EDUCATIONAL ROBOTICS FOR PHYSICALLY ACTIVE YOUTH (P.A.Y.)

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Educational Robotics for Physically Active Youth (P.A.Y.)

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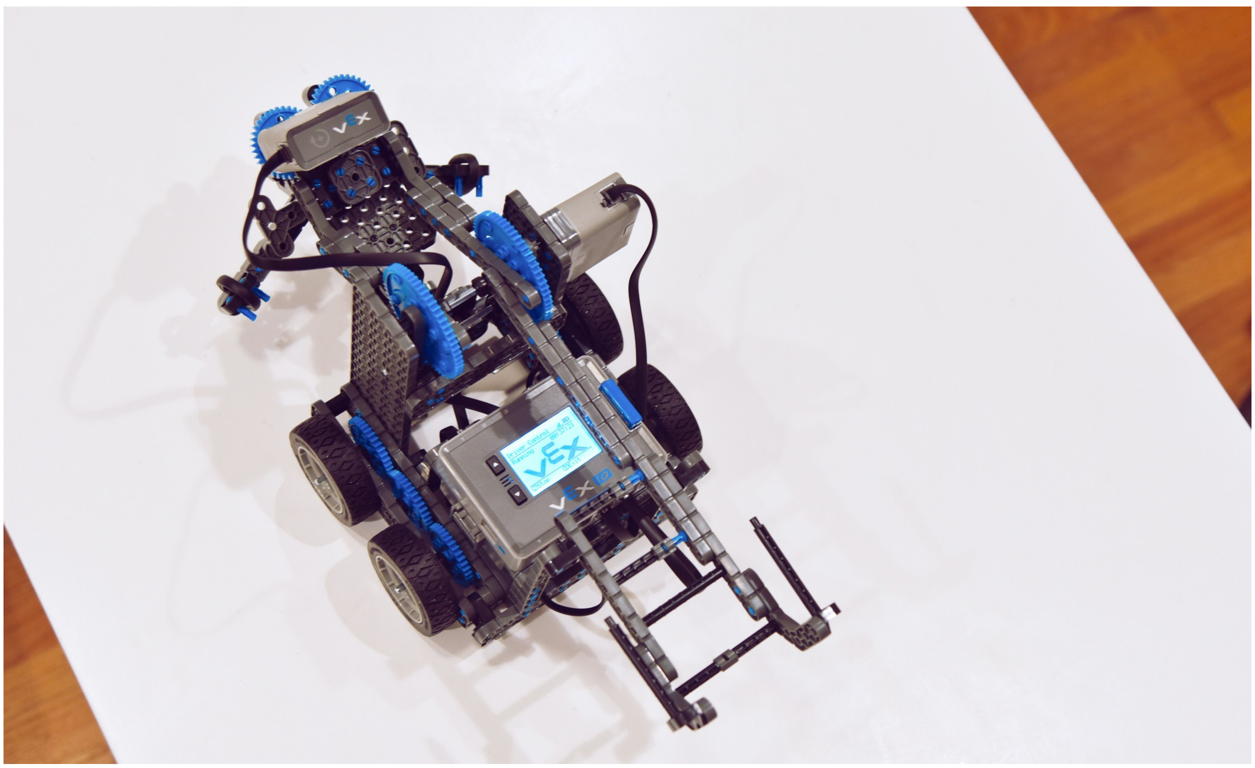
Abstract

Physically Active Youth (P.A.Y.), in Katutura, Namibia, aspires to improve education in Namibia through the inclusion of project-based learning and STEM concepts. The goal of this project was to develop a hands-on robotics curriculum to inspire STEM along with a supplemental toolkit for P.A.Y. staff to support classroom instruction. The first phase of the project included fundraising and applying for grants to satisfy the costs of 12 VEX IQ Robotics Kits for P.A.Y.. We then developed 27 age appropriate and engaging robotics lessons for students ages 6-18 with extensive recommendations for facilitators. We coordinated feedback from educators to adapt the lessons and directed student trials to gauge levels of difficulty and engagement. The impact of this project reaches far beyond the students at P.A.Y., as this curriculum can be implemented in communities by adjusting pacing and relating the content to relevant real-world applications as necessary.



Acknowledgements

There is an assortment of individuals without whom, this project would not have been possible. We would like to acknowledge their contributions to the success of this endeavor.

To our sponsor, Physically Active Youth, for adapting and remaining committed to our project amidst the varying circumstances. Although we were unable to travel to deliver this curriculum in person, we are so grateful for the opportunity to create this impactful collection of resources for their community.

To our advisors, Professors Joseph Doiron and Ken Stafford, for supporting our team through 14 weeks of planning, modifying and executing this project. Their continuous feedback, input, and guidance helped us to develop a resource far more impactful than we could have initially imagined. A special thank you to Professor Stafford, who provided extensive educator feedback on all 27 of the lessons that we created. This was no small task, and his expertise and unmatched experience in the field was incredibly valuable.

To the WPI Tinkerbox program, for awarding the grant that helped to fund the robotics kits for P.A.Y. and helping us to recognize the greater impact and potential for this project. We also greatly appreciate the opportunity to present at the Tech Advisors Network, to gain valuable insight from mentors, and connect with generous contributors.

To the Robotics Education Competition Foundation, specifically Dan Mantz, the CEO and chairman of the board, for coordinating the significant donation that helped us purchase the 12 VEX IQ Kits for P.A.Y., along with valuable resources for the development of our curriculum.

To those who donated to our GoFundMe, for providing supplemental funds to support our project, we are remarkably grateful for the contributions that will allow us to eventually transport the robotics kits to P.A.Y. to complement our curriculum.

To the educators and students, for providing feedback on our lessons and completing trials of our online learning platform, we greatly valued their perspective and evaluations throughout this process. The students at P.A.Y. will benefit immensely from these lessons, and their thorough trials and comments tremendously improved our comprehensive curriculum.

Executive Summary

Introduction
Apartheid created several long-lasting consequences for Namibia, including disadvantages for black native residents and the creation of informal settlements on the outskirts of cities. Katutura is the largest of these informal settlements in Windhoek and faces many hardships, one of the biggest being education. The education system needs to be revolutionized through the introduction of new, innovative, and co-creative curriculum. In the current global society, the workforce demands employees with a strong technical foundation and critical thinking skills. As STEM education increases in importance, efforts tend to focus on science and math, but the curriculum lacks technology and engineering components.

With rapid globalization, developing countries seek to decrease the gap in their technological knowledge, starting in the classrooms. Physically Active Youth (P.A.Y.) is a program attempting to close this gap. P.A.Y. is an afterschool program for children in Katutura who come from disadvantaged backgrounds. P.A.Y. utilizes a three-pillar system of: sport, educational success, and life-skills. In order to improve its students' technical skills and computational thinking, P.A.Y. requested an educational robotics curriculum. Educational robotics provides the opportunity for students to gain exposure to project-based technology and allow them to develop the underlying multidisciplinary skills associated with educational robotics.

Goals and Objectives
The purpose of this project was to introduce the learners of P.A.Y. to educational robotics and provide P.A.Y. educators with the resources to continue to expand the program. The curriculum was created for students ages 6-18 and was intended to provide resources to last students several years. The objectives were the following:

1. Develop a hands-on robotics curriculum that inspires STEM through an online learning platform.
2. Create a comprehensive toolkit for P.A.Y. staff to support the delivery of the provided curriculum.

Methods
The objectives were addressed in the methodology through three parts: equip, create, and review and refine.

Equip
The goal of the equip phase was to plan for all materials and resources needed to execute this project. We researched the different types of robotics kits and determined which kit was appropriate for use at P.A.Y. based on price, difficulty level, durability, and ease of use. We explored fundraising options through grants from WPI, outside sponsorship from companies, and methods of raising money ourselves. In order to determine the best method of transporting the kits to Namibia, we explored shipping and bringing the kits as personal cargo. Lastly, we

researched and experimented with different options for online platforms. We considered various functionalities as well as price, longevity, and user-friendliness.

Create

The create section outlined the steps necessary to develop the curriculum and provide supplemental resources for facilitators. In an effort to most effectively engage students and ensure understanding of the material presented, each lesson was developed following a standard active learning model: identify main idea, lesson development, activate prior knowledge, introduce new material, and guide understanding with questions. An outline for the material was created using resources from VEX IQ, the WPI Robotics Engineering department, and WPI summer programs. The facilitator manual was created by compiling recommendations for delivery, additional guiding questions, materials needed, and predicted duration.

Review and Refine

The previously created lessons were adapted after receiving feedback from students and educators. After each section of the curriculum was developed, lesson feedback was gathered by five educators. The educators were asked to provide suggestions for each lesson as well as comment on the layout, age appropriateness, and potential engagement of the curriculum as a whole. Next, we gathered data in the form of feedback from students of varying ages and robotics experience levels. Participants were asked to complete 2-3 lessons in their appropriate age group and difficulty level. After they finished their selected lessons, they were asked to fill out a feedback survey on their experience. With the information gathered from students and educators, we adjusted the lessons accordingly.

Findings

In order to achieve our objectives, we followed our methodology to equip ourselves for the project, create robotics education material through an online platform, and review and refine our lessons using feedback from multiple sources.

Equip Outcomes

When researching robotics kits, we focused on two different types: Lego Mindstorms and VEX IQ. After comparing these kits with regard to their price, difficulty level, durability, and ease of use, we decided that VEX IQ kits would be the best option for use at P.A.Y.. After the decision was made concerning which kits to use, fundraising began to cover the costs. We applied to the WPI Tinkerbox program and received a grant for $2500. Additionally, we created a GoFundMe page for supplementary donations and raised over $1,000. We also contacted the Robotics Education and Competition Foundation (RECF) regarding possible sponsorship or donations and were given a significant discount on the VEX IQ classroom bundle. In order to decide the best method of transporting the kits to Namibia, we researched all of the challenges associated with shipping the kits to Namibia or bringing them as personal cargo. We determined that the decision regarding transportation should be made at a later date when there are less variables in travel conditions. After researching and experimenting with several free website-builders, we decided Wix was best suited for our needs as it provided all of the capabilities we required.

Create Results

With the intention of building straightforward content for the curriculum, we utilized a lesson creation approach to maintain consistency in the structure of the lessons. The structure is as follows:

a. Beginner (6-10 years old)
    i. Introduction
    ii. Level 1
    iii. Level 2
b. Intermediate (11-14 years old)
    i. Introduction
    ii. Level 1
    iii. Level 2
c. Advanced (15-18 years old)
    i. Introduction
    ii. Level 1
    iii. Level 2

In line with proven effective teaching pedagogy, each lesson incorporates a main objective, presentation of new material, interactive exercises, review of prior knowledge, and guiding questions. Each topic was adjusted in relation to the age group it would be targeting, which dictated the mode of delivering the content. After creating all of the lessons, we formatted them onto the website in a compelling and age appropriate manner for each level. Pages containing videos, more color, and creative characters were presented in the beginner lessons, while the advanced lessons include more text, have less color, and contain more complex language. Following the addition of the curriculum onto the website, a facilitator manual was created. This manual is intended to assist anyone who wishes to use our platform, whether in the classroom or at home. The manual includes general recommendations about how to use our website, along with specific recommendations pertaining to each lesson. This manual should allow anyone, with or without prior robotics experience, to engage students in our educational robotics curriculum.

Review and Refine

The curriculum was adapted after receiving feedback from students and teachers, to provide a comprehensive collection of lessons.

Educator Feedback Data

We received feedback from a wide variety of educators so that we could obtain differing perspectives. This ensured that the curriculum was suitable for all educators to teach regardless of their backgrounds and expertise. After receiving educator feedback, we modified the lessons in accordance with the major themes that were present in the comments. After carefully reviewing all of the feedback, we identified the overarching themes as: layout, age appropriateness, content, and engagement. By implementing the suggestions and feedback we received from educators, we were able to improve our lessons and make certain that they were ready for students. At the conclusion of our modifications, we sent the curriculum back to the educators to see their implemented feedback and to give them an opportunity to see the final product.

