz had female Microsoft experts come and talk to participants for about 2 hours to help inspire and motivate girls about their future. They mentioned that the participants took part in 4 hours of HTML coding during the first sessions in 2017. DigiGirlz also covered 4 hours of another STEM subject that was not related to coding i.e. biology math. They also concluded by mentioning that there were 2-3 hour minecraft sessions that participants could take part in as activities. Students were selected based on a form that asked about their motivations and reasons why they wanted to take the course.*
  Gathered students from north and south region, at end there was a big celebration
- Do you train your mentors/instructors, more specifically how do you choose them
  - Where did the mentors come from, schools, businesses, etc

  Mentors did not have to have any prior experience, they just needed to be interested in STEM. Mentors were selected based on an application form, they applied as a mentor team from each university. Mentors partook in a bootcamp included the STEM side/technical side of the program, lessons on mentorship and how to be a mentor, and entrepreneurship practices. The mentorship program that was instilled made the program sustainable.

**Do you have the outline schedule of the three day program you started in 2017 with digigirlz?Is the curriculum from 2017 something we can have access to?**

In reference to the curriculum, it was sent to partners before implemented completely. The partners reviewed the outline and it was approved. *The team was sent the curriculum of 2017 after the meeting was concluded.

**Were there any challenges with establishing digigirlz?**

Some of the girls that were interested in mentoring were not stem students

- What obstacles do you think we will encounter when developing our curriculum? And how do we avoid them?

They advised the team to accept some mentors that are STEM students or know a little bit about robotics. If mentors are not well versed there may need to be a form of bootcamp necessary. Before mentoring, mentors should have the basics of a STEM or robotics mindset. They also advised that the team hold as many follow ups with mentors as possible, so students/mentees/mentors who are not engaged or are struggling with the program can get help in private or more information sessions can be held.

**What did you use FABLAB for?**

FABLAB held a session on 3D printing. They brought all the material and code needed to 3D print. The girls participating could also practice their own coding skills and see products through 3D printed designs.

They also noted that FABLAB has space to implement robotics activities and had materials necessary to produce robots. FABLAB has a location in Rabat if the team would like access to those materials, Association Anoual could assist in acquiring that resource. They also mentioned that some universities have FABLABS within their programs.

**What are the numbers from digigirlz? How many students, and mentors? Currently?**

DigiGirlz 2017-2018

Kenitra edition : 128 received applications / 48 selected participants

Errachidia edition : 89 received applications / 55 participants (11 participants did not fill the application form)

Kenitra edition : 142 received applications / 58 participants (16 participants did not fill the application form)

DigiGirlz Mentorship Program 2018-2019 (First edition)

Mentors: 262 received applications / 19 selected mentors

Mentees: 206 received applications / 85 participants (not all participants filled the application form)

**How much did it cost you vs. how much funding did you have available**

*Association Anoual was not concerned about funding. Those at Microsoft and other NGOs had reached out to Association Anoual to create DigiGirlz*.

**Souhail Stitou had mentioned a program that ran similarly to the team's vision; what information do you have surrounding STEVEN's initiative (Morocco to US knowledge exchange)**

Association Anoual held a virtual exchange where high school students from Hawaii meet middle school students in Morocco. Students would exchange information on culture, lifestyles, and more. This program was directed towards sharing culture and viewpoints. Students would give presentations about what a specific part of their culture means to them. This program educated both students in Hawaii and Morocco.

**You use social media as a primary source of interest, is there a way you have any connections to schools within kenitra or rabat that we could take advantage of? Souhail Stitou suggested previously that it might be helpful to get into classrooms and present on the proposed project.**

They have contacts in private schools and Kenitra Morocco. They mentioned also putting us in contact with social media managers for Association Anoual so that any marketing needed to be done and be sourced to those managers.

**Anything you wish you knew before you started Digigirlz**

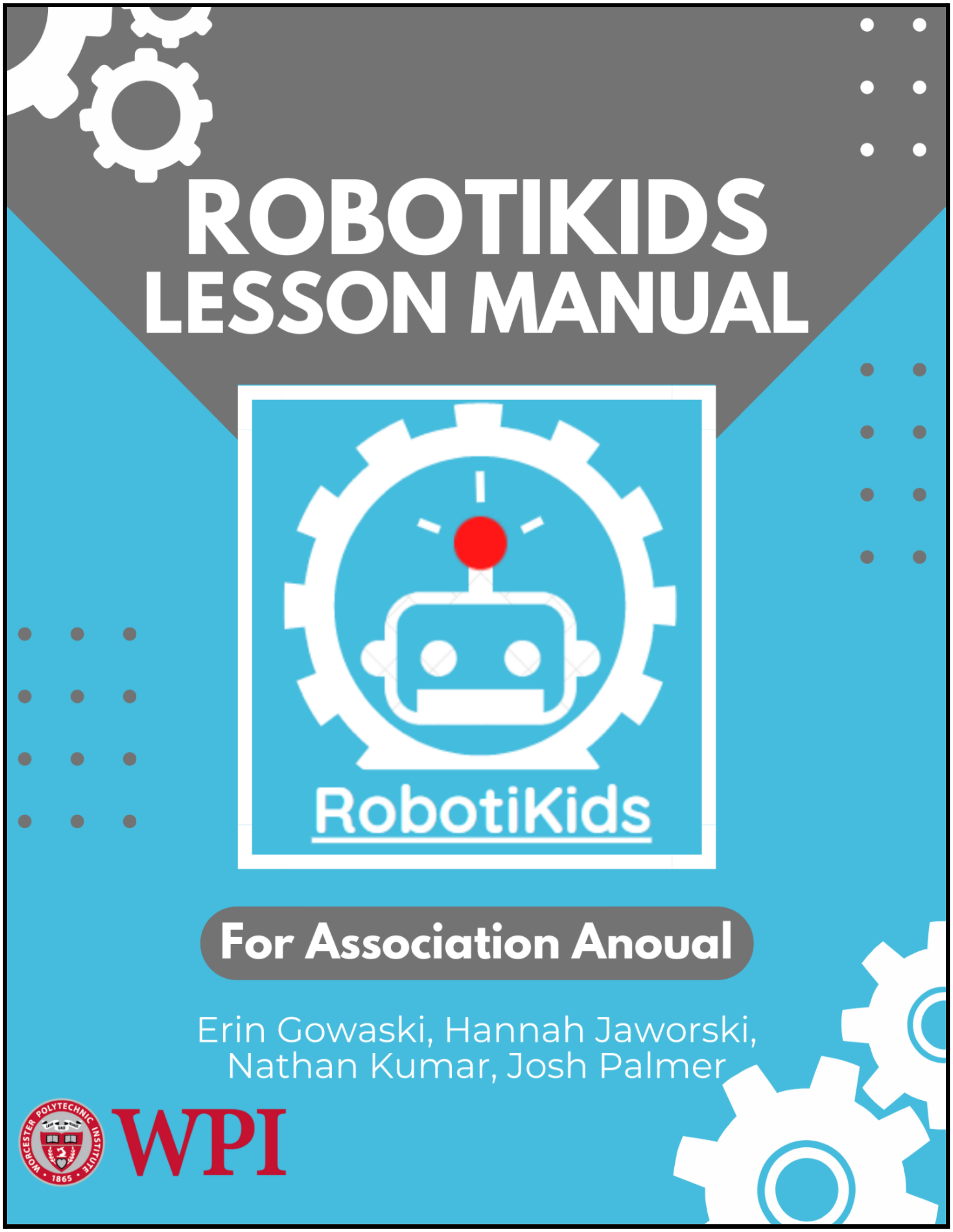
They encouraged the team to ensure that the students that are selected have the mindset and that any application that is developed is reflective of what is expected of those who are looking to participate in the program. They also suggested that students meet with professionals in the STEM field, as they thought it was beneficial during the DigiGirlz program. They continued to suggest that the team implements as many required deliverables from students within a high frequency to help track students progression. These deliverables help maintain evaluation statuses.

They also suggested that sharing an itinerary with students would be helpful for students to see how they can complete the program. They referenced that when the girls participating in DigiGirlz had an idea of their project, they ended up having a hard time finding the pieces to make the robot.

**They ended the interview recapping previous projects and the improvements that DIgiGirlz has made since the 2017 implementation.** *The program begins in november and runs until about February. During those 4 to 6 months girls go through training and meetings to work on their desired projects. There is a July pitching event that concludes their project work.*

# Appendix I: Lesson Manual

The following is intended to be used as a supplemental, stand-alone document. The pages provided are to be used outside of this format.


ROBOTIKIDS
LESSON MANUAL
RobotiKids
For Association Anoual
Erin Gowaski, Hannah Jaworski,
Nathan Kumar, Josh Palmer
WPI

# ROBOTIKIDS - ROBOTICS CURRICULUM FOR MIDDLE SCHOOL STUDENTS
# LESSON MANUAL
# 2022

### RobotiKids Program Purpose

This seven lesson intensive robotics program for students ages 12-15 was created for Association Anoual by four students from Worcester Polytechnic Institute. The program was designed with Association Anoual's mission and values in mind, to empower the future leaders to create positive change in their communities. It is aimed at increasing youth access to science, technology, engineering, and math (STEM) through a robotics' curriculum. The program is created on the basis of teaching STEM using project based learning, which helps to keep students engaged, interested and to develop their soft skills while simultaneously exposing them to STEM. The program's overarching goal is twofold. 1) to expose students to STEM fields and open their horizons to STEM possibilities, and 2) to have youth practice skills like collaboration and critical thinking to succeed in their futures.

### Program Lesson Breakdown

RobotiKids is broken down into seven digestible lesson blocks that can be conducted in a manner that is most conducive to the educator. RobotiKids includes an introduction lesson, four technical lessons (coding, moving and turning, sensors, joints and arms), and two lessons for the final project. The lessons include a breakdown of smaller activities, discussions and teachings that can be altered by inclusion or deletion as the educator sees fit.

The lessons were designed to incorporate as much project-based learning and student interaction as possible with limited lecture-based teaching. The lessons are intended to allow students to have as much hands-on learning as possible, exposing them to as many different students and learning techniques as possible to help to build their critical thinking, collaboration, and communication skills.

To emphasize youth empowerment and project-based learning, the program is designed to finish with a final project that is cumulative of all the lessons previously learned. The students are tasked with a real-world problem and have to construct a robot to solve a version of that problem. They will work in teams to accomplish this and present with a demonstration at the end.

The target age group is for middle school students ages 12-15. The program was intended to be conducted with one mentor per group of two students. This is done because the course is intended to be challenging and students should get as much personalized attention as needed to maximize success. However, the mentors should not be giving the students every answer and should be allowing the students to work individually from the mentor. The students should not be reliant on the mentors. The mentors are recommended to have exposure to STEM fields prior to working in this program. The program best operates with one robotics kit per group of two students.

The original program was constructed and tested with VEX robotics resources, VEX IQ kits and VEX VR online platform. However, this manual provides guidelines that offer direction and suggestions for any platform. To accompany this Lesson Manual, there is a Technical Manual to help navigate the VEX platform in correspondence with this program.

### General Recommendations for Teaching RobotiKids

- To avoid lecture based teaching and to better engage students, limit time standing in front of the class and encourage students to participate
  - Also try to use demonstrations to explain things rather than 100% lecture based
- Discussions and lessons should be student focused and sandwiched by interactive activities
- Supplementary activities and additional tasks should be prepared for each activity in case a student group finishes more quickly, to ensure no group is idle
  - Or if this is not possible, the activities should be multi-layered so that there are multiple steps of success and only the fastest students will achieve the top level
- Two students per robot kit is ideal
- A large table (around 0.5 m wide and 1.5 m long) that would allow students to lay out the kit and test the robot's movement is ideal
- An arena for the final project works best with a large range so the robot does not sense outer objects
- Getting parents involved and optimistic for their child's success is important
  - Could make a communications alias (EG: email, WhatsApp, etc) with all parents where they can be updated at the conclusion of each day with any pictures or achievements their children completed
- The times for each lesson are estimated and can be adjusted as needed
- Students should have a cool down period after breaks where they relax from whatever they were just doing and refocus on what they have been doing before the break

### Before Start of Each Lesson

- Ensure that all kit batteries are charged and all kit parts are present and properly functioning
- Ensure code and downloads are properly working on everyone's laptop
- Ensure mentors are familiar with and aware of the lesson plan and of basic questions that may arise

### For Association Anoual

- Document should be prepared and updated each day with notes on areas of struggle or student issues to ensure further days run smoothly, problems are addressed and to help critique and update RobotiKids program's future
- Participants should be selected based on their aptitude and interest for STEM, access to a laptop and their proficiency in English
- The final presentation can be expanded on in future iterations. Outlined in appendix C lessons 6 and 7, there are versions with contingency plans for expansion based on time for the program

| Lesson 1: Introduction to Robotics 4 hr 0 min | | | |
|---|---|---|---|
| **Purpose:** The purpose of lesson 1 is to introduce and get students excited about robotics. The field of robotics is extensive so this will help frame the ideas to them and get them to think creatively while also building their confidence in the area. It also will lay the foundation and essential skills for the rest of the program to build off as they progress to their final project. | | | |
| **Recommendations** | **Title** | **Duration** | **Key Parts** |
| - Begin with icebreakers after introductions | Introduction to RobotiKids | 20 mins | - Introduce yourself and the project of RobotiKids<br>- Have students meet each other<br>- Fill out survey for benchmarking |
| - Video demonstration of complex robot followed by in-person demonstration of final project<br>- View appendix A | Demonstration and Discussion | 25 mins | - Get students excited about robotics<br>- Open discussion to the potentials of robotics<br>- First exposure to robotics and final product of the program<br>- Defining what a robot is and relating that to humans for easy understanding |
| - View appendix C<br>- View appendix A | Engineering Design Process | 30 min | - Walk through of the 7 steps of the process<br>- Activity with competition |
| - View Technical Manual<br>- View appendix A | Software Introduction | 30 min | - Introduction to the online platform<br>- Time to use the platform independently<br>- Activity with the available playground |
| - View appendix A | Break | 30 mins | - Activity or video about robotics<br>- Or if students are losing focus, do non robot related break |
| - View Technical Manual<br>- Only give students access to necessary parts | Hardware Introduction | 90 min | - Brainstorm what parts are needed<br>- Have students familiarize and identify parts<br>- Divide into groups of two<br>- Begin assembling basebot |
| - View appendix B | End Discussion | 15 min | - Recap what was covered in lesson<br>- Current feelings and hopes for robots with new knowledge |
| | After Dismissal | | - Ensure all basebots are completed correctly and charged for each group regardless of current state |
| **Materials** | Laptop with wifi access<br>VEX VR simulator<br>VEX IQ Kits and Manual<br>Presentation Board or Projector<br>Pen/pencil and engineering notebook/paper | | |
| **Vocabulary** | **Engineering Design Process**- a series of steps that is followed to find a solution to a problem<br>**Software** - programs and other operating information of a computer or robot - the brains<br>**Hardware** - the constructed pieces, equipment and machine | | |
| **Additional Resources** | Video for Demo: Boston Dynamics - Do You Love Me?<br>Video for Break Battle Bots Video<br>Build Manual with VEX IQ Kits | | |

| Lesson 2: Introduction to Programming 2 hr. 30 min. | | | |
|---|---|---|---|
| **Purpose:** The purpose of Lesson 2 is to introduce students to basic programming skills. The topics covered in this lesson will give students the basic skills to code a robot to full capacity. These skills listed below cover the block code that will be used in future lessons and projects. Students should feel welcome to explore any accessible blocks in the simulator. By the end of this lesson students should be able to comprehend and implement the following topics. | | | |
| **Recommendations** | **Title** | **Duration** | **Key Parts** |
| - View appendix B - lesson 2<br>- View technical manual VEX VR and VEXcode IQ<br>- Within this lesson application of robots is optional<br>- Show pictures of block code on VEXcode IQ and VR or show pictures on technical manual | Block Coding and variables | 15 mins | - Introduce what programming is<br>- Show how robots need to be programmed<br>- Reintroduce block coding simulator |
| - View appendix B - lesson 2<br>- View appendix A - lesson 2<br>- View technical manual lesson 2<br>- encourage students to *play* with code | If/then Statements | 25 mins | - Discuss conditional statements<br>- Activity using if/then statements<br>- Show implementation of if/then statements<br>- Show implementation of if/then… else statements<br>- Independent time to play with simulator |
| - View appendix B - lesson 2<br>- View appendix A - lesson 2<br>- View technical manual lesson 2<br>- Encourage students to *play* with code | For Loop | 20 mins | - Discuss loops<br>- Activity using for loops (counting)<br>- Show implementation of for loop statements<br>- Independent time to play with simulator |
| | Break | 30 mins | Students should take a break from robotics and if possible they should be outside |
| - View appendix B - lesson 2<br>- View appendix A - lesson 2<br>- View technical manual lesson 2<br>- Encourage students to *play* with code | While Loop | 25 mins | - Recap conditional statements and loops<br>- Activity using while loops<br>- Show implementation of while loop<br>- Show implementation of repeat until loop<br>- Independent time to play with simulator |
| - View appendix B - lesson 2<br>- View appendix A - lesson 2<br>- View technical manual lesson 2<br>- Encourage students to *play* with code | Forever Loop and Breaks | 20 mins | - Recap conditional statements and loops<br>- Activity using forever loops<br>- Show implementation of forever loop<br>- Independent time to play with simulator |
| - View appendix B - lesson 2 | End Discussion | 15 mins | - Recap what was covered in the lesson<br>- Any questions or concerns should be identified |
| **Materials** | - Laptop with wifi access<br>- VEX VR simulator<br>- VEXcode IQ software | | |