Student Trials Data

We conducted student trials in the beginner and intermediate sections. Due to time constraints, we tested the advanced curriculum ourselves to make sure it was comprehensive. The students were asked to submit a background survey prior to beginning the trial with their age and prior experience with robotics. Based on their responses in the background survey, the students were assigned a recommended starting level in the curriculum. Next, students completed 2-3 lessons in their recommended section and submitted feedback surveys. We used this feedback to assess age appropriateness, student engagement, and difficulty of the lessons. We took into consideration the age and prior knowledge each student had when reviewing responses. Most of the feedback received was positive and the quantitative answers fell within the ranges in which we hoped.

Conclusion

Deliverables

With the purpose of producing a practical and manageable curriculum for our sponsor, P.A.Y., we developed the online learning platform and a facilitator manual.

Online Learning Platform

The online learning platform was developed as a central hub for lessons and resources. Lessons were divided into three separate groups with suggested age groups: beginner for ages 6-10, intermediate for ages 11-14, and advanced for ages 15-18. Each age group encompassed two levels with varying prior knowledge recommendations. There were four lessons in each level, including topics in programming, hardware, building and testing.

Facilitator Manual

Supplemental materials were compiled in a facilitator manual that can be downloaded from the website to complement the collection of prepared lessons. The manual provides additional questions, lists of necessary materials, recommendations for delivery, vocabulary, and predicted duration for each lesson. This resource strived to provide clear instructions such that individuals with STEM or non-STEM backgrounds could facilitate the lessons with ease. Various student and educator resources were compiled to offer support material and a knowledge base for inexperienced facilitators of the lessons.

Recommendations

After completing the project, recommendations were developed addressing feedback that we were unable to incorporate into the final product, further development of the platform that we did not have the time for, or anything else that we felt could be added to improve this curriculum in the future.

For P.A.Y.

Before beginning the curriculum, the students should find out which level they should start out on. Each level has a recommended age range and recommended prior experience. If the level that the student was placed in seems too challenging or too easy, simply direct the student to the previous or next level to find a better fit.

The resources page on the website includes access to the facilitator manual and VEX IQ info. The facilitator manual has various recommendations and the VEX IQ Info page contains instructions regarding the robotics kits. Both of these resources should be reviewed by the instructor in advance so that they can utilize them when teaching robotics in the classroom.

In educational robotics, students work in small teams, typically ranging from 2-4 students, to encourage teamwork, communication, and problem-solving skills. Therefore, the students at P.A.Y. should work either in pairs or groups of three when working through this curriculum.

For Continuation and Improvement

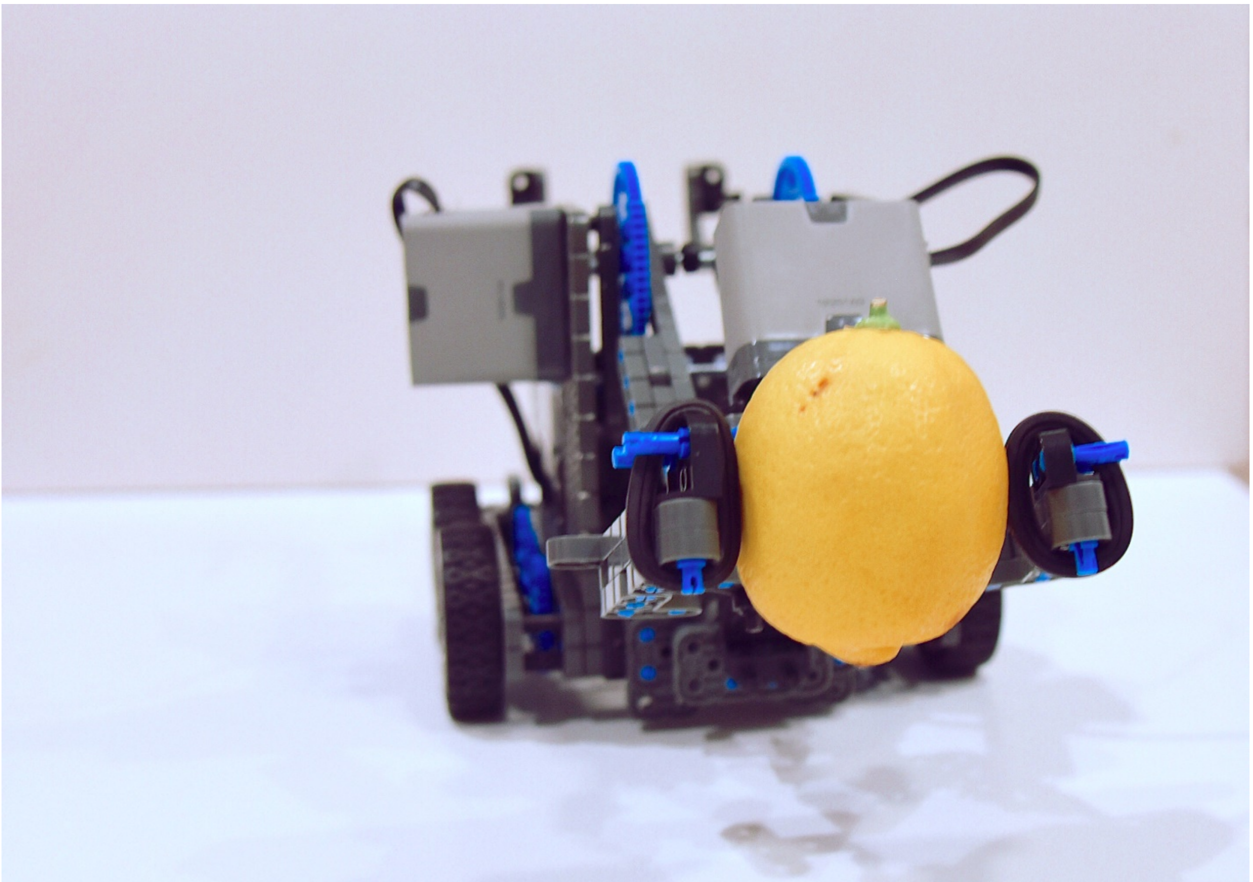
We recommend creating videos to replace any on the website that were found on the internet, to avoid any problems if the original creator removed the video from Youtube. Additionally, some new videos could be made to outline steps, activities, etc. that we were only able to present through text. Aside from video creation, we recommend that a group continuing this project should make additional levels and go more in-depth with the information to expand the amount of material being presented.

For Application at Different Global Projects Sites

We recommend that future teams work on expanding the curriculum both in the number of lessons and focusing on more in-depth material. Project teams should use our curriculum as a resource and modify our lessons to best fit the culture and learning style of a new location.

For Educators and Programs Similar to P.A.Y.

We created a facilitator manual with the purpose of guiding educators through our lessons whether they are experienced teachers or not. For other organizations using our curriculum, we recommended that they follow the facilitator guide, but also that they adjust the lessons where they can to best fit their learners.



Authorship

Mielynn Charter: Edited for content, structure, and grammar. Authored Background: History of Katutura, Background: Current Namibian Education, Background: Modes of Education, Methodology: Student Trials, Methodology: Improvements, Findings: Student Trials Data, Findings: Improvement, Conclusion: Recommendations-Other IQPs; Other Organizations, Conclusion: Reflections

Jenna Hirshfeld: Edited for content, structure, and grammar. Authored Background: Physically Active Youth; Background: Teaching Best Practices; Background: Online Learning: Challenges; Methodology: Equip; Methodology: Educator Feedback; Findings: Equip Outcomes; Educator Feedback Data; Conclusion: Summary of Findings

Anne Hughes: Edited for content, structure, and grammar. Authored Background: Project Based Learning, Methodology: Create, Methodology: Lesson Creation Approach, Methodology: Facilitator Manual, Findings: Lesson Creation Approach, Findings: Online Learning Platform, Findings: Facilitator Manual, Conclusion: Deliverables

Chloe Melville: Edited for content, structure, and grammar. Authored Background: Educational Robotics; Methodology: Development of Online Learning Platform; Findings: Development of Online Learning Platform; Conclusion: Recommendations, For P.A.Y., For Continuation and Improvement

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INTRODUCTION

1. Introduction

Namibia faced a long period of rule under South Africa, and for 75 years, was forced to live under Apartheid. Although Namibia gained their independence as a country 30 years ago, the long-lasting effects of South African rule are still seen today. Apartheid introduced laws of racial segregation and even moved black native residents to informal settlements on the outskirts of what is now known as the capital city of Windhoek. Katutura is the largest of these informal settlements and is home to over half of Windhoek's population. As an informal settlement, Katutura faces many hardships such as overpopulation and severe rural poverty. Additionally, the education system was not given the proper support and resources needed to flourish, and despite efforts of improvement since Independence, Katutura still sustains many challenges that prohibit the education system from fully succeeding.

Education in Africa needs to be revolutionized through the introduction of a new, innovative, and co-creative curriculum. The current education model in Namibia lacks project-based learning and the incorporation of hands-on creative thinking. The system is outdated and does not focus adequately on the skills developed by the learner, and instead implements direct content delivery. In the current global society, the workforce demands employees with a strong technical foundation and critical thinking skills, all components that could be enhanced by inventive, solution-oriented projects. As STEM education increases in importance, efforts tend to focus on science and math, but the curriculum lacks technology and engineering components.

With rapid globalization, developing countries seek to decrease the gap in their technological knowledge, starting in the classrooms. Physically Active Youth (P.A.Y.) is a program attempting to close this gap. P.A.Y. requires development of a curriculum that integrates the technical concepts of computational thinking and educational robotics to prepare learners to be effective citizens of our current global society. Educational robotics is a useful learning approach but can be difficult to implement because it demands technical knowledge from teachers in delivering the course content. The hands-on projects can be challenging to manage in overcrowded classrooms with minimal resources. However, they provide the opportunity for students to gain exposure to project-based technology and allow them to develop the underlying multidisciplinary skills associated with educational robotics.

The purpose of this project was to introduce the learners of P.A.Y. to educational robotics and provide P.A.Y. educators with the necessary resources to continue to expand the program. We have created an online learning platform, housing the curriculum and resources, to accomplish this goal. Extensive research was conducted on educational robotics and best teaching practices in order to develop the lessons listed on the website. We designed lessons for three age groups: 6-10, 11-14, and 15-18. We developed curriculum for each age group, sent it to be reviewed by experienced teachers, then made adjustments accordingly. Following these adjustments, the curriculum was sent to be trialed by students, and then final modifications were applied. The final step of the project was to evaluate the curriculum created for P.A.Y.. We reflected on the project and composed recommendations for P.A.Y., organizations similar to

P.A.Y., the potential continuation of the project, and for future WPI IQP groups completing a project focused in robotics education.

CHAPTER 2

BACKGROUND

2. Background

2.1 History of Katutura

Namibia faced a long period of colonization by other countries. Natives, mainly Nama and Herero tribes, were extended a peace treaty of protectorate status from Germany. Hendrik Witbooi, who was the leader of the Nama tribe, refused to sign the treaty. This refusal led Germany to begin a series of attacks on the native tribes in 1893. The fighting lasted a year, and in 1894, Witbooi finally recognized the treaty and the region was declared a protectorate of Germany (German Protective Troops).

The years to follow held many misfortunes for the natives in the area. Black natives were uprooted from their land and underwent repeated attacks by German soldiers. After World War I, Germany lost their hold and in 1915 the League of Nations gave the land to South Africa. Under South African control, the land was renamed South West Africa and Apartheid was introduced to the territory (South African History Online (SAHO), 2016). The policy of Apartheid set in place laws of segregation that had previously been introduced to South Africa. These laws forced people to use different facilities, live in different areas, and limit interaction between people based on race. In addition to these strict laws, the Land Act, which was introduced to South Africa in 1913, forced people of color to move into a reserve area known as Katutura, which translates to “The place where there is no settling down” (The Old Location, 2015). Even in this location, blacks were unable to own land and instead were required to rent it. As a result, members of the area lived in improper and impoverished settlements that still resemble the living situation of those in Katutura today.

2.2 Education in Namibia

Due to segregation laws, schools during apartheid saw unequal levels of education. The schools in black communities received poor funding, were understaffed, and had low enrollment levels; however, schools in white communities received sufficient funding, allowing free schooling for white children and gradual improvement of the classroom experience. The education system in Namibia has faced many challenges but has taken great strides to improve over the past 30 years. In 1990, when Namibia gained its independence, education was declared free for the primary level. In the decade to follow, enrollment of students at the primary level saw an increase from 60 to 95%, along with a 30% increase in teacher occupations (Isaacs et al., 2016). Despite the major step forward for students in Katutura, the education system still continued to face challenges in the quality of education, number of teachers, and enrollment into secondary and tertiary schools. In 2001, an additional education act was put into place that expanded the range of free education to include secondary levels. This act allowed children in Namibia to receive a free education through 12th grade.

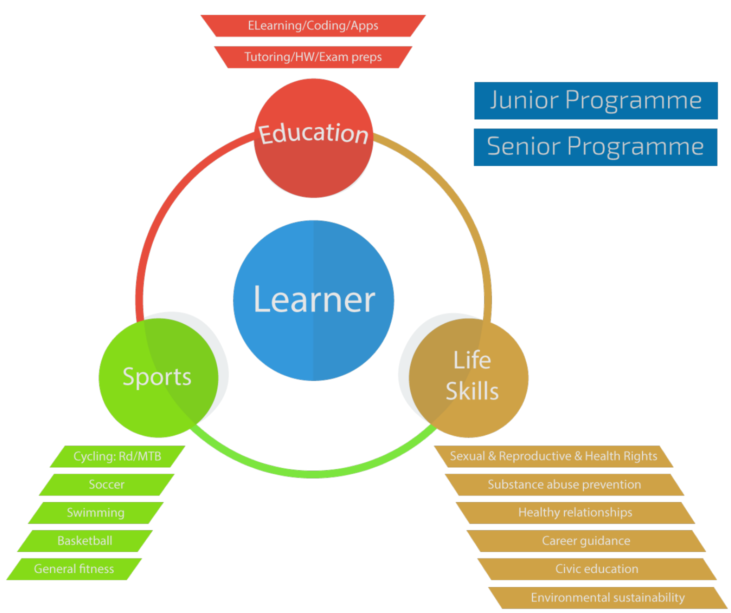
The expansion of the compulsory education range in Namibia has given students from disadvantaged backgrounds the opportunity to receive an inclusive education. In recent years, Namibia has been able to focus efforts on improving its education by better preparing teachers for work in the classroom and shifting focus towards STEM education and project-based learning. Organizations like Physically Active Youth (P.A.Y.) have set out to improve the skills and education of students from underprivileged communities, striving to close the gap in education for students in Namibia.

2.3 Physically Active Youth

Physically Active Youth (P.A.Y.) is a free, after-school program for children in Katutura who come from disadvantaged backgrounds. It was founded in 2003 as a pilot program at the Multipurpose Youth Resource Centre in Katutura, Windhoek, with a focus on evaluating the impact of sport on educational success. Since then it has been expanded to include academics and life-skills and has become an extremely popular program in Katutura (*Physically Active Youth (P.A.Y.)*, n.d.). P.A.Y. utilizes a community-based strategy to create a healthy, educational environment for children based on their three pillars: quality education, sport, and life skills. Every year, 120 participants between the ages 6-18 are registered on a first-come, first-served basis. These participants arrive at P.A.Y. every day after school, where they first have a meal, then receive homework help and tutoring in a variety of subjects, followed by an hour of sport. Once a week, there is a life-skills program including topics such as substance abuse prevention, sexual and reproductive health, healthy relationships, and career guidance (P.A.Y. (a)).

Figure 1

The three-pillar model of P.A.Y. (P.A.Y. (a))



The P.A.Y. staff is composed of both international volunteers and full-time staff members, all with varying levels of expertise. In the past 13 years, there have been over 500 volunteers from both Namibia and various international countries. Some stay for a matter of weeks, while others are long-term volunteers. Many staff members are graduates of P.A.Y. themselves and are examples of the program's continued success. These volunteers range in expertise from cycling to coding, and assist with varying parts of either the academic or athletic programs at P.A.Y.. The permanent staff members also assist with both athletic and academic components, while coordinating the various programs that take place at P.A.Y. (P.A.Y., (b)).

P.A.Y. utilizes a combination of homework help and tutoring sessions to focus on children's academics. The homework help ensures that students are successful in their regular schooling, while the tutoring expands their academic boundaries and gives them exposure to new and exciting material. Typical subjects that are covered include science, math, and English language skills. Additionally, the students have had mild exposure to robotics concepts through the implementation of a coding academy at P.A.Y., along with the opportunity for a select number of students to attend the Robot School in Namibia, an extra-curricular program for students in Windhoek.

2.4 Teaching Best-Practices

Extensive research exists on pedagogy pertaining to early childhood education through high school education. One of the major concepts in this pedagogy is the idea of a learner-centered curriculum in contrast to a teacher-centered curriculum. Learner-centered focuses on exploration of the student and developing critical-thinking skills, while teacher-centered involves a more direct approach of explicitly sharing information, lacking the inquiry component. Learner-centered education is best for developing independently-thinking students, which is a major goal of P.A.Y.. Focusing on the learner and allowing him or her to lead the progress of the lesson drives the participant to "pay attention and notice something new more often" (Yamagata, 2018, p.87). This approach requires problem solving from learners and ultimately creates more critically-thinking, independent students (Yamagata, 2018).

In conjunction with a learner-centered approach, active learning is a concept in which the students play an active role in problem solving. Active learning is crucial for engaging learners and maximizing outcomes from lessons. Lessons "will be easier understood and be remembered longer by students when students are actively involved in learning mentally, physically, and socially" (Setiawan et al., 2019, p.178). An Active Learning Model leads to a higher level of concept mastery and an overall more productive learning experience for the student, in addition to developing non-tangible skills such as problem-solving, critical thinking, and creativity (Setiawan et al., 2019).

Constructivism is an important concept in building lasting and meaningful knowledge in students. The theory of constructivism asserts that "learning involves constructing, creating, inventing, and developing one's own knowledge and meaning" (Liu & Chen, 2010, p.65). In order for the student to successfully develop their own knowledge, the teacher's role is to provide the necessary information and create meaningful experiences for the learner. Learning in the constructivist classroom involves a cycle of questioning and interpreting information, applying it to new concepts, and combining it with past experiences. This model is focused on the learner and emphasizes the critical-thinking process instead of memorizing and reciting information (Liu & Chen, 2010).

2.5 Project-Based Learning

In many classroom environments, the learning process is centered around the transfer of course content from the teacher to the students. Project-Based Learning (PBL) allows teachers an opportunity to pose complex problems incorporating various content connections, allowing the students the ability to gain experience directly applicable to real world scenarios (Euefueno, 2019). In the current global society, the workforce demands employees with a strong technical foundation and critical thinking skills, all components that could be enhanced by inventive solution-oriented projects.

Many obstacles that students will encounter outside of the classroom will not have an explicit problem statement nor an explicit solution. When developing project-based curriculum for STEM classes, instructors often place a significant emphasis on cultivating problem-solving skills. Projects are generally “ill-defined, complex, and open-ended, sparking increased higher-level cognitive strategy use among students” (Stefanou et al., 2013, p. 117). Project teams must gather all of the relevant technical and societal information in order to identify the problem. Following the group’s establishment of the problem, team members then formulate various options for developing a solution (Euefueno, 2019). These possible ideas are then evaluated in order to weigh potential products and decide on the best solution. It is during this stage that PBL allows students to both showcase their previous skills and learn new skills, granting students ownership of their creative process.

The benefits of applying PBL in STEM classroom environments extend far beyond tactical skills. While hands-on activities form a direct connection between course content and real-world events, students often inadvertently develop transferable life skills. This process is known as accidental learning. Team dynamics can challenge group members at various stages in the project process, particularly in terms of design decisions, meeting deadlines, and manufacturing practices (Euefueno, 2019). It is important for teachers to serve as project managers to emphasize the importance of roles within a team and the delegation of tasks in order for a team to be most effective as one entity (Savelsbergh et al., 2012). Instructors should encourage team members to reflect upon failures amidst the groups, in addition to challenges in the project process. At the completion of the project, the team should communicate and present the various phases of the process as well as challenges faced and how the team responded (Euefueno, 2019). Educators have a responsibility to develop relevant knowledge and skills in order to equip students for success in the classroom and the workforce.

The assessment of problems that arise in a group project also allows students to evaluate the successful aspects of the project method. Through PBL, students incidentally learn facets of team building that include problem solving, collaborative thinking, and strategic reasoning (Euefueno, 2019). The direct application of developing solutions to a problem as a group better prepares learners for the workforce where one can contribute their valuable skills, and also improve in areas outside of one's comfort zone.

As opposed to passive lecturing, PBL has a tendency to improve student motivation and encourage learners to establish their own basis of knowledge. The instructor assumes a new role in a PBL classroom setting, as the students have much more freedom to explore their own solutions (Hugerat, 2016). The aspect of ambiguity involved with the delivery of the initial project problem statement may cause frustration for the learners, but it is a vital aspect of the unstructured hands-off approach. Inspiring curiosity and self-motivated learning amongst team members allows for a generation of students prepared to apply their classroom knowledge to complex real world issues in search of multidisciplinary solutions.

2.6 Online Learning

2.6.1 Online Project-Based Learning

Project-based learning is typically done in a classroom environment, which provides a hands-on experience for students. However, when teachers or classroom space are not readily available, a different approach must be utilized: online learning.

One of the greatest strengths in a project-based learning environment is the teamwork aspect. Studies have shown "that peer group work has significant impacts on varied learning outcomes in both face-to-face and online learning environments" (Du et. al, 2005). Working with groups in an online setting can be challenging, but students can still benefit from this important part of project-based learning. In order to make group work more effective, roles can be assigned for everyone in the group. When all members have a designated task or position, it "can promote group cohesion and responsibility", as well as "positive interdependence and individual accountability" (Du et. al, 2005). Another critical aspect of teamwork is communication. Students in an online group project should have consistent methods of communication that they use constantly to keep in contact with their group partners.

In typical face-to-face project-based learning, an important feature is engaging, hands on content. When using an online platform, these features are still essential. Although hands-on learning cannot be done through a screen, with the proper lesson plans and available tools, instruction can be given to lead students in a hands-on direction. In fact, online modules may be better at creating captivating curriculum because of various media platforms, such as text, video lectures, or interactive simulations. With varied types of instruction, students can use learning strategies that are preferable for them, thereby increasing student satisfaction (Bourne et. al, 2005).

2.6.2 Modes of Education

Online learning environments can become difficult learning spaces for students due to the fact that virtual learning removes many aspects of a typical classroom, such as face-to-face interactions and hands on participation. Online learning can take the form of an immersive or non-immersive environment. Immersive online learning is known as learning within a virtual reality (VR) space, while non-immersive involves online interactions that don't use VR, such as a blog or website. Non-immersive environments are more commonly used for online education but can sometimes lack engaging aspects for students.

Creating a successful learning environment requires creating an engaging space. The resources to provide a VR environment are not always readily available, however the same concepts applied to VR learning can enhance a non-immersive experience. Immersion in VR can be separated into three areas: spatial, emotional, and temporal (Doumanis et al, 2019). Spatial immersion is creating an environment that students feel comfortable learning in. Emotional immersion is incorporating participation and interaction among students and educators. Lastly, temporal immersion is creating activities that students will have a desire to complete (Doumanis et al, 2019).

Creating spatial immersion comes with creating a learning environment that not only is interactive for the user but makes them aware of their peers on the same platform. Incorporating this into a non-immersive environment can be something as simple as including user photos and communication channels. Emotional immersion comes from collaboration in activities, and encouragement and support for learners. This can be implemented with group activities and discussions among peers. Lastly, temporal immersion can be created by stimulating background knowledge and reinforcing ideas with components such as Q&A, educator feedback, and encouraging individual exploration of the material. Another important part of temporal immersion is providing clear goals and expectations for students to follow.