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| | - Presentation Board |
| **Vocabulary** | **Computer Programming:** a series of steps a computer can follow<br>**Coding:** writing instructions in a programming language<br>**Code:** lines of program instructions<br>**Algorithm:** step-by-step ordered instructions<br>**Function:** mini program within the code<br>**Iterating:** testing and fixing the code so it works<br>**Bug:** a problem with the code:<br>**Conditional statements:** instruct the computer on a decision to make when given specific conditions.<br>**Nesting:** when you use one given function inside another given function |
| **Additional Resources** | - Technical Manual |

| Lesson 3: Movement and Turning 2 hr. 30 min. | | | |
|---|---|---|---|
| **Purpose:** The purpose of Lesson 3 is to introduce students to movement and turning skills. The topics covered in this lesson will give students the basic skills to move a robot forward, backwards, and turn in all angles. Students will practice block coding, critical thinking, and creativity. By the end of this lesson students should be able to command their robot to move backwards and forwards at varying velocities, and make various angle turns. | | | |
| **Recommendations** | **Title** | **Duration** | **Key Parts** |
| - View appendix A - lesson 3<br>- View appendix B - lesson 3<br>- Students should be able to relate human movement with robotic movement<br>- Students have access to robots connected to code. | Review/ Introduction | 15 mins | - Review lesson 1 and 2<br>- Introduce movement and turning<br>- Discussion of movement<br>- Activity involving movement around obstacles. |
| - View technical manual lesson 3<br>- Encourage students to *play* with robot and code | Forward and Backward Movement | 20 mins | - Show simple code to move forwards<br>- Show simple code to move backwards<br>- Independent time to play with simulator and robot |
| - View appendix B - lesson 3<br>- View appendix A - lesson 3<br>- View technical manual lesson 3<br>- Encourage students to *play* with robot and code | Forward and Backwards Parameters | 30 mins | - Discussion on distance and velocity<br>- Define velocity and compare to speed<br>- Show simple code on moving forward a given distance<br>- Show simple code on moving at velocity<br>- Independent time to play with simulator and robot<br>- Activity involving parameters to determine velocity |
| | Break | 30 mins | Students should take a break from robotics and if possible they should be outside |
| - View appendix B - lesson 3<br>- View appendix A - lesson 3<br>- View technical manual lesson 3<br>- Encourage students to *play* with robot and code<br>- If students have no experience with the unit circle/degrees seek lessons on this topic. View appendix C - lesson 3 | Turning | 40 mins | - Discussion on turning right and left<br>- Review of degrees<br>- Gyroscope explanation (sensor but needed for turning)<br>- Gyro allows the robot to sense how many degrees it turns<br>- Simple code to turn using degrees<br>- Simple code turning at velocity<br>- Activity involving parameters and turning<br>- Independent time to play with simulator and robot |
| - View appendix B - lesson 3<br>- Discussion does not need to be structured can occur while students *play* | Discussion | 15 mins | - Recap what was covered in the lesson<br>- Any questions or concerns should be identified |
| **Materials** | Laptop with wifi access<br>VEX VR simulator<br>VEXcode IQ software<br>Presentation Board<br>Pen/pencil | | |

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| | Engineering notebook/paper |
| **Vocabulary** | **Behavior:** an instruction that is downloaded to a robot brain, which is then executed. Programs usually consist of several behaviors combined in a logical succession<br>**Drivetrain:** the system in a motor vehicle which connects the motor to the wheels<br>**Parameter:** a limit of boundary that defines the scope of particular process or activity<br>**Velocity:** the speed of something in a given direction<br>**Degree:** a unit of measurement of angles, 1/90 of a right angle or the angle subtended by 1/360 of the circumference of a circle<br>**Gyroscope:** A sensor that is essential to movement, it allows the robot to determine how many degrees it has rotated |
| **Additional Resources** | - Technical Manual<br>- Human Robot Movement |

| Lesson 4: Sensors 5 hr. | | | |
|---|---|---|---|
| **Purpose:** The purpose of this lesson is to teach students about sensors. This means teaching them about the three most important sensors in the VEX IQ kit. This lesson will teach why they are needed, how they work, and how to have the robot use them to the fullest. By the end of this lesson students should be able to comprehend and implement the following topics. | | | |
| **Recommendations** | **Title** | **Duration** | **Key Parts** |
| - View appendix B<br>- Focus on relatability, Make the discussion engaging | Introduction to Sensors | 15 min. | - Relate 5 human senses to robot sensors<br>- Make the robot sensors more understandable and relatable<br>- Show why sensors are so important |
| - View appendix A<br>- View appendix B | Touch Sensors | 15 min. | - Discussion on touch as a sense<br>- Demonstrate capabilities: set robot in front of wall and show it stops when the sensor touches wall<br>- Talk about how that program works |
| - View appendix A<br>- View appendix B | Activity | 30 min. | - See who can get robot to empty water bottle as fast as possible without knocking it over<br>- Use only touch sensor to stop the robot<br>- End with discussion |
| - View appendix A<br>- View appendix B | Color Sensor | 15 min. | - Discussion on vision as a sense, specifically color vision<br>- Demonstrate capabilities: let robot drive then hold a red piece of paper in front of it and have it stop then continue when the paper is gone<br>- Talk about how that program works |
| - View appendix A<br>- View appendix B | Activity | 60 min. | - Line following robot: Complete the path<br>- Give students basic code, show how it works, and let them change the values<br>- End with discussion |
| | Break | 30 min. | Students should take a break from robotics and if possible they should be outside |
| - View appendix A<br>- View appendix B<br>- Make sure distance sensor isn't sensing robot itself (the claws need to be open) | Distance Sensor | 15 min. | - Discussion on hearing as a sense<br>- This sensor is hearing and vision mixed (sonar)<br>- Demonstrate capabilities: hold an object in front of robot and have robot print the distance on its screen<br>- Explain how program works |
| - View appendix A | Demo | 15 min. | - Show students the code being used for pathfinding/ avoiding<br>- Demonstrate capabilities: let the robot path find and avoid stuff (make sure there is sufficient space between the obstacles, around 250 mm) |
| - View appendix A | Activity | 90 min. | - Big maze task<br>- Give students access to basic code if this activity proves difficult |
| - View appendix B | End discussion | 15 min. | - Recap what was covered in the lesson<br>- Any questions or concerns should be identified |

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| **Materials** | Laptop with wifi access<br>VEX VR simulator<br>VEXcode IQ software<br>Presentation Board<br>Pen/pencil<br>Engineering notebook/paper |
| **Vocabulary** | **Color sensor:** This sensor allows the robot to see colors and brightness levels<br>**Bumper sensor:** This sensor allows the robot to "feel" its environment because it can sense when the bumper is pressed or not<br>**Ultrasonic or Rangefinder sensor:** This sensor allows the robot to see its environment and where objects are by listening to soundwaves it sends out and gets back |
| **Additional Resources** | - Technical Manual |

| Lesson 5: Arms and Joints: 3 Hr. 20 Min. | | | |
|---|---|---|---|
| **Purpose:** The purpose of this last technical lesson is to introduce arms to the robot. By the end of this lesson, the students should be capable of building and programming an arm of a robot to lift objects in the air. Students should now be familiar with the basic functions of a robot. The students will use their creativity and knowledge they learned thus far in an interactive activity at the end of the lesson. | | | |
| **Recommendations** | **Title** | **Duration** | **Key Parts** |
| -View Review Questions and Answers in Appendix B | Review | 20 min | - Help students understand basic components of robotics through discussion<br>- Think about arms specifically and how robots use them |
| - Set up an obstacle course before the lesson starts.<br>- Explain how we are now combining many features of a robot<br>- View Appendix B | Interactive Activity | 20 min | - Simplify the steps the robot is taking by comparing it to human behavior<br>- Engage students with fun activity<br>- Only pick up a specific colored object and explain how the robot can do similar things |
| - Show an advanced robot so students can work towards that goal | Demonstration | 10 min | - Get students motivated to build the finished product on their own |
| - Each group should have a VEX handout for step-by-step instructions of Arm | Construction of Arm | 30 min | - Assemble Arm of Robot<br>- Teach the mechanics of the robot through hands on activity |
| | Break | 30 min | Students should take a break from robotics and if possible they should be outside |
| - Start with easy examples. View the technical Manual. Show the code to pick up an object in the technical manual | Code Arm | 20 min | Teach students technical skills of robotics with block code<br>- Code robot to grasp objects<br>- Code robot to lift objects |
| - Give the students some guidance, but let them use their creativity<br>- View Appendix B | Interactive Activity | 60 min | - Apply the skills that the students learned to an interactive activity |
| - View Appendix C | Discussion | 10 min. | - Recap what was covered in the lesson<br>- Any questions or concerns should be identified |
| **Materials** | Laptop with wifi access<br>VEX VR simulator<br>VEXcode IQ software<br>Presentation Board<br>Pen/pencil<br>Engineering notebook/paper<br>Various colored objects | | |

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| **Vocabulary** | **Claws** - located at the end of the arm, the two objects that come together on opposite sides to grasp objects.<br>**Arm** - Similar to the arm of a human, it has a joint at which the arm rotates. |
| **Additional Resources** | - Technical Manual |

| Lesson 6: Project Introduction 4 hr. 15 min. | | | |
|---|---|---|---|
| **Purpose:** Give students a project that will exercise their creativity, problem solving skills, and interpersonal skills. It will reinforce aspects of previous lessons as well as the value of teamwork. This activity is designed to help students understand that they can solve real world problems with STEM. It is also meant to motivate them with their own success. | | | |
| **Recommendations** | **Title** | **Duration** | **Key Parts** |
| Small break out groups with varied students to discuss ideas | Opening Discussion | 15 min | - Gauge student feelings for the project<br>- Answer preliminary questions |
| - Explain entrepreneurial standpoint of project<br>- Teams should map out their plan with engineering design process | Project Introduction | 15 min | - Reference demonstration and engineering design process from lesson 1<br>- Frame the project with goals and explanation<br>- Distribute kits and materials |
| - Have mentors guide students | Build Time | 90 min | - Map out design plan with engineering design process<br>- code and build in teams |
| | Break | 30 min | Students should take a break from robotics and if possible they should be outside |
| - Have mentors guide students | Build Time | 90 min | - Map out design plan with engineering design process<br>- code and build in teams |
| - See appendix B<br>- Have students help to answer other students questions if they can | End Discussion | 15 min | - How do they feel about their current robot<br>-What else do they have to do at this point<br>-What are they struggling with? |
| **Materials** | Laptop with wifi access<br>VEX VR simulator<br>VEXcode IQ software<br>Presentation Board<br>Pen/pencil<br>Engineering notebook/paper<br>Arena with various colored objects and walls | | |
| **Vocabulary** | **Entrepreneurship** - Activity of setting up a business to create value for customers<br>**Investor** - A person or company that provides money for funding an idea in hopes to return profit<br>**Pitch** - A presentation of a business idea to investors<br>**Interpersonal skills** - Ability to interact and communicate well with other people | | |
| **Additional Resources** | Arena example template | | |
| **Project Explanation** | - Final project is dependant on whether following the seven lesson plan or extending program<br>- See appendix A for example project<br>- See appendix C for guidance based on time | | |

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| Lesson 7: Project Presentation 3 hr. 35 min. | | | |
|---|---|---|---|
| **Purpose:** This lesson aims to give students the platform to express and show their skills acquired over the past lessons. This is the climax of the program and ultimately the students should take charge to demonstrate their skills. In addition, this is where they will be exercising their interpersonal and entrepreneurial skills with a more formal presentation and explanation as to what their robot can do and why they chose it to be that way. Congratulate and instill the purpose of the program and urge them to keep learning and get involved. | | | |
| **Recommendations** | **Title** | **Duration** | **Key Parts** |
| - Encourage students with positive affirmation of their success | Opening Discussion | 20 min | - Revisit common question areas from the past lessons<br>- Remind what the goal of the project is and emphasize the team importance aspects |
| - Have mentors guide students and offer help when needed | Build Time | 60 min | - Time to work on code, edit robot, test out and ask questions<br>- Final time to work on the robot<br>- Have students test out with arena and objects as necessary |
| - Give order of presentation at this time | Break | 30 min | - Remind students that at this point they should be finished<br>- Students should know how they are going to present |
| - Should be prepared for final run after this practice<br>- Help students who need it<br>- Ensure all students have a robot that can be successful | Practice Run | 60 min | - Allow all students run throughs on the course |
| - Invite parents to attend<br>- Have a stage and seating area arranged<br>-Ask questions about why they chose certain features | Final Presentation | 30 min | - Revisit and emphasize how much has been learned and the project at hand<br>- Student groups present<br>- Applause and feedback time |
| | Discussion | 15 min | - Congratulate and thank the parents, mentors and students<br>- Close out with what was learned and how they feel<br>- Emphasize the importance of interpersonal skills<br>- Encourage them to continue to code and give options for future involvement |
| **Materials** | Laptop with wifi access<br>VEX VR simulator<br>VEXcode IQ software<br>Presentation Board with powerpoint access (optional)<br>Pen/pencil<br>Engineering notebook/paper<br>Arena constructed with various colored objects and walls<br>Seats and stage | | |
| **Final Presentation** | - Final presentation is dependant on time of the program<br>- See appendix A<br>- See appendix C | | |

# Appendix A: Activities

## Lesson One

Activity Suggestions for Icebreakers

The name game - have everyone say their name with a food that starts with the first letter of their name, go in an order and have the next student say their food and name followed by every student who has gone previously and add on accordingly to progress.

Video Demonstration Activity

Boston Dynamics - Do You Love Me?

We recommend following the video up with a discussion (see appendix B) to keep students engaged and then pairing this with an in person demonstration of the robots they will be working with completing a task or movement similar to their final project.

Activity Relating Students to Robots

To supplement the discussion on what a robot is in appendix B, facilitators may choose to have a student volunteer act along and demonstrate the questions that are asked. Have them use their senses first with an object, preferably something they have to learn to use, like a utensil, sport ball or instrument. Then ask them what they are supposed to do with the object, and how they know what they are supposed to do. Then lead into how they interact with other people and the environment and tie it back to the senses around them.