Another challenge faced by online learning environments is the focus on engaging students remotely so that they feel incorporated in the course. Suggestions that the best way to develop a successful online learning environment is to incorporate 6 main concepts:

1. Building a community
2. Clearly outlining course expectations
3. Utilizing online tools for interaction
4. Promoting the exchange of ideas
5. Providing timely and relevant feedback
6. Creating an environment that is student-centered (Khan et al, 2017)

A simple setup like a welcome page outlining all resources and expectations is a crucial way to introduce students to a new learning environment. Interactive activities like discussion boards, polls, or assessments, can encourage engagement among learners. Finally, a clear communication system can provide students with a collaborative setting and allow for educator feedback that is often lacking in online learning environments.

2.6.3 Challenges

Although online learning can be a very effective tool, it presents a unique set of challenges for instructors and students. First, the use of online learning can lead to many technological challenges, especially in settings with minimal resources, such as P.A.Y.'s program. Difficulties in the functionality of software or more basic internet and computer limitations can lead to frustration by the learner or instructor that inhibit the effectiveness of the lessons. Additionally, if the platform is confusing or difficult to follow, this will also reduce the success of the curriculum. In order to combat this obstacle, it is essential to build a straightforward and user-friendly platform (Gillett-Swan, 2017).

It can also be difficult to apply constructivism in an online setting. To create a constructivist environment, "content and skills should be understood within the framework of the learner's prior knowledge" (Doolittle, 1999, p. 9). In an online environment where there is no communication between the creator of the lessons and the student, also known as an asynchronous environment, it is impossible for adjustments to be made to the curriculum based on prior knowledge of the learner. Similarly, no adjustments can be made during the course of the curriculum to either increase or decrease the difficulty level based on progress of the students (Doolittle, 1999). In order to solve this, there should be various levels and modifications that the learner can make to the curriculum in order to obtain the difficulty level that best fits their needs.

Furthermore, it is necessary for high levels of support to be available for students. Using online curriculum "in a setting where e-learning is new...the students will be very confused and in need of much guidance" (Andersson, 2008, p.59). Students will need assistance with all aspects of the curriculum including both the subject material and technological issues. This requires an instructor to be readily available as well as understand the material well enough to be able to answer questions (Andersson, 2008). This required level of support leads to the challenge of having well informed and available instructors in order for students to effectively learn the course material.

2.7 Educational Robotics

Educational robotics is a tool used by educators to aid in STEM education. The term "educational robotics" was developed following Seymour Papert's work, *Mindstorms: Children, Computers, and Powerful Ideas*, where he used turtle robots and his invention, the Logo programming language, to teach children how to program computers. Papert believed that "programming the Turtle starts by making one reflect on how one does oneself what one would like the Turtle to do. Thus, teaching the Turtle how to act or to "think" can lead one to reflect on one's own actions and thinking" (Papert, 1980, p.28). Programming instructors have been following in Papert's footsteps for the last 40 years, using Educational Robotics (ER) to teach programming in an immersive and engaging manner. In order to improve STEM education, educators have been using various types of robots and computer programming languages to engage students in the classroom and provide a visible, tangible representation of coding. Many different robots and coding languages have been developed to aid ER, such as Bee-Bots, Thymio, VEX, LEGO Mindstorms NXT and EV3, among others. In fact, the namesake for LEGO Mindstorms comes from Papert's book on his approach to Educational Robotics (Bumgardner, 2007).

While the main intention behind Educational Robotics is to provide a platform to teach computer programming, studies have shown the following:

> Robotics have a potential impact on student's learning in different subject areas (Physics, Mathematics, Engineering, Informatics and more) and on personal development including cognitive, meta-cognitive and social skills, such as: research skills, creative thinking, decision making, problem solving, communication and team working skills, all of them being essential skills necessary in the workplace of the 21st century. (Alimisis, 2013, p.64).

Although it has been demonstrated that these skills can be developed through ER, many educators find establishing this curriculum to be challenging and sometimes not feasible. Many factors must be taken into consideration such as their comfort level with robots, access to funds, time in class, etc. Furthermore, "the problem becomes worst when paired with perceptions that robotics … is hard, highly gender-biased (only for boys!) and not inviting for most students" (Alimisis, 2013, p.65). However, the benefits of Educational Robotics far outweigh the challenges.

One major benefit of ER is developed through accidental learning. Both technical and life-skills can be acquired with accidental learning in robotics education. When robots are used correctly in the classroom, students of any age can learn a wide variety of technical concepts, such as algebra, coding, and designing, without establishing those skills as concrete objectives. Accidental learning was a part of Papert's vision; he believed students could imagine themselves "as the robot moving and turning: and while [they] do this, [they're] connecting to powerful mathematical and scientific ideas" (Catlin, 2017, p.139-140). Papert himself was an accidental learner; "when … Papert became fascinated by gears, he learned how they worked … this helped the teenage Papert to understand equations with two variables. Many of his friends who lacked his gear background struggled with the math" (Catlin, 2017, p.141). ER goes beyond technical skills, however, and encourages students to develop life-skills they may not otherwise have been able to in school. These skills include, but are not limited to, teamwork, leadership, problem-solving, and critical thinking. Life-skills are truly a direct by-product of robotics-oriented activities. Students can work in groups to assemble or program a robot, discover new approaches to solving a problem, collaborate with their peers, and think outside of the box to find creative solutions to a challenge. Amy Eguchi, a leader in Educational Robotics curriculum and research, conducted studies in the fall of 2011 and 2012 on classrooms where she implemented an ER curriculum. Through evaluations, her studies found that 100% of the students learned collaboration/teamwork skills, 67% of them learned how to think creatively, and 67% of them learned problem-solving skills (Eguchi, 2014).

One of the challenges of establishing an ER curriculum is effectively implementing it across multiple age groups. In a K-12 environment, it is simply not possible to have both six-year olds and 14-year olds working on the same types of projects. Therefore, varying levels of robotics curriculum must be developed for such a setting. Many educators have been taking strides to overcome this challenge, such as Dave Catlin in his paper "29 Effective Ways You Can Use Robots in the Classroom", where he discusses 29 possible robotics activities that can be applied across multiple age groups. In another paper, "A Scenario-Based Approach for

Designing Educational Robotics Activities for Co-creative Problem Solving", Vassilis Komis, Margarida Romero, and Anastasia Misirli discuss a "taxonomy of activities, based on the degree of engagement of the learner in the knowledge building process" (Komis et. al, 2017, p.164). By organizing robotics activities into levels, they "provide content for different ages and educational contexts and [the activities] may be implemented from preschool through secondary education" (Komis et. al, 2017, p.164). Robotics activities can be adapted in many ways in order to enable accessibility. One option is to have students in higher grade levels complete an activity involving full interaction with the robot, while younger students could be taught similar concepts by participating in an activity involving observing or minimally interacting with the robot. In this way, all students will have exposure to robotics and will remain engaged while learning.

Another result of using robotics in the classroom is STEM inspiration, especially for students who have not had previous exposure to such technology. By interacting with robots, students are granted the opportunity to explore STEM pathways and discover where their education can lead them. An example of the impact of early exposure to robotics is robotics competitions, such as For Inspiration and Recognition of Science and Technology (FIRST) and VEX robotics competitions. When surveying students who participated in their competitions, FIRST recorded that 83% were interested in being an engineer or a scientist, 92% had increased interest in going to college, and 97% had an increased desire to learn more about STEM (Brandeis University, 2011). Inspiring students through robotics enables them to see a future for themselves in a technological field that they may not have otherwise been able to imagine.

2.8 Summary

Namibia's history of apartheid and segregation has created inequality in the current education system and left Katutura's population struggling to reach educational success. In recent years, there have been initiatives to address the gap in education, and one such program is Physically Active Youth (P.A.Y.), a free after school program for children in Katutura who come from disadvantaged backgrounds and informal settlements. P.A.Y. wants to foster a STEM curriculum that teaches students both technical and life skills. Current pedagogy related to primary and secondary education stresses the importance of following a learner-centered approach, incorporating active learning, understanding variations in abilities and levels of the students, and ensuring focus on activities that promote constructivism. Educators at P.A.Y. want to develop this type of learning through an online educational robotics curriculum, which they have tasked a team of WPI students to create. Educational robotics is a type of project-based learning that has been used by educators since the 1960's to engage students through hands-on robotics activities. The WPI team will acquire robotics kits, compile a curriculum and resources into an online learning environment for P.A.Y learners, and provide recommendations to assist P.A.Y. volunteers in delivering the online curriculum.

CHAPTER 3

METHODOLOGY

3. Methodology

The goal of this project was to create an educational robotics curriculum with an online component for use at P.A.Y.. The objectives were the following:

1. Develop a hands-on robotics curriculum that inspires STEM through an online learning platform.
2. Create a comprehensive toolkit for P.A.Y. staff to support the delivery of the provided curriculum.

The objectives are discussed within the methodology chapter which is organized into three parts: equip, create, and review and refine.

3.1 Equip

The goal of the equip phase was to plan for all materials and resources needed to execute this project. We began by identifying what elements we would need to meet our objectives and any supplies necessary in the process. There were four areas that emerged from this process: robotics kits, fundraising, transportation, and online platform.

3.1.1 Robotics Kits

First, we needed to decide which robotics to use in our project. We researched the different types of robotics kits available on the market today and determined which kit is appropriate for use at P.A.Y.. Factors such as price, difficulty level, durability, and ease of use were considered in this decision.

3.1.2 Fundraising

The next step was to identify means of fundraising. We explored options for grants and assistance through WPI, as well as outside sponsorship from companies. Additionally, we considered different methods of raising money ourselves.

3.1.3 Transportation

In addition to fundraising and determining which robotics kits to use, we explored the potential methods of transporting the kits to Namibia. Both shipping directly to Namibia and bringing the kits as personal cargo were considered. Challenges such as lack of reliable shipping, potential for theft at airports, and security checks at airports were also taken into consideration.

3.1.4 Online Platform

In addition to the other resources, various online platforms were considered. First, we decided which functionalities were essential for the platform. Some elements that were considered included the ability to: upload our own videos and videos from outside sources, create quizzes and assessments, develop simulations of hands-on activities, have various coding activities, and allow students to save their progress. After we decided which functionalities were essential, different platforms were considered such as education-specific models and standard website builders. Factors such as price, longevity, and user-friendliness were considered in addition to the listed functionalities.

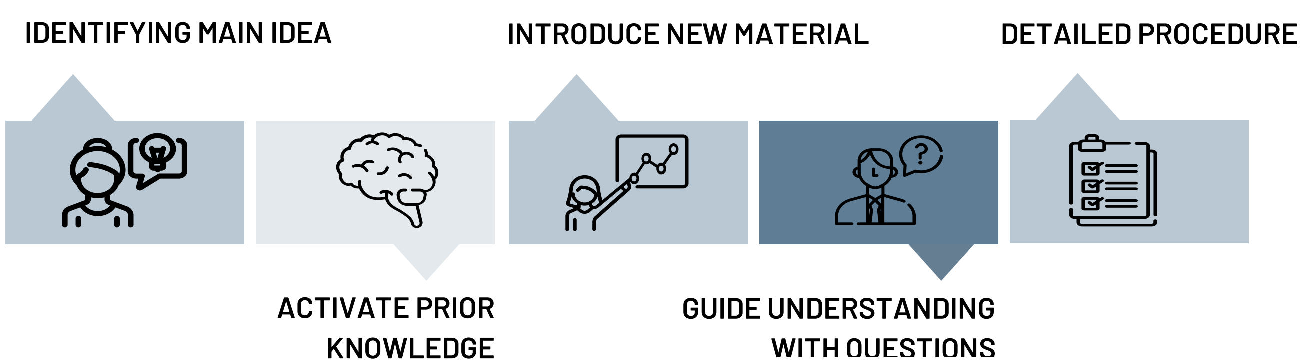
3.2 Create

The create section aimed to outline the steps necessary to develop the hands-on Robotics curriculum while incorporating the online learning component. The lessons generated and supplemental resources for facilitators were developed to support educators and volunteers who may or may not have a STEM background. This section provides the framework for the development of lessons and a facilitator manual, and intentions for incorporation of the online component on the online learning platform.

3.2.1 Lesson Creation Approach

In an effort to most effectively engage students and ensure understanding of the material presented, each lesson was developed following a standard active learning model to encourage problem-solving and critical thinking, as depicted in Figure 2 (Setiawan et al., 2019). The first step in creating a successful lesson was the identification of the main objective and overarching ideas/ key takeaways. This ensured that each component of the lesson related to the fundamental theme. After establishing the objectives, we formulated lessons for the online learning module, with careful attention to potential student engagement. Each lesson emphasized activation of students' prior knowledge, introduction of new knowledge through material and activities, and guidance of learners' understanding with probing questions. Throughout this process, it was important to keep in mind the eventual procedure for delivering the lessons in a classroom, noting resources and recommendations to be included in the facilitator manual.

Figure 2
Lesson Creation Approach



The instructions indicated in the supplemental facilitator manual for the lessons were intended to be clear and straightforward so that future instructors (with STEM or non-STEM backgrounds) will be able to facilitate the lessons with ease. Each lesson was evaluated to determine the materials needed for preparation prior to beginning the section in the online learning module and this information was included in the facilitator manual.

3.2.2 Development of Online Robotics Curriculum

Although some lesson plans had been developed for the original project, the team had to develop a new format for the online platform. The first step in this process was to create an outline for how the curriculum would be organized. The team created this outline by using research on teaching pedagogy and educational robotics, evaluating the needs of the students and staff at P.A.Y., and gaining insight from experts in the fields of education and robotics.

After creating a format for the lessons, the team had to determine what material would be covered within each one. The team used their outline of the lesson structure to figure out which topics needed to be covered. Starting with broader topics, the team narrowed them down into sub-sections that could be taught in an individual lesson. The team looked at current online robotics courses, videos from the WPI Robotics department, and curriculum from WPI summer programs to get an idea of how robotics curriculum is already presented online, what material is covered, and which age levels are being targeted.

Along with what material was to be covered, the team also thought about how the material would be covered. The team needed to determine which tactics could be used to effectively capture the attention of students using the website. Factors such as age appropriateness, layout, and engagingness were considered.

3.2.3 Facilitator Manual

An aim of this project was to develop lessons that can successfully be delivered by non-STEM educators. The teacher manual exists to provide supplementary and useful information to act as a resource for those facilitating the lessons. In an effort to provide more detail about the lessons and additional resources, this tool serves as a compilation of support materials. An important aspect of the lesson plan model is directing student learning through probing questions. By providing possible questions for educators to ask the students, it presents the opportunity to ensure understanding of the material covered in the lesson.

3.3 Review and Refine

The previously created lessons were adapted after receiving feedback from students and teachers. The goal of this process was to create lessons that were age appropriate, engaging, and the right level of difficulty for students.

3.3.1 Educator Feedback

After each section of the curriculum was developed, feedback was gathered by teachers who had volunteered to review the lessons. The teachers were identified through the Robotics program at WPI and personal connections from group members and advisors. Once the teachers had been contacted and expressed interest in reviewing the lessons, they were sent one section (age group) of the curriculum. The lessons were sent to five teachers for each age group. The teachers were given a form in which they were asked to provide comments on each of the lessons in that section as well as any feedback they might have on the layout, age appropriateness, and potential engagement of students. After receiving the feedback, the lessons were modified, and the final product was sent to all of the teachers that participated.

3.3.2 Student Trials

After the teacher feedback was completed, we gathered data in the form of feedback from students and facilitators (teachers, coaches, parents, guardians) on some of the developed curriculum. The test group was composed of students with varying ages and prior robotics experience. Some of the participants had access to robot kits and some did not, therefore they only completed lessons that did not require the kit. Participants were sent a background information survey for information on their age and prior experience, which then recommended a level for them to start in. They were sent all of the lessons in their recommended level and asked to complete 2-3 within a week. After they finished their selected lessons, they were asked to fill out a feedback survey on their experience. With the information gathered from the survey, we adjusted the lessons accordingly.

3.3.3 Improvements

At the conclusion of the project, we evaluated the process and compiled recommendations for possible follow-up projects. The recommendations were based on ideas we were unable to add within the timeframe and ways to enhance the program. Expanding upon our developed curriculum both for educators and future IQPs, has provided a foundation for any groups who hope to continue this work in the future.

CHAPTER 4
FINDINGS

4.1 Equip Outcomes

4.2 Create Results

4.3 Review and Refine

4.4 Summary

4. Findings

In order to achieve our objectives, we followed our methodology to equip ourselves for the project, created robotics education material through an online platform, and reviewed and refined our lessons using feedback from multiple sources. This chapter will present the findings in respect to the various steps of the methodology.

4.1 Equip Outcomes

4.1.1 Robotics Kits

When researching robotics kits, we focused our investigation on two different varieties of kits: Lego Mindstorms and VEX IQ kits. We concentrated on these two due to their classroom functionality and capabilities for varied and long-term use, as there were no other options that would provide the same caliber of possibilities. We then compared these kits with regard to their price, difficulty level, durability, and ease of use. After weighing the options, we decided that VEX IQ kits would be the best option for use at P.A.Y.. VEX IQ is very straightforward and easy to learn, has simple programming, and can be teleoperated or programmed to function autonomously.

4.1.2 Fundraising

After the decision was made concerning which kits to use, fundraising began to cover the costs. We applied to the WPI Tinkerbox program for a grant of $5,000 and presented our project to the WPI Tech Advisors Network (TAN) in an effort to acquire mentorship and potential donors. Through this process we received half of the grant that we applied for, so we had $2,500 to help finance the robotics kits. Additionally, we created a GoFundMe page for supplementary donations, to cover transportation of the kits and other miscellaneous costs and were able to raise over $1,000. These donations came from family, friends, and donors that supported our project at the TAN presentation. We also contacted Dan Mantz, CEO and Chairman of the Board for the Robotics Education and Competition Foundation (RECF) regarding possible sponsorship or donations. He was able to arrange for a significant discount on the robotics kits, which made the VEX IQ Classroom Bundle kit, containing 12 kits, affordable with the funds that we raised.

4.1.3 Transportation

In order to determine the best method of transporting the kits to Namibia, we researched all of the challenges associated with shipping the kits to Namibia or bringing them as personal cargo. Logistically, shipping the kits would be very difficult due to the lack of reliable shipping companies and the fact that P.A.Y. does not have an address or a way to receive shipped goods. We considered the possibility of carrying the kits to Namibia on a personal flight, but are unsure when we will be able to travel to P.A.Y.. Due to these constraints, we determined that the decision regarding transportation should be made at a later date when there are less variables in travel conditions.

4.1.4 Online Platform

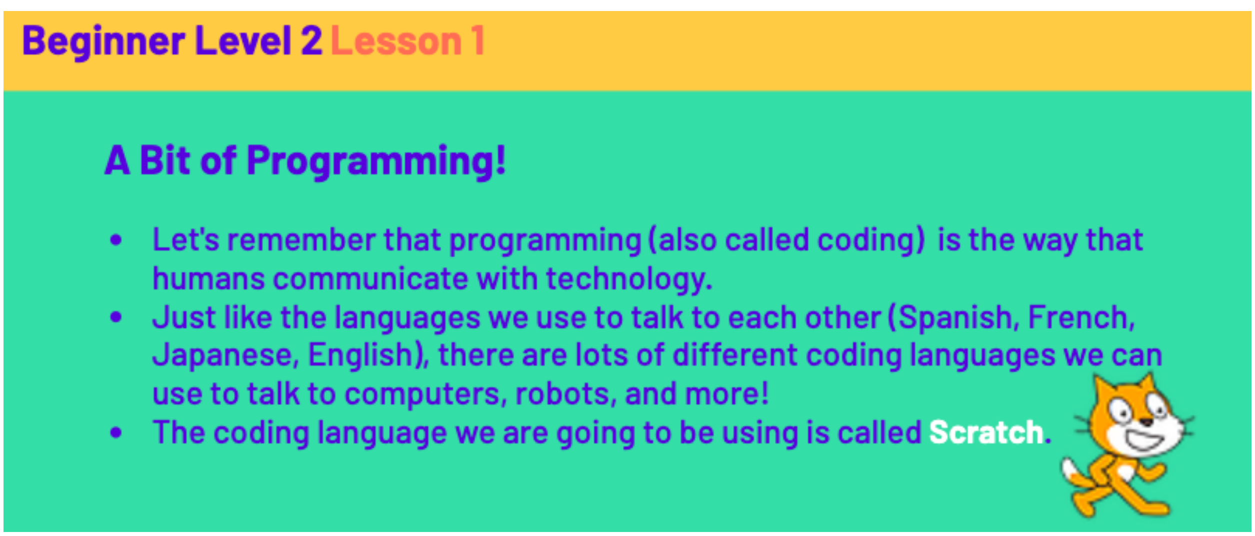
During our research of online platforms, we compiled a list of necessary elements that would allow for the most effective representation of the educational robotics curriculum. We concluded that the ability to upload our own videos and videos from other sources, user-friendliness, and open accessibility were all essential for the presentation of our curriculum. We needed to ensure that we could include various videos, that the website would be easy to use for children, and that it would be open for anyone to use without a username or password required. We decided that the ability to create quizzes and assessments, develop simulations of hands-on activities, and allow students to save their progress were not essential. We decided it was important to choose a free platform so that it would not be taken down once our subscription ended, which eliminated almost all of the education-specific platforms. After researching and experimenting with several free website-builders, we decided Wix was best suited for our needs.

4.2 Create Results

4.2.1 Lesson Creation Approach

With the intention of building straightforward content for the curriculum, we utilized a lesson creation approach to maintain consistency in the structure of the lessons. At the beginning of each level, we included an introduction lesson, which aimed to provide background information to engage all students on a level playing field before starting the level. At the top of each page, we identified the objective and intended outcome of the lesson. Figure 3 is an example using Beginner Level 2 Lesson 1.

Figure 3
Beginner Level 2 Lesson 1 objective



This allows the student to acknowledge the main idea and keep in mind the key takeaways as they complete the exercises. We then presented new material, followed by activities and other interactive exercises. The new material and activities in Beginner Level 2 Lesson one is exemplified below in Figures 4 and 5.