Activity for Break

Battle Bots Video

Talk a little about what battlebots area; two machines battling off to disable each other, they are remote controlled so they are not technically robots because they don't sense their environment and act on what is around them. But they are pretty close because they have some autonomous actions (middle man between robotics and mechanics)

Activity for Engineering Design Process

After finishing the discussion about the steps of the engineering design process (See appendix C) Distribute paper and tape to teams of 2-3 students, before having the students immediately begin to work, assign them with the task of building a paper tower and the teams should try and reach a certain height with only a certain number of pieces of paper. The students must plan their tower before building and estimate what their performance will be. The higher the tower and the less paper and time used allots to a better tower: Cap the construction period at 5-8 minutes to leave time to assess the buildings.

Software Activity

This activity is semi-structured. Allow the students to log onto or access the online coding platform that will be used and perform a real time walk-through demonstration that explores the platform and they can follow along with. Allot some time for the students to code and explore on their own without instruction or task. After, if using VEX, direct the students to the virtual playground game Castle crashers and code with the instructions provided. This may be difficult without a lesson in teaching motion so monitor frustration and offer prior guidance as necessary.

Hardware Activity

After the discussion about what pieces are and basic connection, administer instructions for how to construct a basic base bot and give time for the students to work together in groups of two to construct the robot. Have mentors float around and help as necessary.

## Lesson Two

Activity involving If/Then:

Students will play a game of 'stoplight.' Make the students stand up and walk when the teacher holds up a green card and stop when the teacher holds up a red card.

Show the students this if/then statement and explain:

If green then
    Walk
If red then
    Stop

Activity involving For Loops

Have students explain brushing your teeth. Write out the steps to this exercise. Ask if there are any steps that need to be repeated and how many times they need to be repeated. This is a counting loop or "repeat" in the vex coding languages.

Activity involving While Loops

Think of a number 1 - 20. Have students guess a number until they get the number you are thinking of. This shows how while loops work by repeating a task for as long as it takes until the condition is met.

Activity involving Forever Loops:

Relate back to stoplight example and show this example

Forever {
If green
Then walk
Else Stop
}

The point of a forever loop is that it is repeating

## Lesson Three

Activity involving movement

Have students direct/instruct verbally a mentor or instructor to a location in the room. There may be obstacles or more challenging tasks that prevent the instructor from moving straight forward to location. Students should be specific on the instructions given. As the person being directed, follow the student's directions specifically. If students do not instruct you to stop, do not stop (be careful).

Activity involving parameters to determine velocity (speed)

Have students time how long it takes for the robot to move a given distance (ie 500 mm). Then using the velocity equation have students measure time how long it takes to move and find velocity (speed)

Activity involving parameter and turning:
Have students design an action that they turn left, right, and move forward to reach a location. This can be a map, however, students should practice turning degrees other than 90 degrees.

## Lesson Four

Teacher demonstration (Stopping at wall)
Set the robot 500 mm away from a wall, then tell the robot to go 1 m. Be sure to reduce the velocity of the robot to a smaller number so that it stops quickly. Ideally this demonstration should show that the touch sensor gives feedback to the robot's brain and causes it to stop.

Activity involving touch sensor
Have students time how long it takes their robot to get to an empty water bottle, if they knock it over their time does not count. They can change the robot's velocity among other things to improve time. For example, if the water bottle is 1 m away they can set the robot to 100% velocity for the first 900 mm then decrease it to a smaller number for the last few mm. Also give them time to refine their code and complete trial runs.

Teacher demonstration (Stop Sign)
Program the robot to drive forward and create an if statement that tells the robot to stop driving when it sees red. To demonstrate this, allow the robot to drive for a while then hold a red object in front of the robot and show that it stops and that it continues driving when the object is removed.

Activity involving line following
Have students time how long it takes their robot to complete a course. The course is a dark line laid out on a light colored surface and it can be any shape, so it is up to students to fine tune the code given or create their own better version. Again, make sure they have plenty of time to experiment with the robot and their new code.

Small Activity/ Demonstration
Have students download the given code that measures the distance an object is from the robot and prints it on the brain. This is a good way to show how the sensor works and why it is important.

Activity involving the "Big Maze"
Create a complicated maze for the students to solve, it should include line following, object detection and decision making from this, and decisions based on colors. All of these ideas can be used to whatever extent is necessary, but this activity should start to compound on the other lessons and show them how complex problems can be solved. Students should have access to some basic code so that they do not need to start from ground zero. It is intended to be difficult.

## Lesson Five

Activity involving moving, sensing, and arms (no robot)
Mentor will pick one volunteer from the class to give verbal instructions to the mentor to move around the room to a specific object. The student will guide the mentor to pick up the object and place it on a box.
Ex. "Go straight for 5 steps, right 2 steps, and straight 1 step. Now pick up the red ball and place it on top of the box."
Inform the students that you now only want to pick up objects of a certain color. A different student will then instruct the mentor to pick up all of the 'red balls' on the ground one at a time and place it on a box.

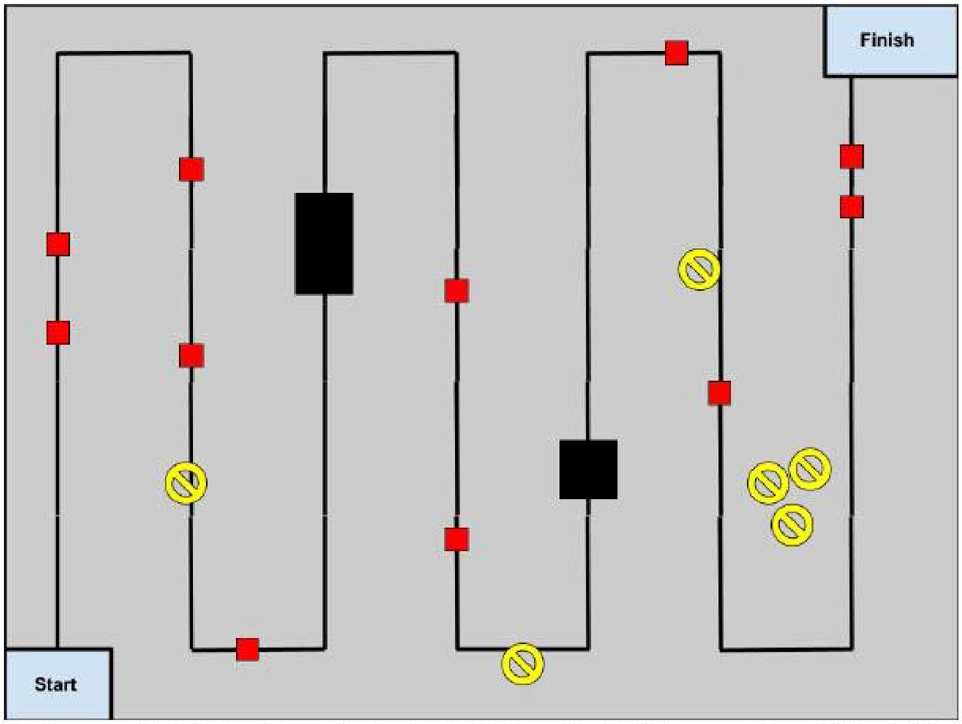
Activity for picking up objects
After the robot is fully constructed with the arm, students will now use their creativity to program a robot to drive and pick up an object. Have the students complete as many of the following activities in the allotted time:

1. Place an object in front of the robots arm and program the robot to pick it up
2. Have the robot drive in a straight line and pick up an object
3. Have the robot drive in a straight line, pick up an object, and then place it on top of a box
4. Have the robot drive and only pick up a specific colored object
5. Have the robot drive, only pick up a specific colored object and then place it on top of a box

## Lesson Six

Final Project
Example Problem Frame: With summer coming, the beaches are in need of a clean-up and removal of trash that is all over. There is trash and other obstacles that are also on this beach. Your job is to construct and code a robot that will navigate the beach and be able to pick up trash while avoiding the cats that are at the beach. There are also walls that will be in the way. The trash is represented with the color red and the cats are yellow. The goal is to remove as much trash as possible by bringing it back to a designated location (see technical guide).
For the final project and presentation, we recommend creating a standard arena in a defined grid. Amongst the grid, it is recommended to have gathered objects of light weight and at least 3 by 3 inch dimensions with varied colors. We recommend having obstacles or walls set up amongst the area and as the border.

In the startup and beginning iterations of RobotiKids, the final project may need to be scaled back or altered based on timing and difficulty of tasks. If the color sensing and path finding is too difficult and time consuming for starting, instead have the trash set up on a line and the final task should be for the students to do line following and pick up the trash on the line. The project goal can be altered or adjusted as needed as well.




This is a possible playing field for the final project, where the black lines are the path the robot will travel using path finding. The red objects are trash it will pick up while traveling, and the yellow objects are objects it needs to either pick up and move or play a noise to get them to move. The black objects are rocks that cannot be moved and need to be avoided by the robot.

## Lesson Seven

Project Presentation

Set up seating arrangements and have mentors and parents, if invited, sit to one side and students with their finished robots sit to the other. Give opening remarks, praise for accomplishments and hard work, retell what the project is and what the task was and then allow students to take center and demonstrate their work through the arena and present on their robot and their choices for the code and construction. If time allows, have the students prepare a slide with the main components or key features of their robot. This is also a time that the student can talk about the engineering design process and their process rationale.

Essential elements that need to be considered and outlined before executing the entire lesson plan include having a predetermined set of standards. These can be changed iteration to iteration but a well defined project will make a difference in the outcome.

# Appendix B: Discussion Questions

### Lesson One

Discussion Questions on Robot Demonstration

***What do you think of the robot in the video***? Prompt on motion, parts they observed

***What do they think that robots can do?*** What their idea of a robot is, is a toaster a robot?

***Do they have any ideas for a cool robot?*** All answers are correct and encourage everyone to answer

Discussion Questions on Program and Robot Introduction

After walking through what the program will cover with description

***Ask for what they think a robot needs to accomplish each lesson of the program .***

***What does a robot need in order to move and turn?*** All answers are correct - wheels, motor, gears, brain

***What kind of sensors can you think of?*** All answers are correct - bumper, light, objects, sound, color, a computer to sense these

***What does a robot need in order to move joints and arms?*** All answers are correct - levers, joints, arms, claw, gears, motor

Discussion on What a Robot Really is and Defined as

Supplement with activity in appendix A - comparing a robot to a student in school

***Are you a robot?*** All answers are correct

***What is something that makes you human?*** All answers are correct but guide in the direction of sensors - students have to be able to recognize their environment

***What do you do with the information about your environment?*** Guide students in the direction of having to compute and learn about it, compare to students going to school and having the ability to learn

***What do you do with the information you learn?*** Guide students to having to learn how to act and behave like learning how to play a sport or instrument

***What happens when you move around with the information?*** Guide students to recognize they have to interact with their environment - other people, objects, places - this will lead into having to sense what is around them which brings the discussion full circle

***Robots must be able to sense their environment***

***Definition of a robot -*** A robot is a device that uses sensors to make decisions that control actions in the real world...and uses feedback to monitor the actions.

Discussion on Engineering Design Process

When asking questions, use each to lead into one of the steps of the design process and write each step down once a student says. Can give an example problem to help illustrate.

***When faced with a problem, what is the first thing you usually do?*** All answers are correct

***What kind of information do you need to solve a problem?*** Research, questions about the problem, available resources

***What are some ways you plan to solve a problem?*** Brainstorming, word web, list, talk to other people, etc

***What do you do once you have an idea?*** Create and Test

***What do you do when things go wrong?*** All answers are correct, continue to try

<u>Discussion on Hard and Software</u>

We recommend keeping this semi-structured and allowing the students leads with prompting questions:

***What do you think this category of code does?***

***What do you think this part does or is used for?***

***How will the robot move with this?***

***What is your favorite part?***

## Lesson Two

<u>Discussion Questions on block coding:</u>

***What can you compare block coding to?*** Building a lego house or jenga blocks to build the actual structure.

***What coding languages are there?*** There may be various answers, Key languages to focus on are the block coding and Python and C++

***Have you ever used code in the past?*** All answers are correct

## Lesson Three

<u>Discussion Questions on movement:</u>

***What things move?*** All answers are correct

***How do they move?*** All answers are correct

***What directions can they move in?*** All answers are correct, but specifically looking for forward backward left and right

***How can we tell something that doesn't know left and right to turn left and right? (harder question)*** if someone brings up using degrees

***Why would we want a robot to move forwards and backwards?*** All answers are correct

<u>Discussion Questions on parameters:</u>

***What is a parameter?*** a limit of boundary that defines the scope of particular process or activity

***What if I want the robot to only move 300 millimeters? How do I get the robot to do that?*** View code in technical guide

<u>Discussion Questions on Velocity:</u>

***What is velocity?*** Velocity = distance traveled/ time traveled

***What is speed?*** Speed = distance/time

***What is the difference between velocity and speed?*** Velocity has direction

<u>Discussion Questions on Turning</u>

***Now what if we want to turn right?***

***What is an angle?*** the space between two intersecting lines or surfaces at or close to the point where they meet.

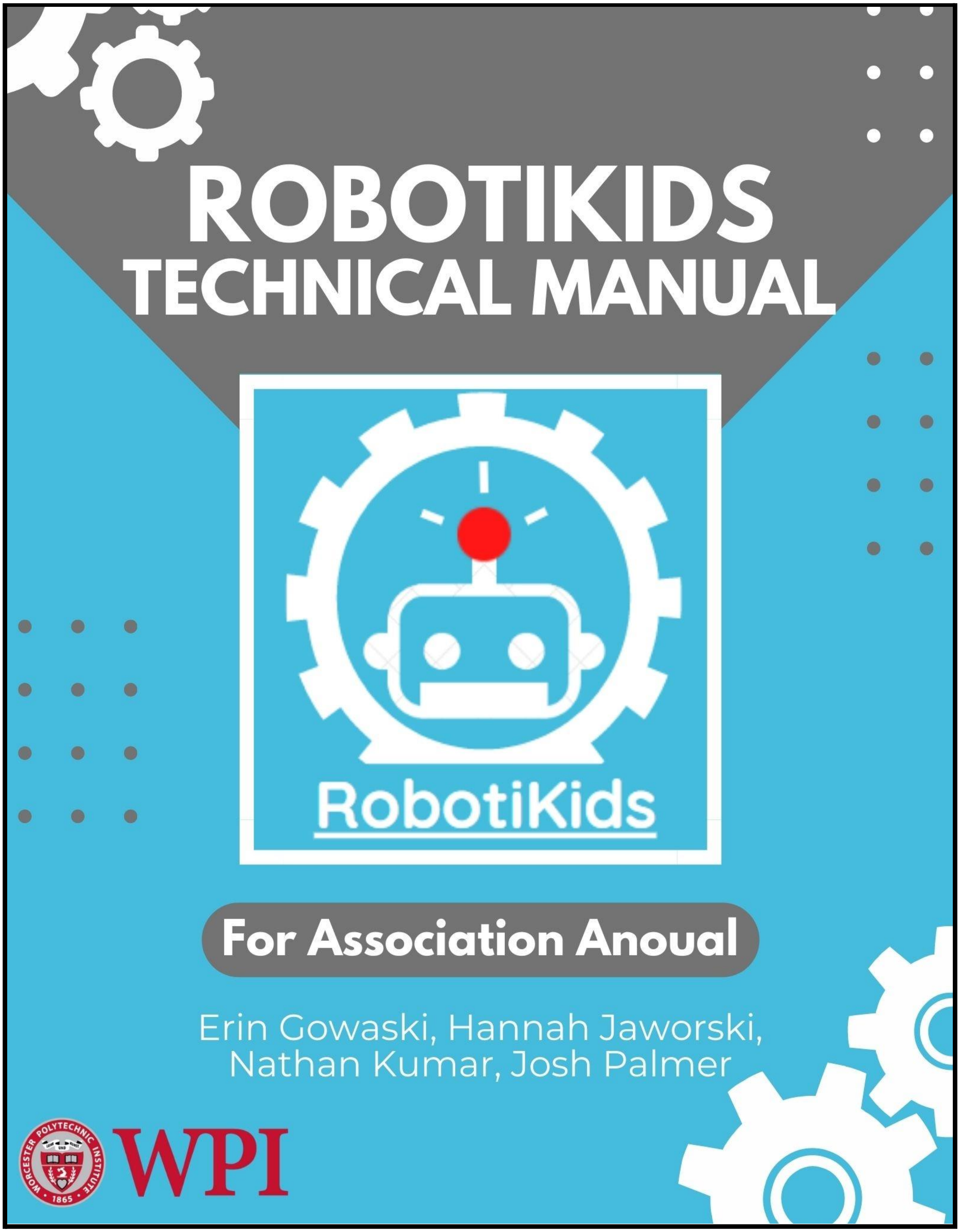
***How do you measure an angle?*** Using a degree

***What is a degree?*** Measure of an angle

***What degree is it if we want to turn around?*** 180

# Appendix J: Technical Manual

The following is intended to be used as a supplemental, stand-alone document. The pages provided are to be used outside of this format.