Figure 4

Beginner Level 2 Lesson 1 presentation of new material

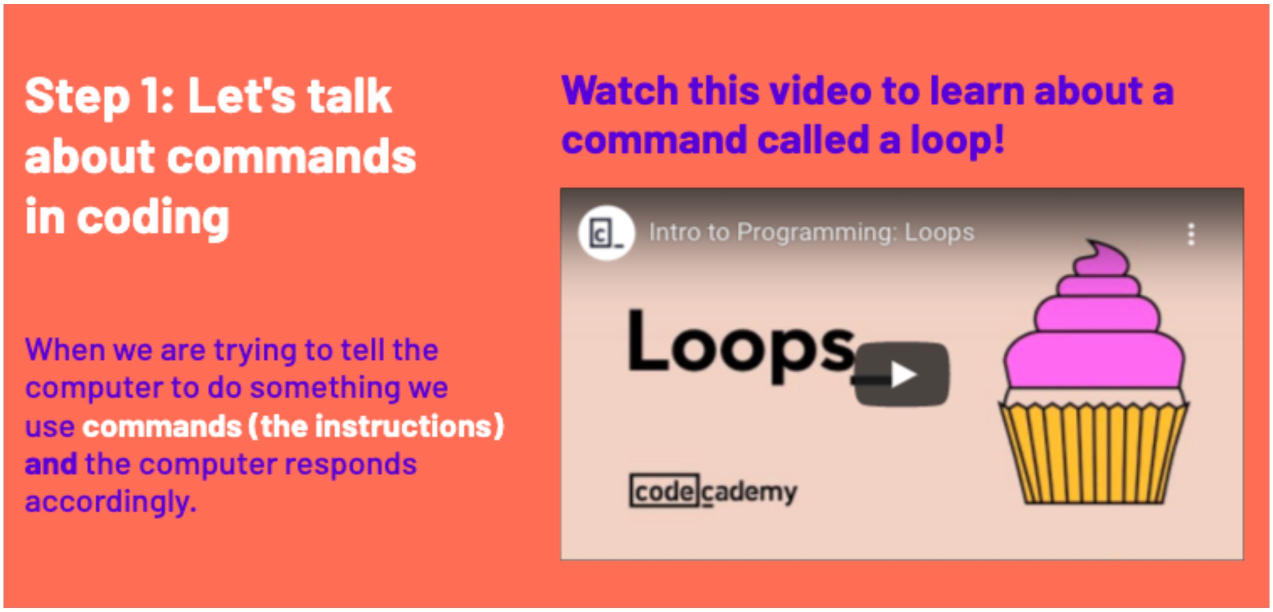
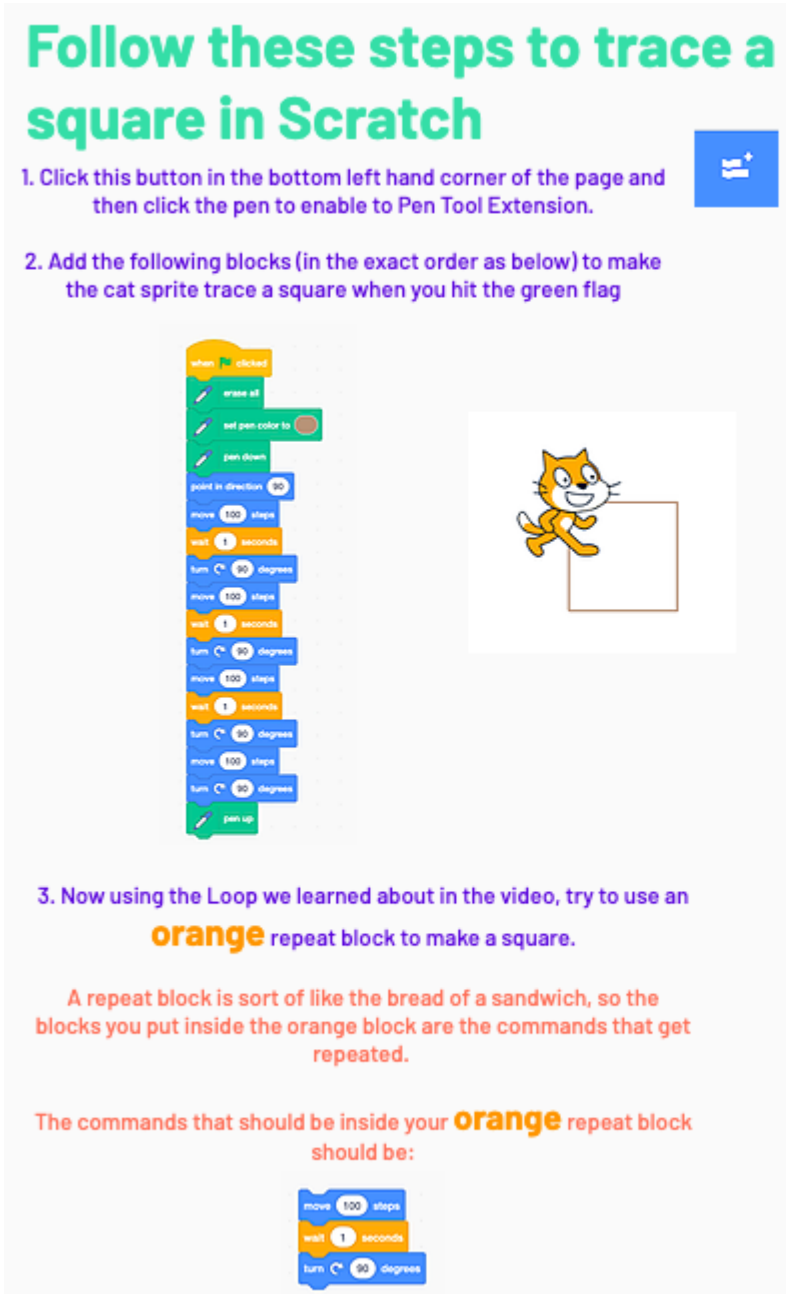


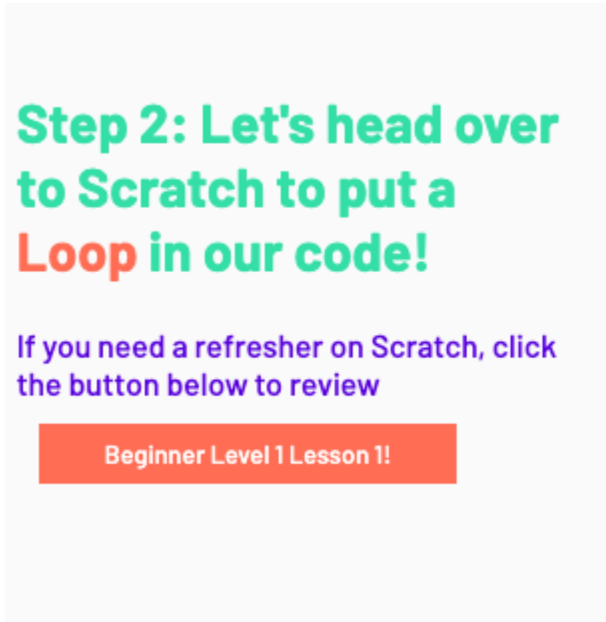
Figure 5

Beginner Level 2 Lesson 1 interactive activity



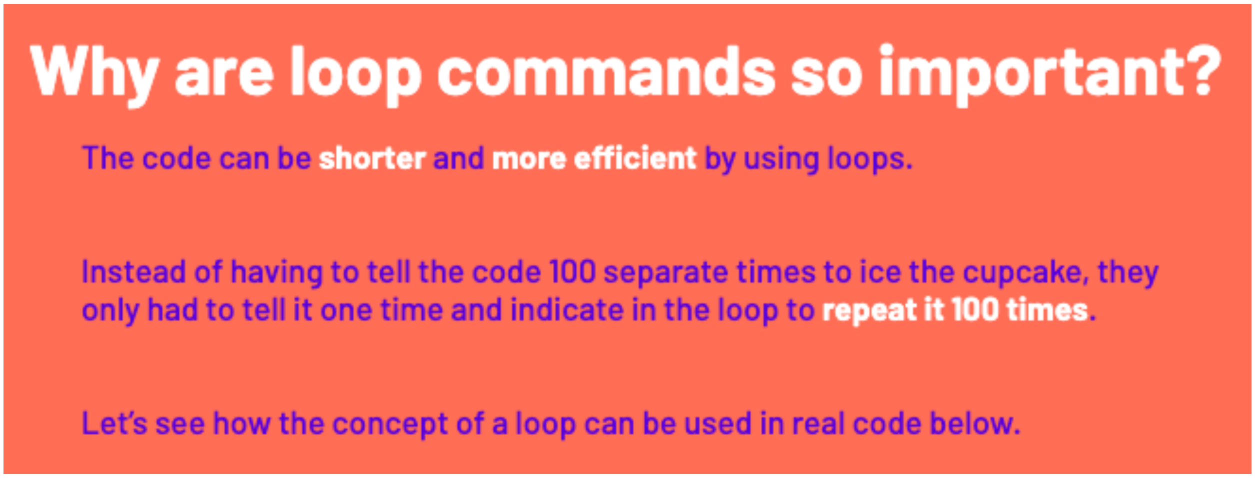
Every lesson aimed to activate a student's prior knowledge through connections to real life or references to prior lessons for review. Figure 6 demonstrates how previous lessons were utilized in order to review concepts.

Figure 6
Beginner Level 2 Lesson 1 reference to prior lessons



Each topic was adjusted in relation to the level it would be targeting, which dictated the mode of delivering the content. For younger age groups, the new material was presented through more videos to ensure engagement, as the reading comprehension level is lower. For older age groups, a balance of video content and text was presented to maintain student interest. Probing questions were introduced throughout each lesson to guide learners' understanding and direct the applications of the concepts to the real world. Figure 7 is an example of a probing question in Beginner Level 2 Lesson 1:

Figure 7
Beginner Level 2 Lesson 1 probing question



4.2.2 Development of Online Robotics Curriculum

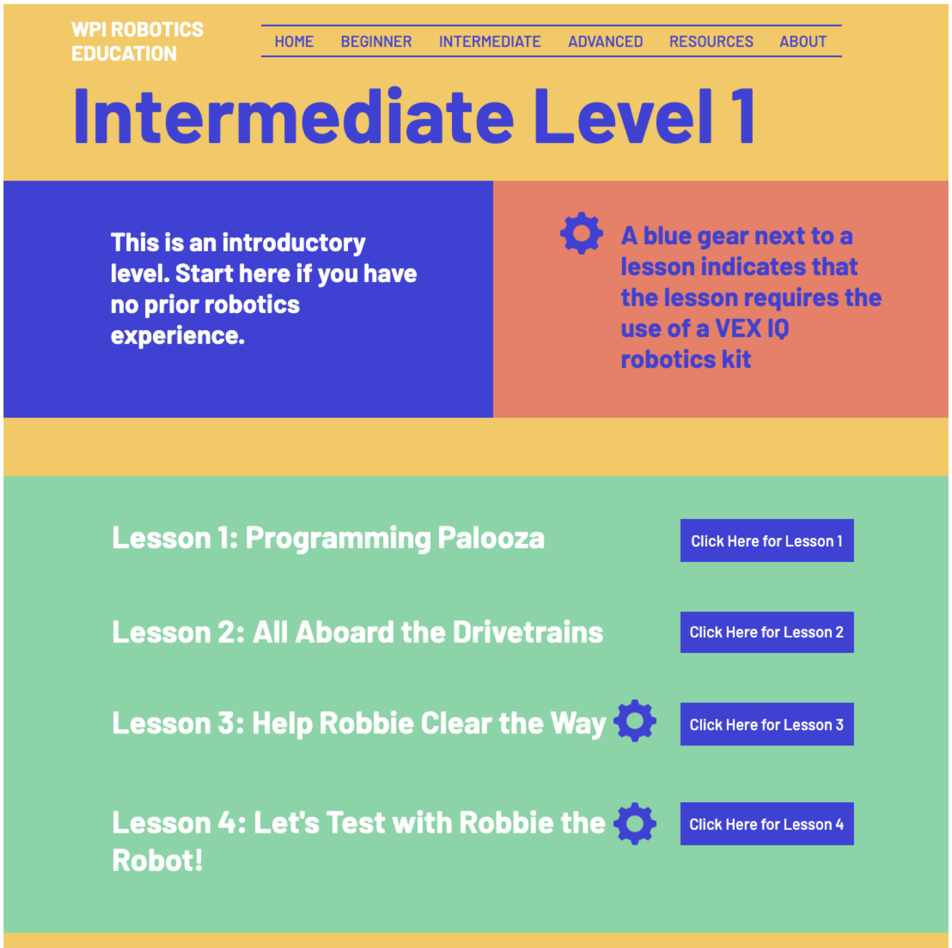
First, we established which material would be covered on the online platform. The main subjects for an educational robotics curriculum can be split into hardware and software. These two broad topics were broken down into multiple sections and presented in varying levels of difficulty. In order to decide which concepts would be taught, we looked at current online robotics courses from VEX IQ, videos from the WPI Robotics department, and curriculum from WPI summer programs. We noted the order of lessons, difficulty levels, and what material they cover. These resources were also used to decide which subjects would be covered within different age groups and the difficulty levels that they should fall under. We then outlined the topics as indicated in Figure 8.

Figure 8
Organization of the content presented in the Educational Robotics curriculum

	Level 1 No prior experience	**Level 2** Some prior experience
Beginner Ages 6-10	Lesson 1: Introduction to Scratch	Lesson 1: Programming Loops in Scratch
	Lesson 2: Simple Machines	Lesson 2: Gears
	Lesson 3: Build a Lift Robot	Lesson 3: Build Using Gear Ratios
	Lesson 4: Testing	Lesson 4: Testing
Intermediate Ages 11-14	Lesson 1: Introduction to Scratch with Loops	Lesson 1: Conditional Programming
	Lesson 2: Drivetrains	Lesson 2: Gear Ratios
	Lesson 3: Building with the Engineering Design Process	Lesson 3: Designing and Building for a Task
	Lesson 4: Testing	Lesson 4: Testing
Advanced Ages 15-18	Lesson 1: Bump and Ultrasonic Sensors	Lesson 1: Color Sensors
	Lesson 2: Mechanical Forces	Lesson 2: Object Manipulation and Appendages
	Lesson 3: Building with Sensors	Lesson 3: Building with Design Constraints
	Lesson 4: Testing	Lesson 4: Testing

The curriculum was organized into three overarching sections: beginner, intermediate, and advanced. These sections had suggested age levels accompanying them, with beginner covering 6-10 year olds, intermediate covering 11-14 year olds, and advanced covering 15-18 year olds. Within each section, there were two levels that contained four lessons each. Those lessons were then organized by topic, and as the levels increase, more challenging material is covered and previous material is taught more in depth. Figure 9 is an example, displaying Intermediate Level 1 on the website.