ROBOTIKIDS
TECHNICAL MANUAL
RobotiKids
For Association Anoual
Erin Gowaski, Hannah Jaworski,
Nathan Kumar, Josh Palmer
WPI

# ROBOTIKIDS - ROBOTICS CURRICULUM FOR MIDDLE SCHOOL STUDENTS
# TECHNICAL MANUAL
# 2022

**Technical Manual Purpose:**
This is a supplementary manual that documents the use of VEX IQ robots in the RobotiKids program. This technical manual was referenced in the LESSON MANUAL submitted to Association Anoual.

The program of RobotiKids was developed, created and tested with the use and assistance of the various VEX resources. This technical manual offers insight into the models of robots used for each lesson, the code used for each lesson and advice that relates accordingly. Note that there are various ways to accomplish a task with the code and robot, so answers are not limited to this manual's answers. The intent of this manual is to offer guidance and support to VEX code and hardware in relation to the RobotiKids program. While the program can be supplemented with other robotic kits we highly recommend VEX for its ease of use and its relationship with RobotiKids.

**Additional Resources**
These resources aided the development of RobotiKids and can offer further help around issues that may arise. We recommend becoming acquainted with VEX before facilitating the program.

- VEX IQ Robotics Education Guide
- VEX IQ Teacher Supplement
- VEX IQ Video Demos
- VEXcode IQ Program Download

## Two Manuals included in the VEX IQ Kits

**The Control System User Guide** - Explains the connecting and software components of the kit, for the program the most important components are:

- Batteries and charging (blue)
- Connecting the smart devices (green)
    - Sensors
- The robot brain (red)
- Built in Programs (optional) (purple)
    - Search Patterns


From VEX IQ Kit Control System User Guide

**Build Instructions** -Detailed step-by-step construction of the hardware pieces of the kit, for the program the most important components are:

- Building the basebot
- Construction of arm
- Construction of claw
- Attachment of smart devices


3

## Hardware Information

We recommend using the basebot that is outlined and explained in the hard copy of the VEX IQ Kit that provides step-by-step instruction for construction.

The kit includes many parts to construct the basebot or build a new robot by adding supplemental parts to the basebot.
The pieces included in the VEX IQ kit are illustrated in a poster that outlines their real size, dimensions, product number and count in the kit.
The parts can be organized into four categories:

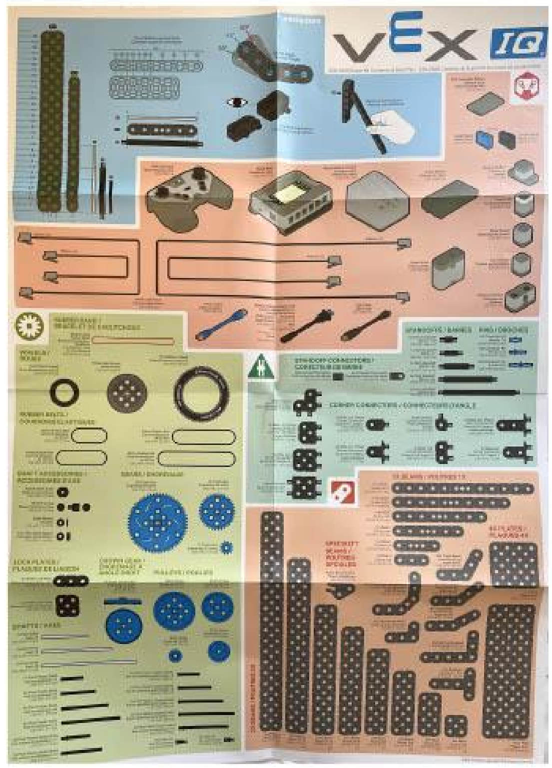
**Brain and Smart Devices**
- The robot brain
- Battery and charging
- Sensors and radios
- Cables

**Movement pieces**
- Rubber bands
- Pulleys
- Gears
- Shafts and shaft accessories

**Connectors**
- Standoffs and standoff connectors
- Corner connectors
- Pins

**Bases**
- Various 1X beams
- Various 2X beams
- Plates
- Specialty beams

The pieces snap together and have connection points within them that offer security but also ease of release.

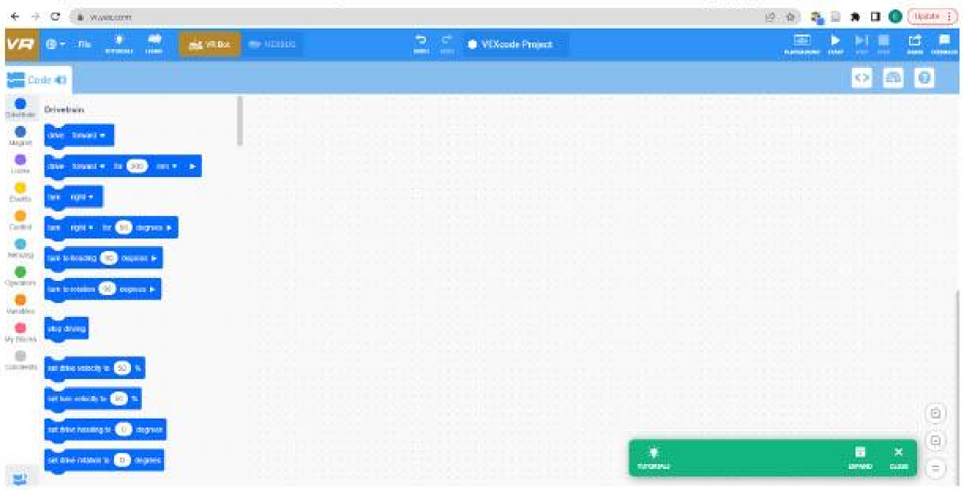



From VEX IQ Kit Hardware Illustration

## VEXcode VR Simulator

The VEXcode Virtual Robot (VR) simulator is an online resource that allows the user to use block coding to simulate actions of a VEX robot.
The following link will bring you to the VEXcode VR online platform: https://vr.vex.com/

Having followed the attached link you will be welcomed to the following page:



At the top, is a toolbar.

This toolbar includes a tab called ***tutorials***. These tutorials will help you get set up with the VEXcode VR platform.

The code functions are organized on the left hand portion of the screen and can be dragged and dropped into an open grid.

The playground button in the top corner opens a virtual robot to mimic the code that was constructed. The playground has a variety of areas and grounds to experiment on.

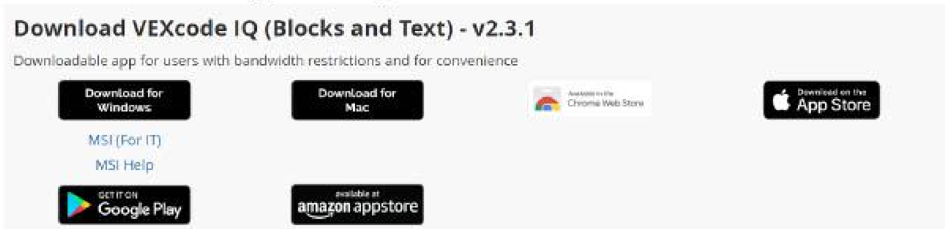
**TIPS:**

- VEXcode VR automatically saves the progress.
- There is an undo, a play and a stop button in the top banner strip.
- The code must always be started with a start function.

## VEXcode IQ

VEXcode IQ is a program of block code that can be downloaded directly to the VEX IQ robot brain. This software is similar to the VEX VR simulator. Follow the Steps listed to download software

1. Visit: **https://www.vexrobotics.com/vexcode-download**
2. Scroll to **VEXcode Blocks**
3. Select **IQ**
4. Select the format that is applicable for your device



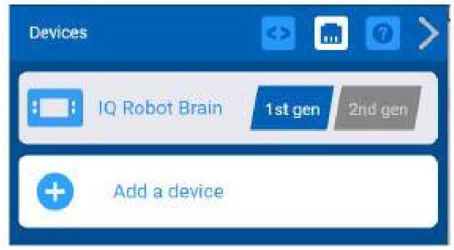

Setting up the software:

1. Open the downloaded software
2. Turn on your robot/robot brain
3. Plug in the programming cable from the robot to the computer

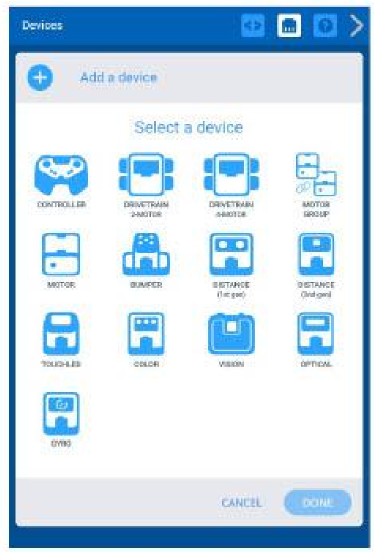
**How to add a device to a port in VEXcode IQ**

1. Once you have opened VEXcode IQ, select the devices page

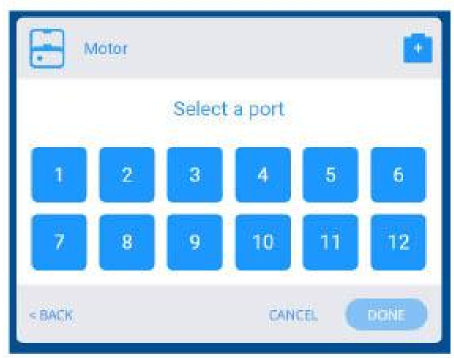
2. Add a device




3. You will need to add: a two motor drive train, a motor for both the arm and claw, a bumper, a distance (1st gen) sensor, a color sensor, and the gyro




4. Click the port number that the motor is plugged into on the physical robot.

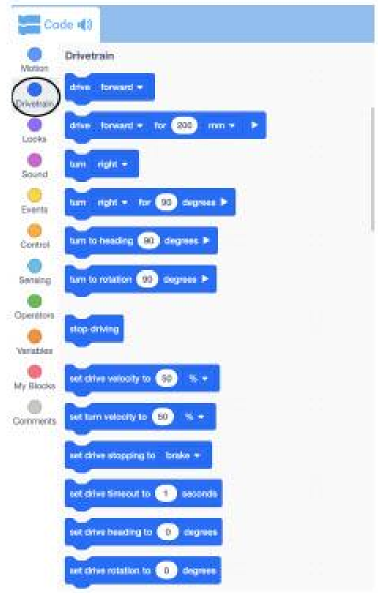


5. You can rename the motor. Then press "DONE"

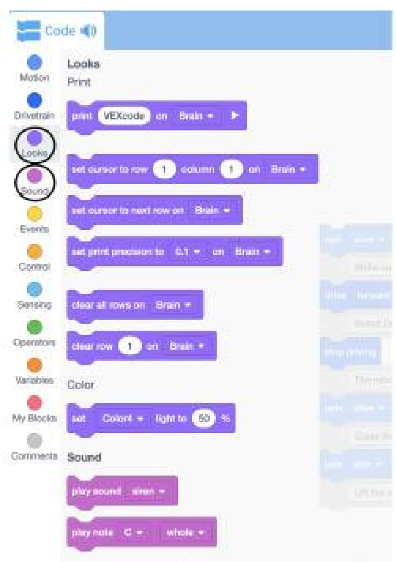

## Reviewing Code Sections:

**Motion:**
The motion section of the VEXcode IQ includes block code that deals with the <u>movements of the arm and claw</u>. You can lift/lower the arm as well as open/close the claw of the robot. *Note that the name of the dropdown 'claw' may be different depending on what you name the motor.*

**DriveTrain:**
The drivetrain section of the VEXcode IQ includes code that will <u>*drive* the robot</u>. This includes setting the speed and distance the robot can travel.

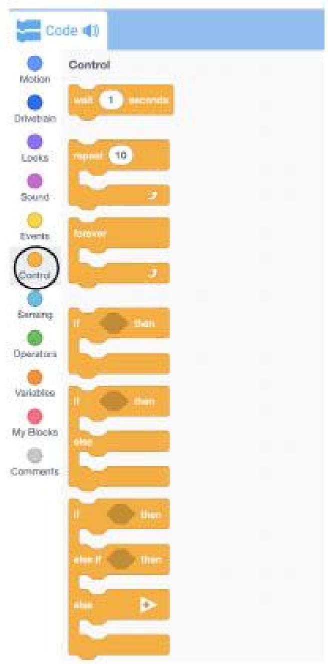



**Looks & Sound:**
The looks section on VEXcode IQ will allow for <u>text to be *displayed* on the brain of the robot.</u>
The sound section allows for <u>audio to be played.</u>



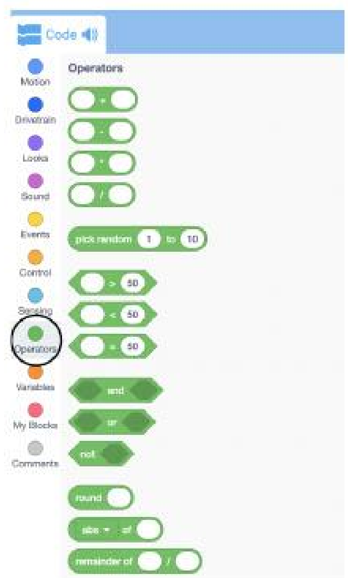
**Events:**
The events section of the VEXcode IQ included blocks that will begin code and broadcast events. The most important block in the event section is "*when started*." It indicates the start of a program and proceeds to execute the code in the program.


**Control:**
The control section is where conditional statements are found.



**Sensors:**
The sensor section is where blocks that let the robot detect objects and their color, as well as many other functions. *Note the names in the picture, "color 4" and "distance 3" will be different depending on what you name the motor.*


**Operations:**
The operations section is useful <u>with conditionals, especially, *and, or* and *not*</u>. These are often used within an *if statement* which are found in the control section.

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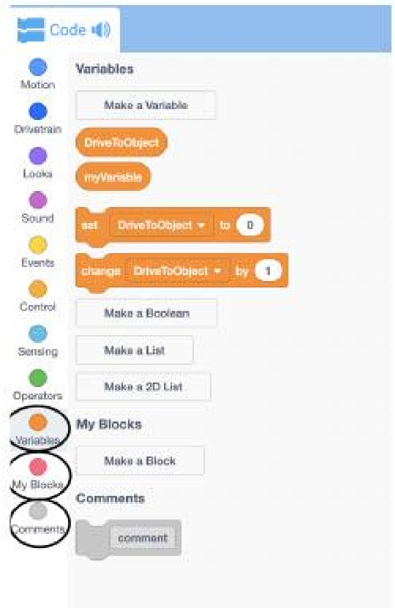
**Variables & My Blocks & Comments:**
The variable section can be used to create a custom variable.
My blocks can be used to store a custom block of code.
Comments are used to describe the contents of code.

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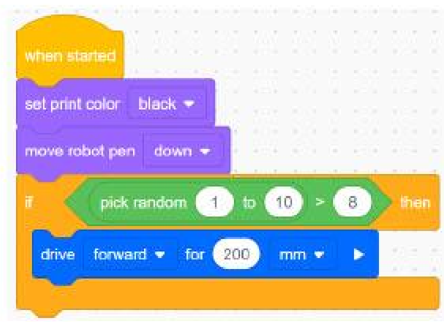
## Lesson 2: Introduction to Coding

VEX offers two platforms for block coding. The first, VEXcode VR (Virtual Robot) operates solely as a virtual robot and does not coordinate with the VEX kit. It allows students to drag and drop code into the grid and then see the motion of the virtual robot on the platform. This translates into VEXcode IQ which is a parallel format, except the code can be delivered to the constructed robot. **Note:** that the following code will only work in the VR simulator. However, the concepts and logic can be used in VEXcode IQ.