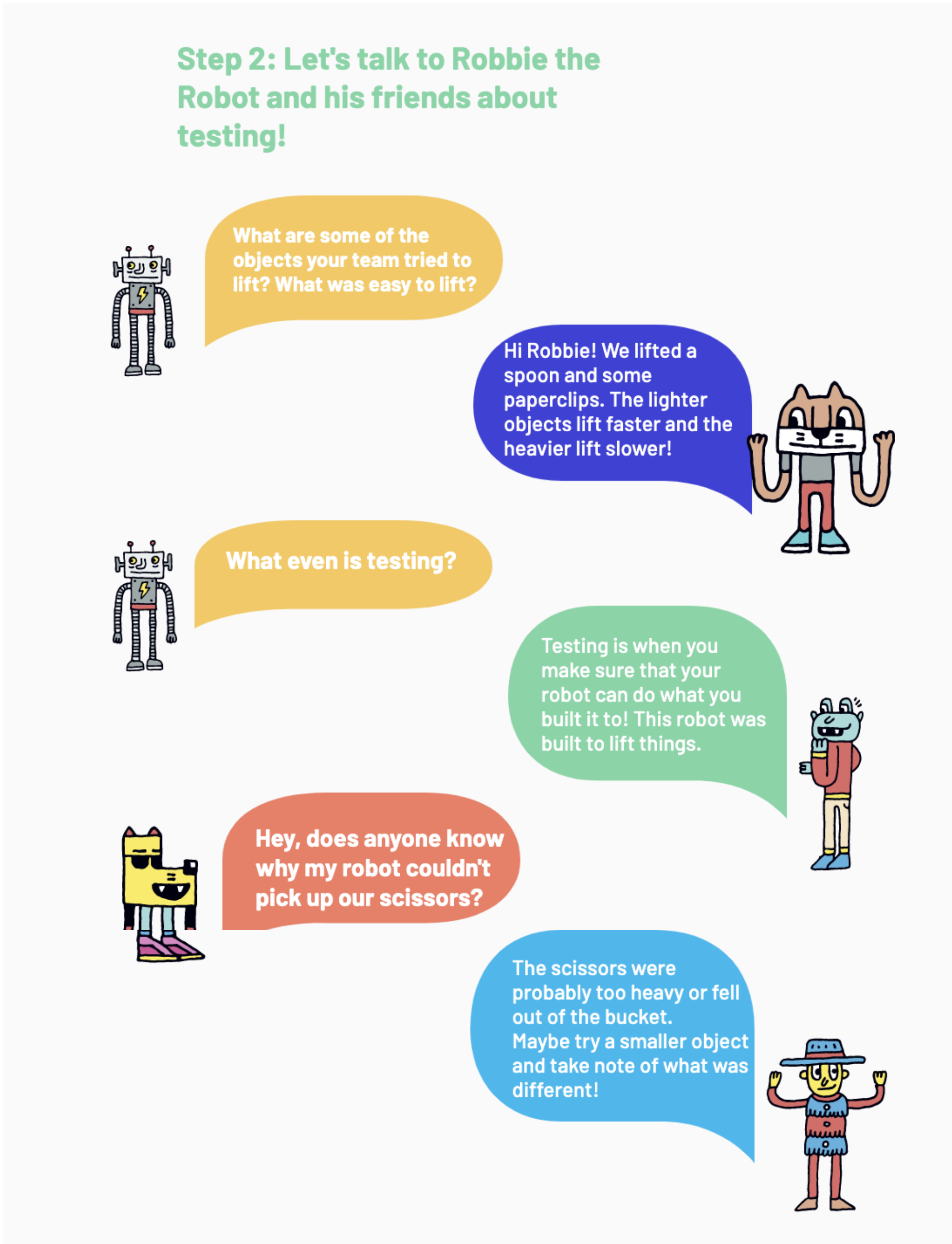
Figure 9
Intermediate Level 1 curriculum overview page



Once we decided what material to cover, we had to determine the best way to present it on the Wix website. One aspect of this process was engaging all three age groups. In order to do this, we made sure that within each age group, we showcased the material appropriately. For example, in the beginner lessons, the pages are colorful, use clear and simple language, and the videos are targeted towards a younger audience. Figure 10 is an example of an activity included in the beginner age group, focused on engaging younger students.

Figure 10

Beginner level activity with Robbie the Robot



In the intermediate and advanced lessons, the pages have more text, are less colorful, include less cartoon themed pages, and use more complex language. Figure 11 is an example of an activity in the advanced section, with more difficult language and concepts.

Figure 11

Advanced level activity

The layout was another factor that influenced the engagement of the website. We had to be sure that it was easy to navigate, interesting to look at, and logical in construction. This was accomplished by creating navigational buttons, providing a consistent format, and utilizing color themes.

All of the lessons were compiled in the online platform and can be found at the following web address: https://wpiroboticsed.wixsite.com/iqp2020.

4.2.3 Facilitator Manual

The facilitator manual serves as a guide to provide supplementary and useful information for any/all individuals facilitating students through these lessons. In an effort to support educators and volunteers who may or may not have STEM backgrounds, this manual provides lesson details, recommendations, and additional resources for each lesson. The manual outlines lesson details such as necessary materials, the predicted duration of each lesson, further questions to ask students, and recommendations for guiding student understanding. The manual offers insightful questions that guide students' understanding as the new content is presented. As we developed the lessons, we explored and identified many external resources on the topic material and robotics kits. A compiled list is included in the manual to provide opportunities for facilitators to enhance their background on the topics and direct students for further learning. The curriculum and lesson creation approach were adapted after receiving feedback from students and teachers. The lessons were adjusted following the evaluation of student success, efficacy of resources, and ease of facilitation.

4.3 Review and Refine

The curriculum was adapted after receiving feedback from students and teachers. The lessons were adjusted following the evaluation of student success, efficacy of resources, and ease of facilitation.

4.3.1 Educator Feedback Data

We received feedback from a wide variety of educators with varying experience and levels of comfort with the topic. We aimed for this variety so that we could obtain differing perspectives in order to ensure that the curriculum was suitable for all educators to teach regardless of their backgrounds and expertise. The following graphics, Figures 12-15, summarize the different backgrounds of the educators who reviewed our lessons:

Figure 12
Educator's years of experience

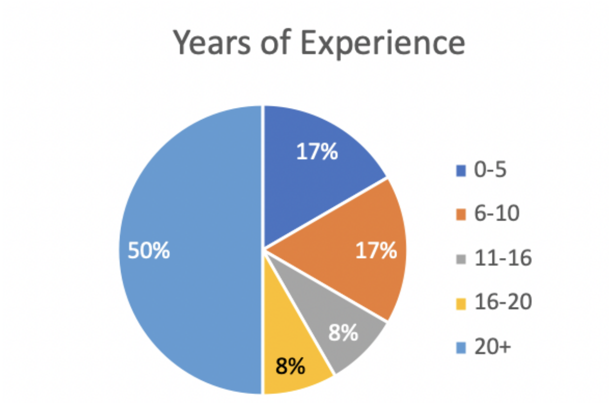


Figure 13
Subjects taught by educators

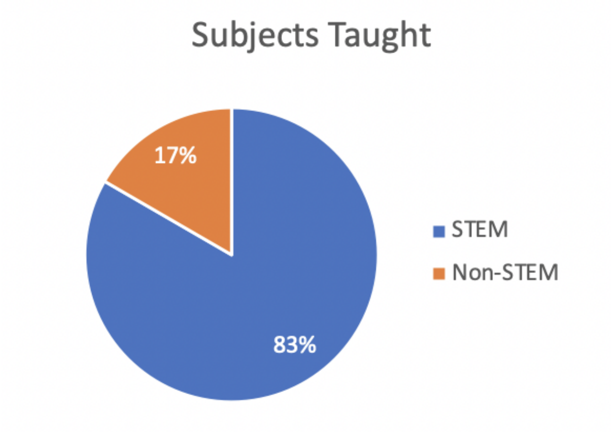


Figure 14
Educator's level of robotics proficiency

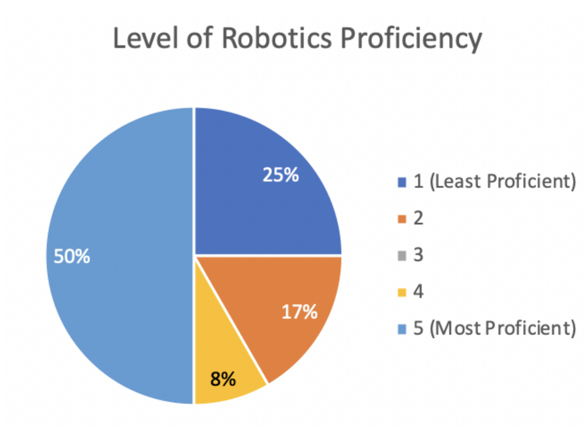
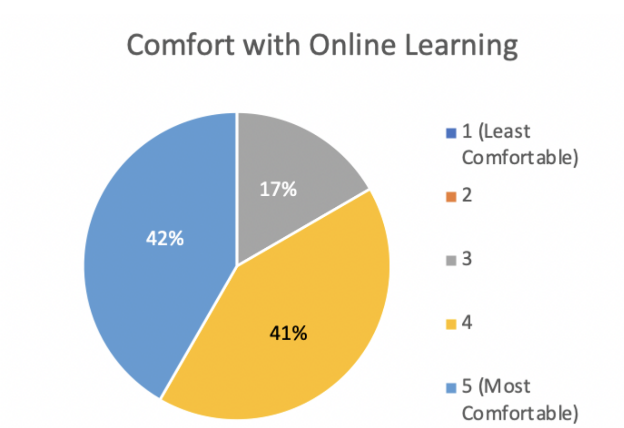


Figure 15
Educator's comfort with online learning



Although there was a wide variety of backgrounds, we had slightly more participation from educators who were in the STEM field, had more experience, a greater level of robotics proficiency, and higher levels of comfort with online learning. This is because we wanted to ensure that we received valuable comments on our content and recommendations from knowledgeable educators in order to create the highest quality lessons possible.

After receiving educator feedback, we modified the lessons in accordance with the major themes that were present in the comments. After carefully reviewing all of the feedback, we identified the overarching themes as:

- Layout
- Age appropriateness
- Content
- Engagement

In general, the comments on layout were positive with minor suggestions. The majority of the feedback focused on having a consistent format, eye-catching graphics, and ensuring that navigation was easy. Many educators appreciated the "consistent color scheme (Educator B)" and one stated, "I like how all the lessons are formatted in a similar way that will be easy for students to follow (Educator G)." There were also positive remarks on the eye-catching graphics, with feedback expressing that the website is "visually appealing with color coordination and images (Educator D)" and that it was "bright and appealing (Educator B)". As far as navigation of the site, one teacher commented, "The layout was super. It was very well organized which made it very easy to navigate and bounce around from topic to topic (Educator J)." Many agreed, but some had suggestions to ease navigation such as including back buttons on the various pages and adding in hyperlinks to certain lessons. We incorporated these suggestions in the appropriate lessons to make the website more straightforward and user-friendly.