The following examples use basic movement forwards and backwards and turning, this can be used as an introduction to movement seen in lesson 3.
If you would like to implement the following code open the "Art Canvas" playground in VEXcode VR to see the code work to full potential.

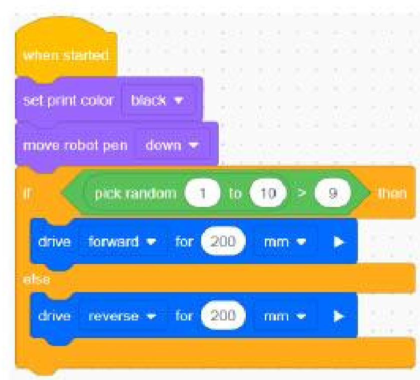
**If/Then Statements:**
If/Then states are explained in the Lesson Manual.

When the play button is pressed the pen on the robot will be set to black and placed on the canvas. The computer will randomly select a number 1 to 10. If the number is greater than 8 the robot will drive forward 200 mm. If the computer does not select a number greater than 8, the robot will not move and the loop will terminate.



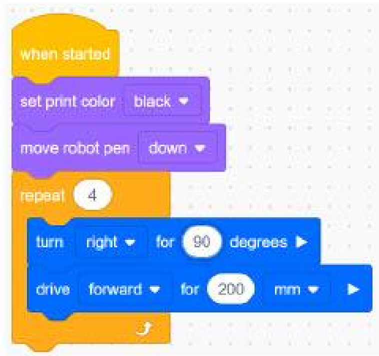

**If/Then…Else Statements:**
If/Then…else statements are explained in the Lesson Manual

When the play button is pressed the pen on the robot will be set to black and placed on the canvas. The computer will randomly select a number 1 to 10. If that number is greater than 9, the robot will drive forward 200 mm leaving a black line drawn. If that condition is not met, the robot will drive backwards for 200 mm leaving a black line drawn.



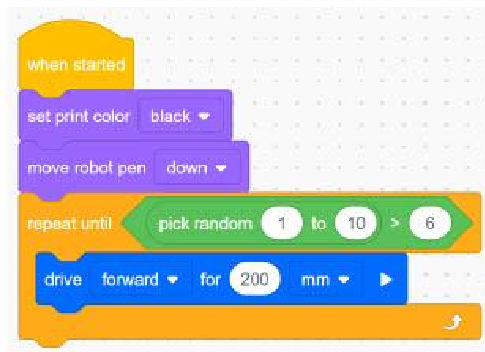
**For Loop:**
For loops are explained in the Lesson Manual. For loops are referred to as "repeat" in VEXcode software.

When the play button is pressed the pen on the robot will be set to black and placed on the canvas. The robot will make a 90 degree right turn and move forward 200 mm. That sequence will repeat 4 times.
*this will draw a square!




**Repeat Until Loop:**
Repeat until loops are explained in the Lesson Manual.

When the play button is pressed the pen on the robot will be set to black and placed on the canvas. The robot is then instructed to move forward in increments of 200 mm until the computer randomly selects a number larger than 6, from the range of 1-10. Once a number larger than 6 has been selected the "repeat until" loop terminates and the robot stops moving.




**Forever Loop:**
Forever loops are explained in the Lesson Manual.

When the play button is pressed the robot will turn right (varying in degrees) forever. This loop will not end, until instructed to do so by a *break* or end project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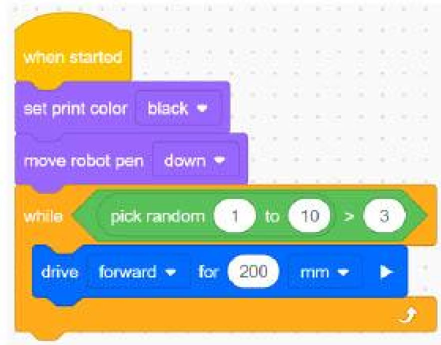
**While Loop:**
While loops are explained in the Lesson Manual.




When the play button is pressed the pen on the robot will be set to black and placed on the canvas. The robot will then move forward until the computer selects a number that does not fit the condition of being greater than 3.

## Lesson 3: Movement and Turning

This lesson is applicable for both the VEXcode VR and the VEXcode IQ platforms.
The following lesson outlines the code and necessary steps it takes to code for the movement of forwards, backwards, and turning left and right.
With each lesson students, and yourself, should feel welcome to play around with other values and formats.

**Movement Forwards:**

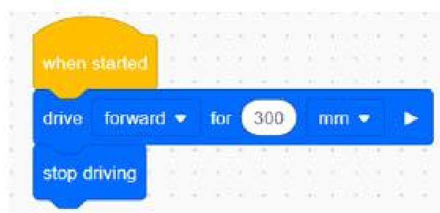
Basic movement forwards with no defined parameters. Once the play button is pressed the robot will move forward infinitely.


**Movement Backwards/reverse:**

Basic Movement backwards with no defined parameters. Once the play button is pressed the robot will move backwards indefinitely.


**Movement forward/backwards with defined distance parameter:**

Movement forwards for 300 mm. The robot will stop driving once 300 mm have been traveled.

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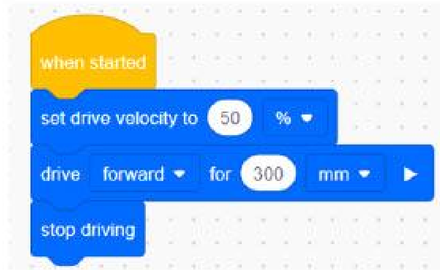
**Movement forward/backwards at velocity measured in percentage:**

*NOTE: Throughout this technical manual, velocity and speed will be interchangeably.*

Movement forward for a defined distance parameter (300mm) at 50% velocity.

The velocity of this robot is undefined, however students should feel welcome to see the robot move at 100% percent speed and a slower rate.




**Movement forward/backwards at rpms:**

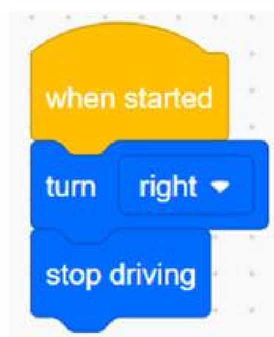
Movement forward for a defined distance parameter (200 mm).

Rpms are explained in the lesson manual. Students should feel welcome to see how fast 100 rpms is and how fast 500 rpms is.


**Turning Right/Left:**

This movement to turn right uses the gyroscope. Use the lesson manual to describe what the gyroscope does. This movement will automatically turn the robot 90 degrees right.

By selecting the drop-down arrow next to "right" students can select "right" or "left" directions. This code can be used for either right or left turning

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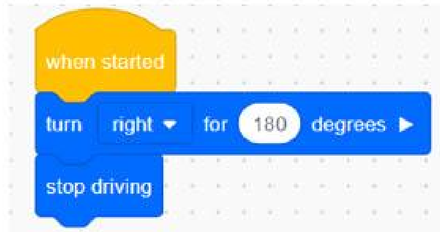
**Turning using Degrees:**

This movement allows the robot to turn in increments other than 90 degrees. Lessons on degrees are detailed in the Lesson Manual. The gyroscope is used for this function: see Lesson Manual for explanation.

Turning right 180 degrees.




**Turning at Velocity:**

*NOTE: Throughout this technical manual, velocity and speed will be interchangeably*

This movement allows the robot to turn at a given speed. The turn velocity is only defined by percentage.

The velocity of this robot is undefined, however students should feel welcome to see the robot move at 100% percent velocity and a slower rate.

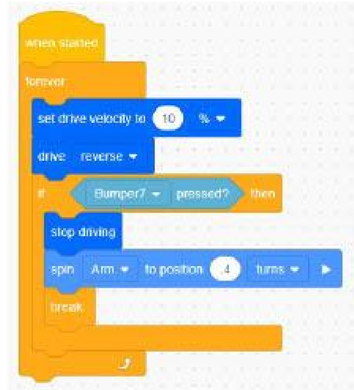
## Lesson 4: Sensors

This lesson is applicable for both the VEXcode VR and the VEXcode IQ platforms.
The following lesson outlines the code and necessary steps it takes to use a variety of sensors for robot movement and automation driving.
With each lesson students, and yourself, should feel welcome to play around with other values and formats.

**Bumper Sensor:**

The VEX Instruction booklet details how to configure the bumper sensor. This is intended to be a *demonstration* of how the sensor works on a basic level.

The bumper sensor is explained in the Lesson Manual.



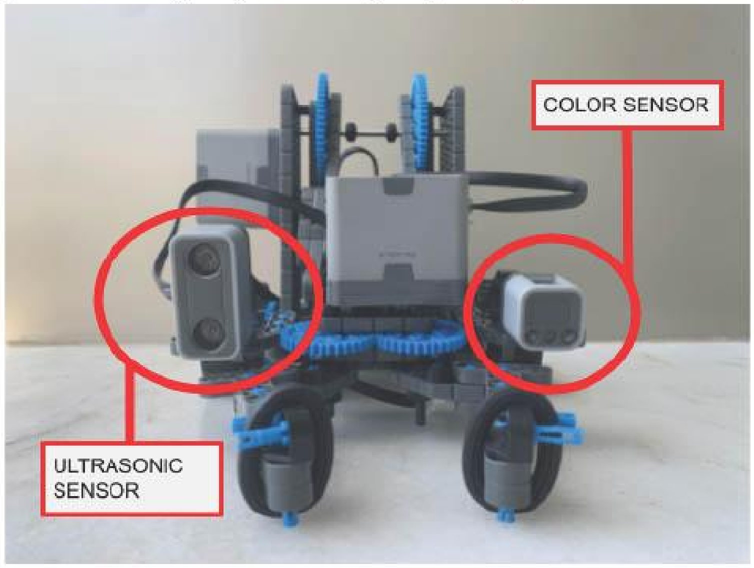

**Water Bottle Activity:**

The water bottle activity is outlined in the Lesson Manual.

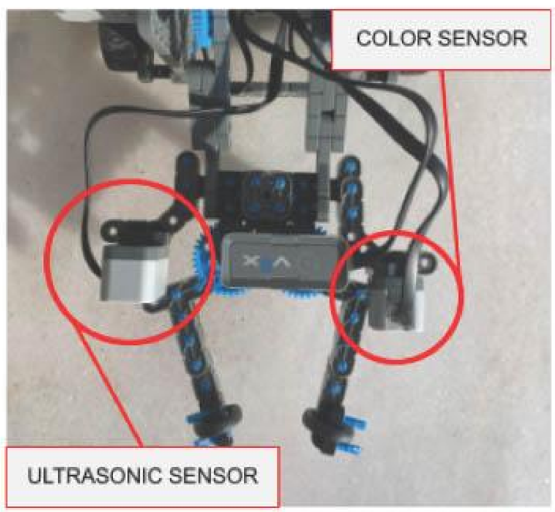
The robot will set its velocity to 100% and move backwards 1000 mm. Once that distance is reached, it will lower its velocity to 10%. The robot will continue to move backwards until the bumper sensor is pressed. When the sensor is pressed the robot will stop.

Students should feel welcome to manipulate the code to make it more efficient or complicated. This may be necessary in some cases depending on how far the bottle is away from the robot.

The following shows how to set up the color and ultrasonic (distance) sensors. Note that both are attached by the same bracer piece (4x4 offset right angle beam)




Location of Ultrasonic and Color Sensors

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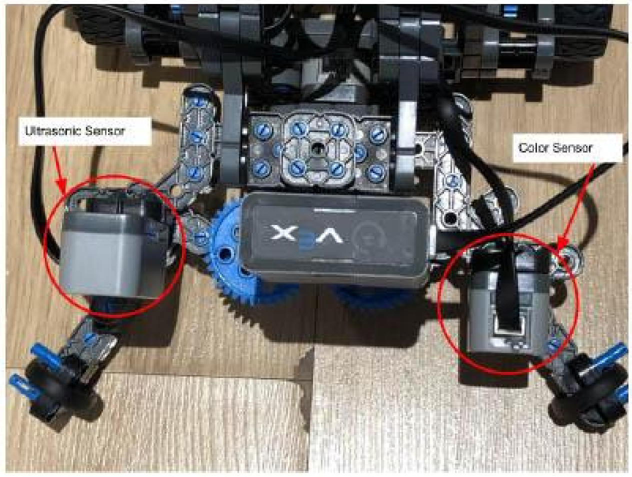
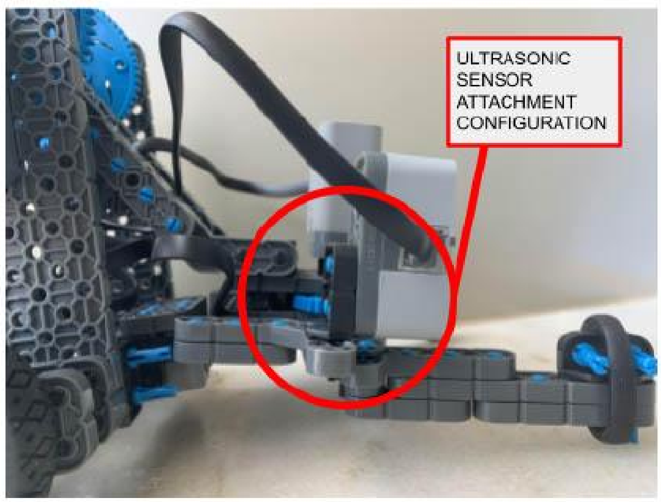



Overhead view of Ultrasonic and Color sensors




Attachment Configuration of Ultrasonic sensor

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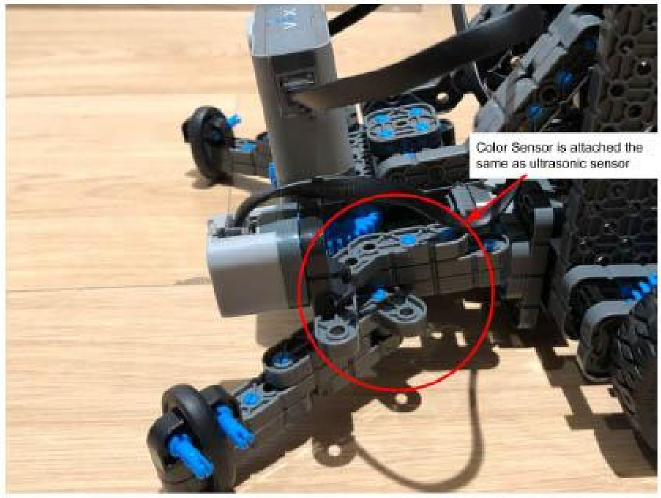


Attachment Configuration of Color Sensor

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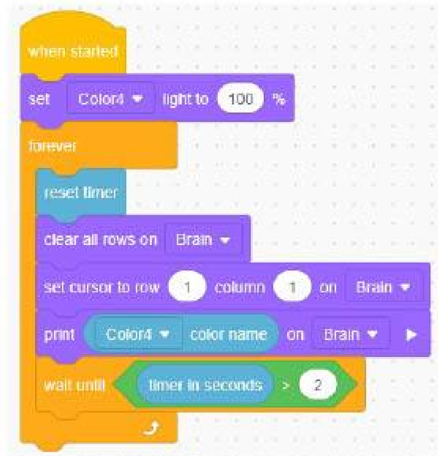
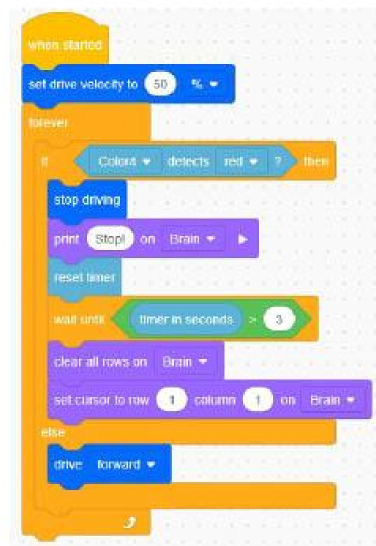
**Color Sensor:**
The color sensor is explained in the Lesson Manual.



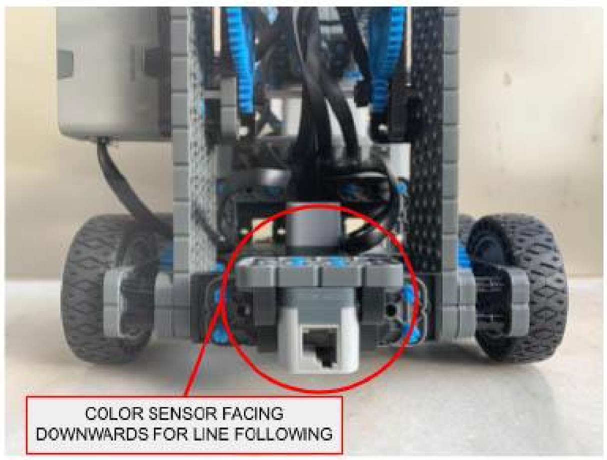

When the play button is pressed the robot will turn on its light to 100%. The robot will follow the next sequence forever: it will reset its internal clock, clear all the rows on the robot brain, set the cursor to row 1 column 1 on the brain, and print the color that the color sensor sees on the display of the brain. Then it will wait until the timer is greater than 2 in seconds. It will continue to do this process. This is to help determine if what we see is the same color as the robot sees.

**Red Light Demo:**
The red light demo is detailed in the Lesson Manual




When the play button is pressed the robot will set its velocity to 50 %. If the robot's color sensor detects red then the robot will stop driving and print "stop!" on the brain display and reset the timer. The robot once it has seen red and stopped driving will wait until the timer has passed 3 seconds then clear the display and check again. This is meant to be fun and interactive for the students but also to teach them a bit more about the sensor and how it works.

**Line Following:**
The following images are the robot configuration for line following using the color sensor. This configuration is needed to have the robot perform line following and decision making at the same time. The bumper piece that needs to come off and the color sensor piece that needs to be attached for the line following configuration are shown below. The motors also need to be put into the VEX IQ as individual motors for this part of the lesson, so when you see "RightMotor" that is the right motor set up as an individual motor, and same for the left motor.




Color Sensor location for line following


The back of the detached bumper sensor assembly

24

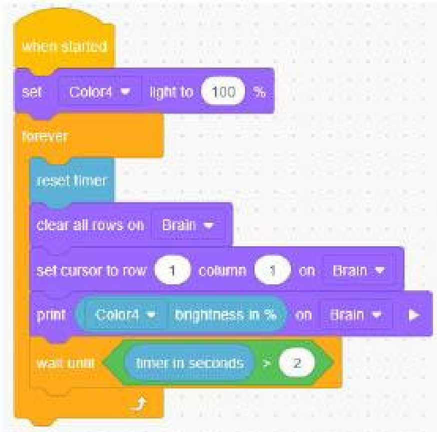
The front of the detached bumper sensor assembly

The back of the detached color sensor assembly

The front of the detached color sensor assembly

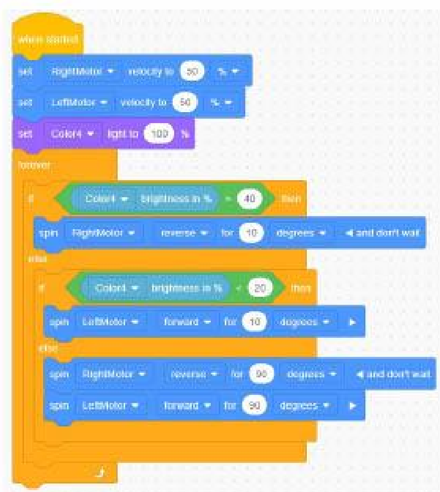
25

**Color Sensor Determining Brightness Values:**
This helps to determine the brightness values used to make the robot turn right or left to stay on the line




When the play button is pressed the color sensor will adjust its light to 100%. The robot will reset the timer, clear all the rows in the brain, set the cursor to row 1 column 1 on the Brain. The robot will then print the brightness level in percentage on the brain. The robot will wait until the timer is greater than 2 seconds and repeat the process forever. This helps to determine the 40 and 20 down below in the follower code.

**Line Following:**
This is the line follower code, it is just a baseline and would need to be adjusted to be more accurate and make the robot go faster.

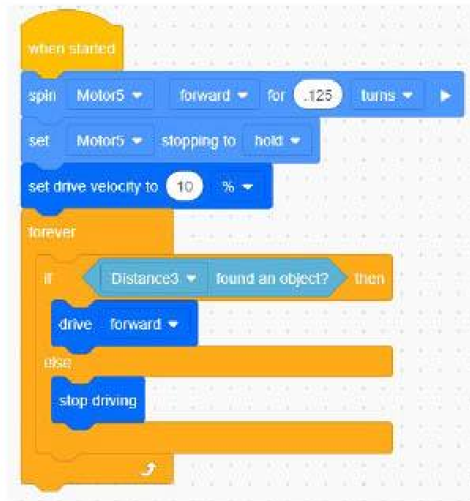


When the play button is pressed the right and left motor's velocity will be set to 50%. The robot will set its light to 100%. Then if the robot detects light with a brightness over 40% then the right motor will spin in reverse (forward because the motor is upside down) for 10 degrees. Else, if the robot detects light with a brightness less than 20% then the left motor will spin forward 10 degrees. If that condition is also not met then both motors will spin in the robot forward direction and it will drive forward.

**Ensuring the Ultrasonic Sensor Works:**
The ultrasonic sensor is also referred to as the "distance sensor".

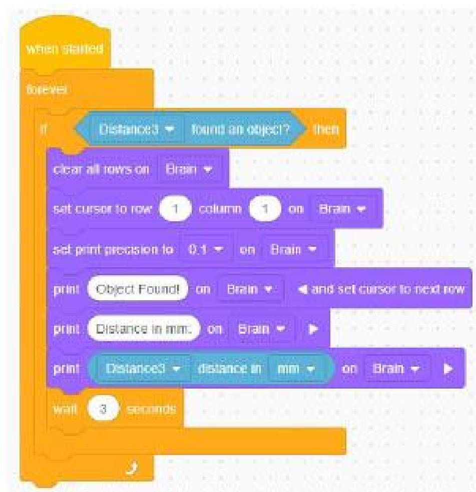
The ultrasonic sensor is explained in the Lesson Manual.

When the play button is pressed the motor in the 5th port will spin forward .125 turns. The motor will then hold at that position for the remainder of the code. The drive velocity will be set to 10%. The robot will then detect if an object is seen. If an object is detected the robot will move forward. Else the robot will stop moving.




**Robot as a Ruler:**
This activity is detailed in the Lesson Manual.

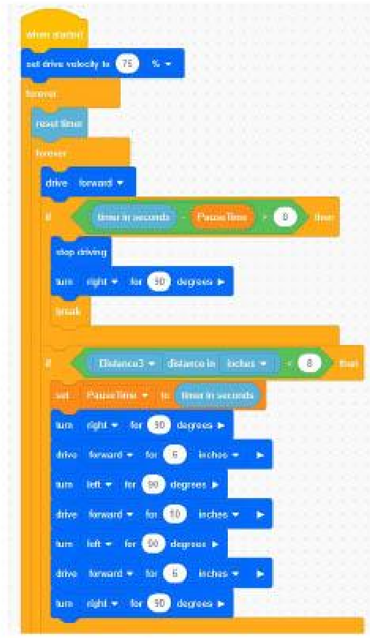
When the play button is pressed the robot will search to detect an object, if the robot does detect an object then all rows on the brain will be cleared, the robot will set the cursor to row 1 column 1 on the brain. The robot will set print precision to 0.1 on the brain. The robot will print "object found!" on the brain and set the cursor to the next row. The brain will then print "distance in mm:" on the display. The robot will print the distance detected on the display. The robot will wait 3 seconds and repeat the actions.



**Path Finding and Object Avoidance: *challenging activity* or *optional***

In this activity the robot is supposed to drive in a lawnmower path (forward and back), but there are obstacles it needs to avoid so it has to path around them. The code for this activity is somewhat inconsistent, but it would be beneficial to show students the possibilities that come from a program like this. The values can all be changed to make it work better or differently if needed.

When the play button is pressed the robot sets a time and begins to drive forward. The robot will move forward and run through a series of if/then statements to constantly check the conditions set forth in the if/then statements. It constantly checks if it has traveled far enough by using the first if statement. It also checks if there is an object in the way by using the second if statement. If there is an object in the way then the robot records that time and stores it until the object is avoided. Then the robot keeps checking if it has passed the required time. Once it passes the required time it goes through the if statement and breaks out of that forever loop and moves to the next forever loop. It does this for all the steps and keeps repeating the search pattern until it is told to stop.



28

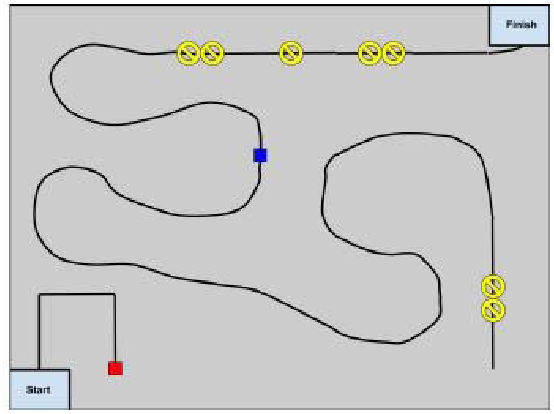
**Path following and objective avoidance (cont.)**



29

**Big Maze Activity**

The image to the right shows a possible playing field for the maze activity. The red and blue squares are decisions where the robot will have to do something. The yellow objects are pieces the robot will pathfind around and avoid. The reason "solo" motors are being used is because it makes it easier to control moving forward while also paying attention to pathing. See "How to add a device to a port in VEXcode IQ" on how to add a motor.




The code in this part of the lesson works by constantly running through a series of if/then statements. The main function that the robot should be doing is line following, which is accomplished in the first two if/then statements. The other two processes the robot is doing are object avoidance (3rd if statement) and decision making (4th and 5th if statements). The decisions the robot makes at the different colors is arbitrary and can be changed.

30

**Big Maze Activity (cont.)**

When the sensor detects an object less than six inches away, then the left and right motor will turn ,as shown in the picture.

If the sensor detects red, the left and right motors will move in the direction as shown in the picture. It will make the robot turn left, go straight for one meter and then turn left again.


31

**Big Maze Activity (cont.)**

If the sensor detects a blue object then the right motor will spin for 1025 degrees followed by the left motor spinning 1025 degrees. After, the notes displayed in the picture will be played.

## Lesson 5: Joints and Arms

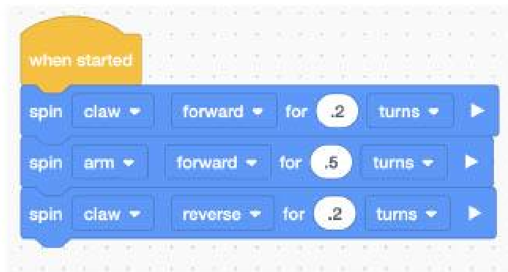
This lesson is applicable for both the VEXcode VR and the VEXcode IQ platforms.
The following lesson outlines the code and necessary steps it takes to code for arm and claw movement.
With each lesson students, and yourself, should feel welcome to play around with other values and formats to understand logic.
Ensure that arm motors are attached in the devices of VEXcode IQ platform

**Picking up an Object located in Between Claw:**

Note that the students will have to test various objects to pick up as depending on the shape and weight of the object, it could be difficult to complete some of the tasks.

When the play button is pressed:
1. The claw spins forward .2 turns
2. The arm spins forward .5 turns
3. The claw spins in reverse .2 turns.

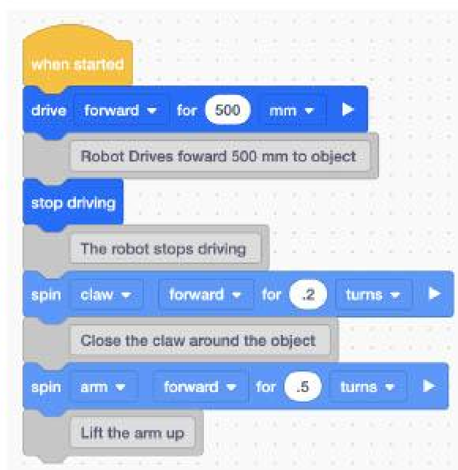
Note: The example code is using turns, but it is also possible to use degrees. If you close the claw with more than .2 turns, it will not work. You will also have to test different objects to determine what works best.




**Forward Movement to Pick up an Object:**

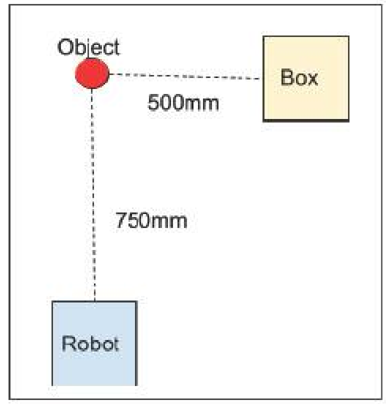
Movement forward for a defined distance parameter (500mm). The motor to the claw spins forward .2 turns to close the claw. The arm motor will then spin forward .5 turns to lift up the arm.

Students should feel welcome to see the robot move different values in distance and turns.



**Picking up an object and placing the object on a box:**

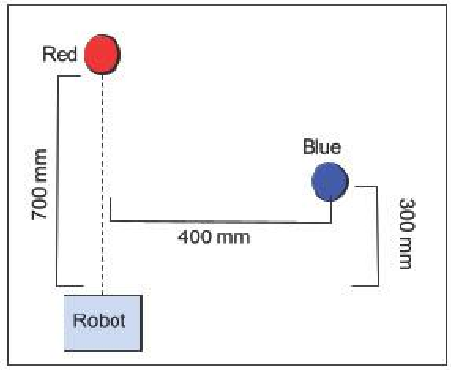
Set up activity based on the picture seen right. The values are adjustable




When the play button is pressed the robot will drive forward 750 mm. The robot will then spin the claw motor forward .2 turns and the arm motor forward .5 turns, lifting the arm. The robot will then turn right 90 degrees and move forward 500mm. Once the robot has moved forward 500 mm the arm motor will reverse .3 turns lowering the arm. Then the claw motor will reverse .2 turns opening the claw and placing the object.

The distance and direction of the box is subject to change based on the student preference, this is just one example. The lowering of the arm will depend on the height of the box.

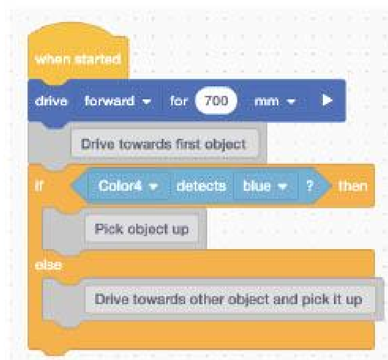
**Picking up an Object Based on Color:**
***this is a difficult task***




This is a difficult task as the color sensor on the robot is inconsistent. Students should test different objects to determine if the robot can detect that color. This can be done by designing code that will play a sound when the robot detects a specific color. The student should hold the object in front of the robot and move it back and forth in front of the color sensor until a sound is played.

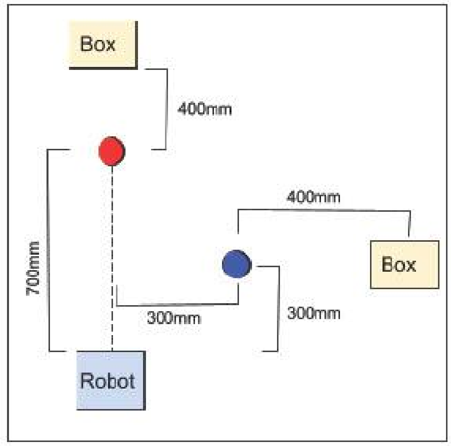
Set up activity based on the picture seen right. Users can select values and colors as they see fit. Adjust the following code according to the user's selected distance and color selection.

The code demonstrates **the logic** of detecting the blue object and picking it up. Note that the code is designed for the diagram shown on the right. The students should test their code with trial and error and use the logic provided if needed.



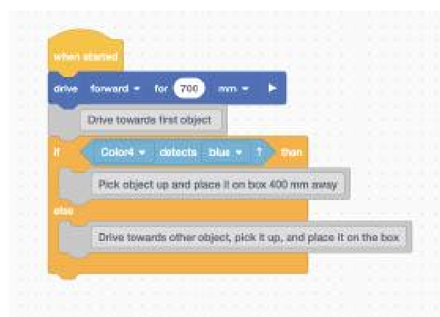

When the play button is pressed the robot will drive 700 mm forward. The robot will check if that object is blue. If the object is blue then the robot will pick the object up. Else, drive towards the other object, detect if it is blue and if so, pick it up.

**Picking up an object based on color and placing it on a box:**
***this is a difficult task***




This is a difficult task as the color sensor on the robot is inconsistent. Students should test different objects to determine if the robot can detect that color. This can be done by designing code that will play a sound when the robot detects a specific color. The student should hold the object in front of the robot and move it in front of the color sensor until a sound is played.

Set up activity based on the picture seen right. Users can select values and colors as they see fit. Adjust the following code according to the user's selected distance and color selection.




The logic for this code is explained in the example above. The only difference is that this example also includes placing the object on a box. The best way to tackle this problem is by testing the code a little at a time.

When the play button is pressed the robot will drive 700 mm forward. The robot will check if that object is blue. If the object is blue then the robot will pick the object up. Else, drive towards the other object, detect if it is blue and if so, pick it up and move the correct distance to place the object on the box. Reference "*Picking up an object and placing the object on a box*" for guidance on how to place an object on a box.

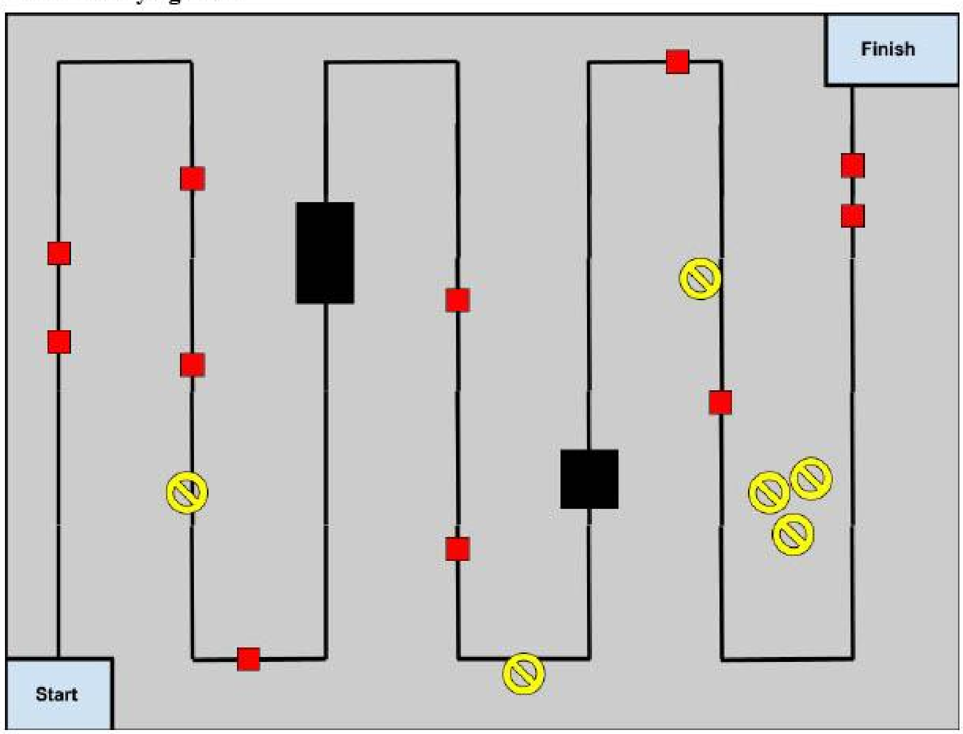
**Lesson 6 & 7: Project Introduction and Presentation**

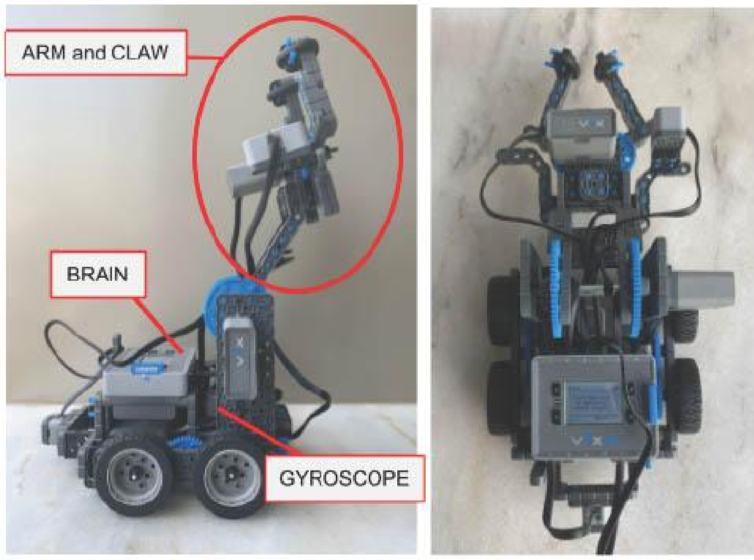
The project introduction, prompt, and presentation details are outlined in the lesson manual.

For the final project and presentation, we recommend creating a standard arena in a defined grid. Amongst the grid, it is recommended to have gathered objects of light weight and at least 3 by 3 inch dimensions with varied colors. We recommend having obstacles or walls set up amongst the area and as the border. The project goal can be altered or adjusted as needed. Below is a visual of a possible final robot, it is the basebot, equipped with a gyroscope, arms and claws, and a bumper sensor.

This is a possible playing field for the final project, where the black lines are the path the robot will travel using path finding. The red objects are trash it will pick up while traveling, and the yellow objects are objects it needs to either pick up and move or play a noise to get them to move. The black objects are rocks that cannot be moved and need to be avoided by the robot. There are a variety of ways to code the final robot that are introduced in the above lessons and should help to guide completion of the tasks

**Potential Playing Field:**






Picture of potential final robot

## Appendix K: Infographic for Student Interest

# Appendix L: Student Interest Application

**Welcome to the RobotiKids Interest Application!**
This program is a 3 day intensive robotics program, in which students will learn the basics of robotics, teamwork, and hands-on-learning.
This program is restrictive to ages 12-15, who are current middle school students.

→

Information about applicant

| | |
|---|---|
| First Name | |
| Middle Initial | |
| Last Name | |
| Email Address | |
| Phone Number | |

→

How old is the applicant?

- 12
- 13
- 14
- 15

Is the applicant available all day on April 15 through April 17?

- Yes
- No

Can the applicant commute to the Rabat-Sale Region?

- Yes
- No

Does the applicant have access to a laptop for the dates stated above?

- Yes
- No

What is the Applicant's English comprehension?

| not confident | | | | | | | | | | confident |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

Can read and write in English

Can understand spoken English

Can Respond in English

Why is the applicant interested in taking part in this program?

# Appendix M: Mentor Interest Application

Please enter your first and last name

Please enter your email

Please enter you phone number

Are you interested in become a mentor for our Robotics curriculum?

Yes

No

How experienced are you with robotics? (0= no experience, 10 = very experienced)

0 1 2 3 4 5 6 7 8 9 10

Tell us about your knowledge in Robotics (if applicable)

Are you available all day on April 15?

Yes

No

Are you available all day on April 16?

Yes

No

Are you available all day on April 17?

Yes

No

Are you able to commute to the Rabat-Sale region?

Yes

No

Do you have any questions or concerns?

## Appendix N: Student Pilot

The following outlines the steps the team would have taken if the answer to both conditional questions were yes.

*Preparing and Conduct Pilot with Middle School Students*

First, it was necessary to gather mentors for our pilot to assist in facilitating our program. Mentors would be volunteer STEM students or STEM teachers working with Association Anoual. They would be chosen according to our mentor interest form which was based on their availability, english comprehension, interest and experience in STEM. The form was designed to ensure that the mentors were well versed in robotics so they could provide proper guidance to students. After receiving the application for the mentors, we planned on picking five mentors to take part in our program. To make sure that they were prepared with the contents of the program, we planned on sending them the details of the curriculum before we hosted an explanatory zoom call with them. On the zoom call, we first would run through the program and then they would give their recommendations and suggestions to make the curriculum more coherent. They would also have time to ask clarifying questions. These steps would have ensured that the mentors were well prepared to assist in our program.

We had to market our program in order to gather students to participate in our curriculum. We accomplished this by creating an infographic to post on Association Anoual's social media. Along with the infographic, is an application form for the students to complete in order to be considered for our program. We selected 18 students to participate in the pilot program, this was based upon the 9 available VEX kits that students would pair up and use. Students were selected based on  availability, experience or knowledge of robotics and STEM, English comprehension, and location.

Students were taught the outlined curriculum as detailed in the lesson planned. The same students would return each day to complete the entirety of the program. In order to gain feedback for our curriculum, our team planned to evaluate the status and success of the curriculum through surveys and focus groups. The surveys and focus groups would gauge the engagement of the class and the mentors' abilities to convey the necessary subjects. We planned for the students to fill out two surveys in the pilot program, one at the start of the course and one at the end. This was for comparative results for each individual student. We also used our focus groups to observe the results of the piloted program first hand on a day to day basis. The weekly surveys would have provided the team information on the course's impact and outcome to make suggestions to Association Anoual on the implementation of the actual program.

Through the focus groups and surveys we planned to compile all the data in order to improve our program for Association Anoual. Similarly, the information that would have been gained during the piloting phase would have been used to identify obstacles and limitations with implementation of a robotics curriculum in Morocco, so the full scale use of the program would run as smoothly as possible.

# Appendix O: Lesson Manual Evaluation Form

The following survey is an evaluation of the Lesson Manual, which has been constructed by four students from Worcester Polytechnic Institute on behalf of Association Anoual. This survey is being used to collect data for recommendations and implementation of the RobotiKids program.

Participant Information

| | |
|---|---|
| First Name | |
| Last Name | |
| Occupation | |

This survey is focused on reviewing the Lesson Manual, which consists of our lessons and the information in them that makes up our course. We appreciate your time and you may stop at any point if you choose to do so.

What was your overall opinion on the lesson manual?

0 1 2 3 4 5 6 7 8 9 10

Would not Use

Are there any additional comments about your rating?

How understandable was the lesson manual?

0 1 2 3 4 5 6 7 8 9 10

Not Understandable at All

Are there any additional comments about your rating?

Do you feel these lessons are engaging?

0 1 2 3 4 5 6 7 8 9 10

Not at all Engaging

Are there any additional comments about your rating?

How difficult do you feel the lessons would be for students 12-15?

0 1 2 3 4 5 6 7 8 9 10

Extremely Difficult

Are there any additional comments about your rating?

Did you feel like anything was missing from the lesson manual?

Please add any other additional comments that were not covered earlier in the survey

Would you be interested in learning more about this program?

# Appendix P: Technical Manual Evaluation Form

The following survey is an evaluation of the Technical Manual which has been constructed by four students from Worcester Polytechnic Institute on behalf of Association Anoual. This survey is being used to collect data for recommendation and implementation of the RobotiKids program.

→

Participant Information

First Name

Last Name

Occupation

This survey is focused on reviewing the Technical Manual, which consists of our supplementary information used to help guide the lessons via VEX software and explain the code based activities. We appreciate your time and you may stop at any point if you choose to do so.

What was your overall opinion on the Technical Manual

| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|

Would NOT use

Are there any additional comments about your rating?

How understandable was the Technical Manual?

| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|

Not understandable at all

Are there any additional comments about your rating?

Do you feel these lessons are engaging?

0 1 2 3 4 5 6 7 8 9 10

Not Engaging at all

Are there any additional comments about your rating?

How difficult do you feel the lessons would be for students 12-15?

0 1 2 3 4 5 6 7 8 9 10

Extremely Difficult

Are there any additional comments about your rating?

Do you feel like anything was missing from the Technical Manual?

Please add any other additional comments that were not covered earlier in the survey.

Would you be interested in learning more about this program?

# Appendix Q: Interview with Super Mentor at Association Anoual

**Location:** Zoom
**Time:** April 28, 2022 17:00 GMT
**Interviewee:** Moroccan Student Mentor

**Preamble:**
We are a group of students from Worcester Polytechnic Institute in Worcester, Massachusetts in the United States of America and we are working with Souhail Stitou and Association Anoual to create a middle school robotics curriculum aimed at increasing youth access and interest in STEM fields and developing their soft skills. Currently, we are interviewing people to gain a better understanding of how to most effectively teach robotics and implement a program in Morocco. This will also help us to determine how to construct our own curriculum and offer recommendations. Your participation in this interview is completely voluntary and you may withdraw at any time. You are not required to answer any of the following questions. Please remember that your answers will remain anonymous. No names or other identifying information will appear on the questionnaires or in any of the project reports or publications.

1. **What are your overall opinions of the lesson manual and technical manual that we have developed?**
   *It is very good in detail and the length of the curriculum. If the mentor does not speak English very well, then they would need help translating the documents. The mentor told us to be aware of what schools we are teaching this curriculum to as public schools don't teach English.*

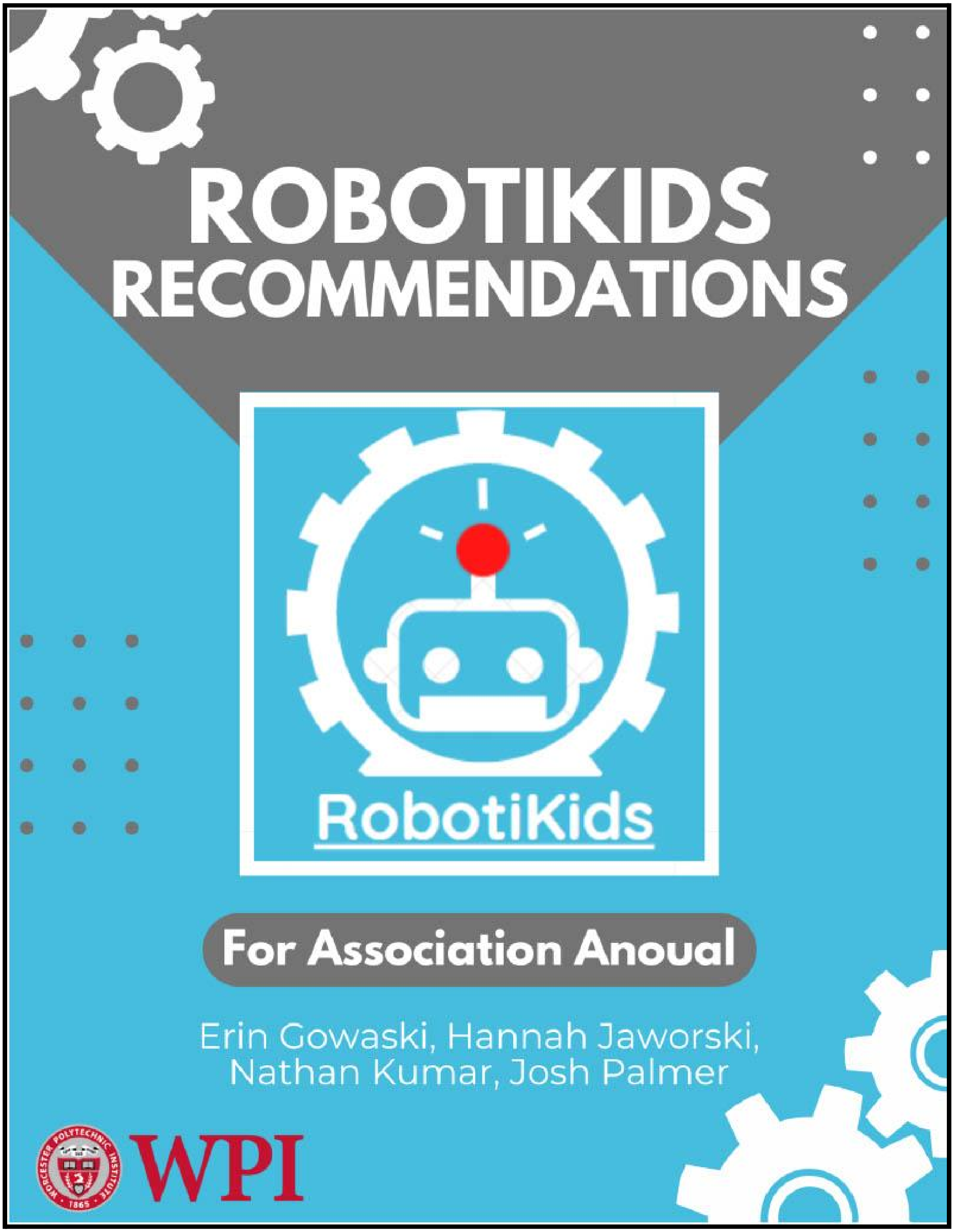
2. **Would you make any changes to either the lesson plan or technical manual?**
   *A ten minute break will not be sufficient enough for the students, this needs to be longer. Students will get bored and will not fully understand the concepts of programming making engagement a concern. Make sure to involve many interactive activities.*

3. **What specific content would be difficult for the students?**
   *Both the hardware and specific coding aspects of the robot will be difficult. The mentor was afraid that they would not understand the concept of programming loops.*

4. **What did you think of our interactive activities?**
   *Activities seem to be good in length, but the kids will get bored sooner than we think, making breaks a necessity. Be careful with programming as it will be their first time for most students.*

# Appendix R: Recommendation Document

The following is intended to be used as a supplemental, stand-alone document. The pages provided are to be used outside of this format.


ROBOTIKIDS
RECOMMENDATIONS
RobotiKids
For Association Anoual
Erin Gowaski, Hannah Jaworski,
Nathan Kumar, Josh Palmer
WPI

## ROBOTIKIDS - ROBOTICS CURRICULUM FOR MIDDLE SCHOOL STUDENTS
## PROGRAM OVERVIEW FOR ANOUAL
## 2022

**Content for Recommendations**

- Thank you and Future Aspirations
- Breakdown of the Manuals
- Mentor Training
- Final Project Suggestions
- Benchmarking Success and Future Assessment
- Expanding RobotiKids
- Leaving an Impact

### Thank you and Future Aspirations

The team wants to express how thankful we are to have been able to work on this project and for the support and encouragement of Association Anoual throughout the entire process. It has been an extremely rewarding experience that we have grown very passionate about. We hope this program will be able to reach and impact students in Morocco and ignite their interest in STEM and possibly future endeavors. We would love to see RobotiKids grow and become a program that Association Anoual can use as a foundation to implement into a full scale program or to be introduced into schools for even greater outreach. Here are our recommendations that we have organized from our construction of the program and how we believe it will best be run.

### Breakdown of the Manuals

Lesson Manual

A detailed lesson manual was developed to operate as the main component of guidance for facilitating the Robotikids program. It was organized into seven main lesson plans: an introductory lesson, four technical lessons with the topics of coding, movement and turning, sensors, arms and joints and then two lessons delegated to the project explanation and demonstration. The lessons are created in a manner that allows them to be stacked or spread that best suits the teacher's ideal lesson layout. They also are versatile and although they are created around VEX IQ kits, they can be taught with other robotics kits and deliver the same lesson and skills. The lesson manual is equipped with a timeline and outline of a recommended order of lessons, discussion and activities. Further detailed information is included that explains activities, provides discussion points, additional resources, recommendations and lesson material.

Technical Manual

Supplemental material that is directly relevant to VEX IQ robotics was compiled and explained through the technical manual. It provides an explanation on how to use the online platforms, coding examples and insight into the hardware. There are examples of the bots that can be constructed as well. This resource is intended to provide more structure and clear instruction to the facilitator with VEX robotics by providing a knowledge base. It is expected to be used in tandem with the lesson manual because the lessons align and correlate.

Examples covered in the Lesson Manual and the Technical Manual are not exhausted; there are extensive other possibilities that are available through the platform and with exploration of the robot. We recommend becoming as familiar with VEX as possible which will assist with implementing, facilitating and building RobotiKids.

**Mentor Training**

It would be highly beneficial to have at least one main facilitator of RobotiKids that is well-versed in VEX and the program. All mentors should be comfortable with pertinent STEM fields (especially coding) prior to assisting facilitating this program. We predict that it would be best if mentors could return for multiple iterations of the program, so they become more acquainted and also can help train new mentors that may not be as familiar with VEX. We have created a form to gauge a mentor's willingness to participate in the running of this program. The lesson manual and technical manual should be administered to the mentors beforehand and they should review all the material and become acquainted with the online platform, code and robotic functions.

After reviewing the material individually, a session should be held with all participating mentors to debrief any questions and also train how to work with middle school children. This bootcamp should prepare them for how to efficiently work with students and support them properly along with problem solving techniques. Given Association Anoual has conducted many youth programs, we had envisioned a bootcamp that operated similarly to one that already exists, particularly one like Digigirlz. Mentors should be there for guidance and know how to complete all of the tasks but not take over for the students when they have questions. We recommend having a ratio of one mentor per two or three students.

**Final Project Suggestions**

The final project and presentation is a critical component of RobotiKids. It is the motivation for the other lessons to lead up to a project where the students can demonstrate their knowledge and practice working on a team. Ideally, the project is worked on in a team; the team will have planned, built and executed both the code and construction of a robot to complete a task framed in the form of a real life problem. The final project should include a presentation or pitch that allows them to explain their ideas and methods that will tie in entrepreneurship and interpersonal elements.

We recommend not limiting the program to a single final project but rather have it change with each iteration. This will help to identify areas of the lessons that need improvement and also drive the program in the entrepreneurial front by addressing multiple possible real-life problems.

Example Problem:

A recommended problem can be framed as a beach clean-up and removal of trash. This includes having an arena setup with different types of trash of different color, objects to avoid and walls that obstruct. Trash should be picked up and removed accordingly. Variations are welcomed and can alter the difficulty of the project. Students should execute this by creating a robot with code and test out its functionality. It can be made into a competition with different parameters, like what robot can remove the most trash or do it the quickest. The preparation process should include mapping a plan with the engineering design process to address the problem. The presentation portion should include preparing a presentation to showcase their process and decisions and pitch what their robot is capable of.

Timing:

After conducting our field evaluation, we concluded that a full scale completion of the robot and code would require multiple days of work. The construction of the code and robot with a series of tests to ensure it works properly would not be feasible in the allotted time of the original lesson plan. This, in addition to preparing their pitch, would be a time consuming process and require extensive guidance from mentors. If a full scale final project with a fully operational robot and code, was to be implemented, two to three days of build time will be necessary. We recommend striving for this in future iterations of RobotiKids as it would leave a profound impact on the youth. This can be done by adding work days in between lessons 6 and 7.

If more work days are not feasible at the time, one solution could be to scale back the presented problem. For example, using the color sensor is one of the most time-consuming and difficult tasks so this element could be removed and replaced with line-following instead. Here, students would code their robot to follow a line and identify trash that was placed on it, this would eliminate the need of a search pattern and other more difficult coding. Another option that would work with the original seven-lesson plan is to shift to take on a more entrepreneurial standpoint. The project could be presented as if it were to be executed, but instead, have the students focus on the process they would go through if they were to create a functional robot. This includes mapping out their engineering design process, highlighting what key features from the lessons that they would include, how they would do this, why, and an explanation of why their robot is the best. It should be framed as a startup that is pitching to their investor. This version of the final project would be able to run in the time frame of the original lesson plan. Given Association Anoual's passion for entrepreneurship, this was recommended to implement tactics and strategies from other programs to instill the importance of entrepreneurship into their lives and continue to grow in these areas.

Essential elements need to be considered and outlined before executing the entire lesson plan including having a predetermined set of standards. These can be changed iteration to iteration, but a well defined project will make a difference in the outcome. Ensure to specify exactly how to handle practice times, where field elements will be placed, allowed human interaction zones, when the official runs will begin and how many trials are allowed. These are not exhaustive limitations and standards, but rather guiding parameters to consider.

Regardless of the chosen final project, it is incredibly important that the students feel successful in their final project demo. Given that they have put in an abundant amount of time and faced challenges, this should be a rewarding experience that encourages them to pursue STEM further.

**Benchmarking Success and Future Assessment**

To continue to improve the program and work towards expanding, it is important to benchmark success and continue to note where changes should be implemented by taking record of what works and doesn't work. We recommend having both students and mentors fill out a survey before and after the program. This survey should include their perception of robotics and STEM fields but also ask for opinions on the program. In addition to taking record of these feedback surveys, we recommend holding both mentee and mentor focus groups and recording opinions and feedback through these semi-structured meetings. These should be hosted to see from another perspective what went well, what didn't and areas of improvement. In the beginning stages of the program, it would be beneficial to record observations in real time and have mentors do the same so successes and struggles can be noted and adjusted accordingly. The team predicts that having a structured written format in addition to the notes written from the surveys, focus groups and observations would be helpful. A rubric would offer a standard to guide with and can be used to assess student success. A similar rubric can also be formatted to gather data on students' feelings towards the program to supplement the pre and post program survey.

Rubric Template :

| Category | 10 | 5 | 2 | Score |
|---|---|---|---|---|
| Scientific and Problem Solving Skills | Understood and exercised multiple ways to address a problem | Exercised some ways to address a problem | Did not understand or grasp different ways to tackle a problem | |
| Interpersonal, communication and teamwork skills | Worked with multiple people, communicated efficiently, understood and worked with different perspectives | Somewhat worked well in teams and attempted to communicate well with different perspectives | Did not work with other people or communicate with others for their perspectives | |
| Engagement and Interest | Was interested and engaged in the curriculum at all times | Somewhat was interested in the lesson and activities | Was not engaged with what was being taught or the activities | |
| Technical Understanding | Understood and could apply the lessons and material | Understood some lessons and material | Did not understand any lessons or material | |
| Engineering Design Process and Entrepreneurial Use | Used the design process when faced with a problem and to help create their pitch | Attempted to use the engineering design process to guide their plan and pitch | Disregarded the engineering design process and made no plan for their pitch | |
| Presentation Skills | Effectively communicated their results and logic | Attempted to somewhat communicate their results and logic | Did not communicate or present their results and logic | |
| Final Project Execution | Worked towards a functioning robot that addressed the task, designed and presented appropriately | Partly completed a final robot and part of a presentation with their design and pitch | Made little to no progress on their final project and did not execute their pitch or logic | |

**Expanding RobotiKids**

The seven lesson plan format that was constructed and tested by the team of developers was organized with the intention that it would be versatile to the teacher and easily implemented into a variety of forms. We envisioned that this would help Association Anoual implement RobotiKids in a form that was most conducive to their desired structure. Since it is in early stages and developed into this format, we recommend deciding and creating a standard for RobotiKids, whether it be an after school program, a summer camp, an implementation of lessons delivered to schools or extended into a long term program. This will help to solidify the program and ensure it has a solid foundation and vision going forward. Additionally, we highly recommend the use of VEX IQ kits for the most seamless operation of this program. If it were to expand, it would be necessary that participating students have access to kits so investing in more kits or creating a schedule that allows students the most access to the kits is essential. We hope RobotiKids will become an engaging program that is impactful to the youth and naturally draws the attention of Morocco. In order to assist this, we believe promotion on social media and advertising would be greatly beneficial to the program's growth in the future.

**Leaving an Impact**

Our hope for the project is that students will not be discouraged by this program but rather use it as a testament for what they are able to accomplish. We urge that with the conclusion of the program students will know that they can continue to learn and be curious about STEM fields. We recommend providing ways to continue to get involved in STEM education and robotics through other programs and recommending robotic competitions. In addition, students should be encouraged to continue to code on VEX VR and explore their passions. Given Association Anoual's passion for entrepreneurship, we recommend implementing tactics and strategies that are used in other programs to instill the importance of entrepreneurship into their lives and give them outlets to continue to grow in these areas.

# Appendix S: Rubric

| Category | 10 | 5 | 2 | Score |
|---|---|---|---|---|
| Scientific and Problem Solving Skills | Understood and exercised multiple ways to address a problem | Exercised some ways to address a problem | Did not understand or grasp different ways to tackle a problem | |
| Interpersonal, communication and teamwork skills | Worked with multiple people, communicated efficiently, understood and worked with different perspectives | Somewhat worked well in teams and attempted to communicate well with different perspectives | Did not work with other people or communicate with others for their perspectives | |
| Engagement and Interest | Was interested and engaged in the curriculum at all times | Somewhat was interested in the lesson and activities | Was not engaged with what was being taught or the activities | |
| Technical Understanding | Understood and could apply the lessons and material | Understood some lessons and material | Did not understand any lessons or material | |
| Engineering Design Process and Entrepreneurial Use | Used the design process when faced with a problem and to help create their pitch | Attempted to use the engineering design process to guide their plan and pitch | Disregarded the engineering design process and made no plan for their pitch | |
| Presentation Skills | Effectively communicated their results and logic | Attempted to somewhat communicate their results and logic | Did not communicate or present their results and logic | |
| Final Project Execution | Worked towards a functioning robot that addressed the task, designed and presented appropriately | Partly completed a final robot and part of a presentation with their design and pitch | Made little to no progress on their final project and did not execute their pitch or logic | |

# Appendix T: IRB Approval

WORCESTER POLYTECHNIC INSTITUTE

100 INSTITUTE ROAD, WORCESTER MA 01609 USA

## Institutional Review Board

FWA #00030698 - HHS #00007374

**Notification of IRB Approval**

| | |
|---|---|
| **Date :** | 04-Apr-2022 |
| **PI:** | Kenneth A Stafford |
| **Protocol Number:** | IRB-22-0516 |
| **Protocol Title:** | A Robotics Curriculum for Increasing Interest in STEM in Moroccan Youth |
| **Approved Study Personnel:** | Davis, John-Michael~Stafford, Kenneth A~Oates, Karen K~Gowaski, Erin~Jaworski, Hannah J~Palmer, Joshua~Kumar, Nathan M~ |
| **Start Date:** | 04-Apr-2022 |
| **Expiration Date:** | 03-Apr-2023 |
| **Review Type:** | |
| **Review Method:** | Expedited Review |
| **Risk Level:** | Minimal Risk |
| **Sponsor*:** | |

The WPI Institutional Review Board (IRB) approves the above-referenced research activity, having conducted a review according to the Code of Federal Regulations (45 CFR 46).

This approval is valid through 03-Apr-2023 unless terminated sooner (in writing) by yourself or the WPI IRB. Research activities involving human subjects may not continue past the expiration date listed above, unless you have applied for and received a renewal from this IRB.

We remind you to only use the stamped, approved consent form, and to give a copy of the signed consent form to each of your subjects. You are also required to store the signed consent forms in a secure location and retain them for a period of at least three years following the conclusion of your study. You are encouraged to use the InfoEd system for the storage of your consent forms.

Amendments or changes to the research must be submitted to the WPI IRB for review and approval before such changes are put into practice.

Investigators must immediately report to the IRB any adverse events or unanticipated problems involving risk to human participants.

Please contact the IRB at irb@wpi.edu if you have any questions.

*if blank, the IRB has not reviewed any funding proposal for this protocol