The majority of the comments on age appropriateness focused on the difficulty level of the lessons and the type of language that was used. Especially in the beginner age group, there were several comments that some of the lessons may be too difficult for younger students. Educator C commented that she "thinks the lessons would be too challenging for an average class of k-1, or even 2nd grade students. I think the sweet spot for these lessons is 4-6th grade." Other teachers agreed by asserting that younger students may need help reading, assistance with terminology, and following the long sets of directions. We received similar feedback that some of the language used in the beginner age group was too challenging for the younger students, and to use "more specific words, and less is more" (Educator B). With the two older age groups, we received positive comments on the age appropriateness such as "this is certainly age appropriate for a motivated and engaged group of students (Educator J)" and "seems perfect - not too elementary, but still engaging (Educator E)". We were able to modify the beginner age group to simplify the language and content, and included recommendations in the educator manual that younger students may need additional assistance with certain lessons and activities. The positive response to the age appropriateness of the intermediate and advanced lessons was reassuring as there were no significant modifications to the difficulty level or language needed.

We received many suggestions on the content from the teachers experienced in robotics. These suggestions included the major topics: pacing, accuracy, succinctness, and completeness. There were several comments on the lengths of certain lessons and the importance of ensuring that the curriculum was paced correctly. For example, Educator E explained that "it seems that you spent more time on explaining lesson 1 in level 1 than the rest." This comment and other similar comments led us to readjust the placement of some of the material in addition to including time estimates for each lesson and recommendations for overall pacing in the facilitator manual. There were also several comments on accuracy and making sure that we used precise language with no misleading assumptions or concepts. After receiving this feedback, we corrected terminology and eliminated any misleading assumptions. It was challenging to obtain a balance of succinctness and completeness, but feedback was provided to help us identify where one of the two was lacking. In one of the lessons in the beginner curriculum, Educator A commented, "this lesson seems incomplete. [I] think you need more guided increments on developing the actual robot code." In a different lesson, we were cautioned "children might run out of stamina trying to do too much in one sitting (Educator B)." We were able to use this feedback to modify the lessons to ensure a combination of succinctness and completeness.

The last theme in the feedback, engagement, focused on the activities that were included, avoiding content overload, and applicability to real life situations. A large portion of the feedback that we received was positive, with some constructive feedback generally centered around the balance of videos, text, and activities. Positive feedback included: "the kids will absolutely not get bored!!! (Educator C)," "since this is a very hands-on lesson for kids, I think it is of high interest. I like the practice activities, video links, partner discussion questions (Educator G)," and "I don't think they will get bored at all (Educator J)." Additionally, many teachers approved of our incorporation of real-life examples. Educator B pointed out that "most children have a bike, or have seen a bike in real life or on TV, so I think they can relate to this lesson and think more about how an object like a bike really works". The constructive criticism we received explained that some lessons had too many videos and not enough activities, and that there were certain sections with too much text content likely leading to students losing interest. We were able to fix these identified weaknesses and create a curriculum with a higher potential level of engagement.

By implementing the suggestions and feedback we received from educators, we were able to improve our lessons and ensure that they were ready for students. We obtained an extremely large number of comments and made all of the corrections that we decided were appropriate and would enhance our curriculum. These adjustments were made on a rolling basis as comments were submitted, so that the lessons were updated quickly and efficiently to prepare us for the next stage of the project. At the conclusion of our modifications, we sent the curriculum back to the educators to view their implemented feedback and to give them an opportunity to see the final product.

4.3.2 Student Trials Data

After reviewing the educator feedback in each section, we began student trials. We had one trial for each section, asking students to test our beginner and intermediate lessons. Due to time constraints, we tested the advanced curriculum ourselves to make sure it was comprehensive. The students were asked to submit a background survey prior to beginning the trial. This survey asked their age and prior experience with robotics. The charts below, Figures 16-17, depict that there was a variety of ages and experiences among participants.

Figure 16
Ages of participants participating in trials

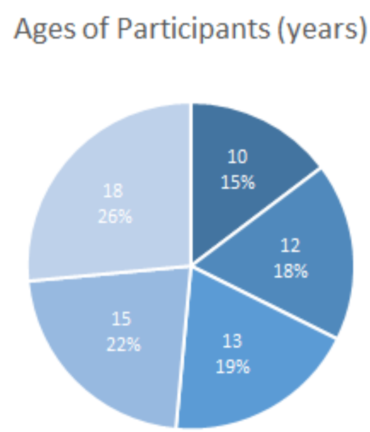
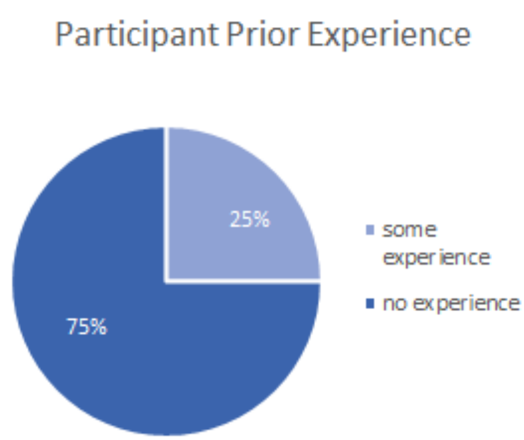


Figure 17
Prior experience of students participating in trials



Based on their responses in the background survey, the students were assigned a recommended starting level in the curriculum. Next, students completed 2-3 lessons in their recommended section and submitted feedback surveys. We used this feedback to assess age appropriateness, student engagement, and difficulty of the lessons. We took into consideration the age and prior knowledge each student had when reviewing responses. Most of the feedback received was positive and the quantitative answers fell within the ranges we hoped for. The charts below, Figures 18-21, illustrate our quantitative results from the student feedback survey.

Figure 18
Results of Students' Enjoyment of Lessons

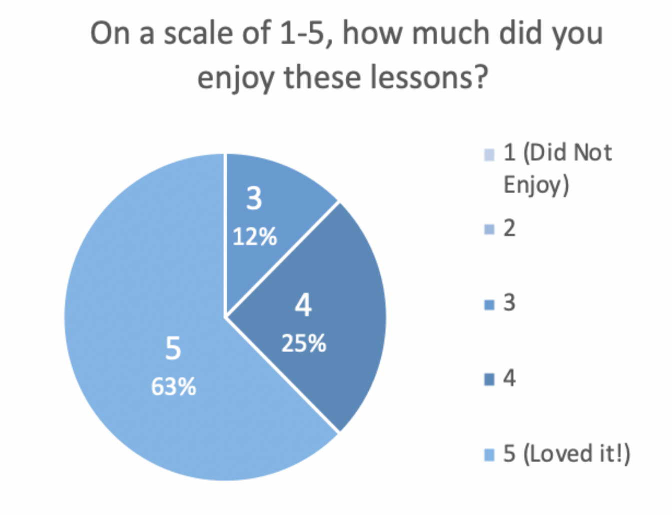


Figure 19
Results of Students' Opinion on the Difficulty of Lessons

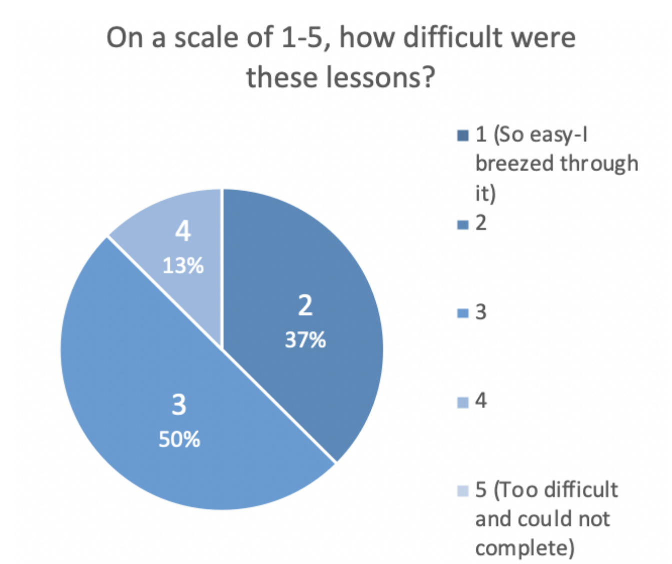


Figure 20
Results of Students' Continued Interest in Robotics

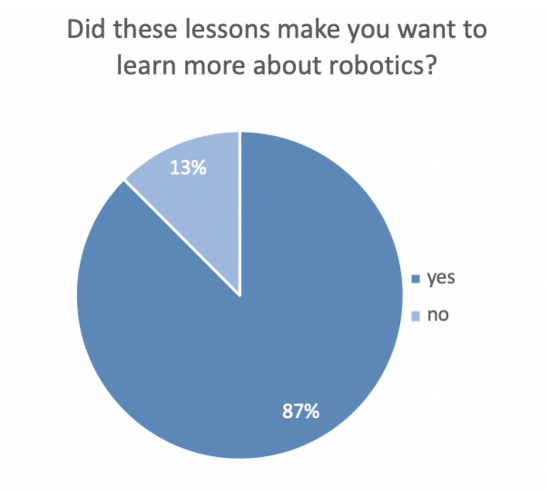
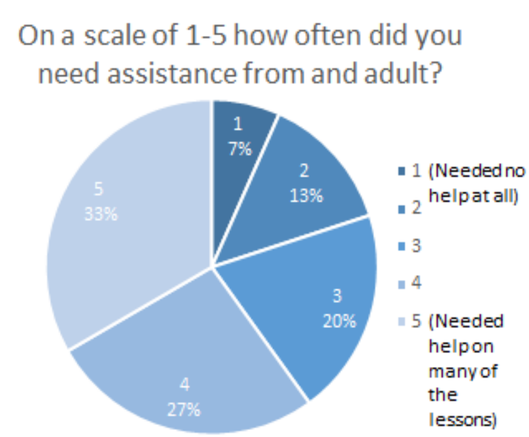


Figure 21
Results of Students' Need for Assistance from an Adult



As depicted, the results for enjoyment of students fall within the higher ratings, and the difficulty and assistance responses average around the middle. This was reassuring because it supported that the lessons were engaging and appropriate for their age group. We also acknowledged that a significant amount of the students in the trials had worked with robotics before. The curriculum was slightly easy for the students participating in the trial, indicating that the lessons are the appropriate difficulty level for our target audience, P.A.Y., where very few students have previous robotics experience. We also asked students if these lessons made them want to learn more about robotics. All of our participants responded yes to this question except one. While reviewing we realized that this participant had completed the incorrect age group, and consequently found that he already knew all the concepts. This indicated that we needed to clarify our description of the different age groups and levels. In addition to modifying the website and instructions for the trial, we contacted the student and explained the situation, and he decided to repeat the trial with the correct level. In his second feedback survey, he had much more positive feedback and was satisfied with the information that was presented.

In the feedback survey, we also asked students what their favorite and least favorite parts of the curriculum were. Many of the students said that their favorite part was the programming activities and getting to work with Scratch. The responses for the least favorite parts were still generally positive comments. One of the participants said that their least favorite part was "Having to stop because I did not have the VEX IQ kit. (Student A)", while others said that their least favorite part was that they already knew some of the material. We again considered this to be a result of the more experienced backgrounds some of the students had, and that working on the more advanced lessons would likely be a better fit for them.

Although the majority of the feedback was not constructive, it was still beneficial to our study to confirm the quality of the lessons and reveal that there were no major obstacles with the curriculum. The results of the student feedback trials resolved concerns of engagement and age appropriateness. Students had fun participating and their feedback assured that lessons were appropriate and fun for each age group.

4.3.3 Improvements

Throughout this process, we came across many ideas and challenges that could not be addressed within the timeframe of the project. These ideas were added to a list of recommendations that are available for any future endeavors. We addressed ways that the curriculum can be expanded upon and recommendations for P.A.Y., our target audience. We also created recommendations for facilitators with the best ways to implement the lessons. These recommendations were all compiled in the facilitator manual previously discussed.

4.4 Summary

In preparation for the execution of this project, we arrived at conclusions regarding the decision to use VEX IQ robotics kits and the development of lessons on the WIX Website platform. Decisions regarding the means for transporting the kits to Namibia will be made at a later date. Twenty-seven lessons were developed for students ages 6-18, divided into 3 recommended age groups, using the lesson creation approach to ensure continuity. We collected feedback from both educators and students, with the intentions of reviewing the responses and applying edits to the curriculum. The educational robotics curriculum is accompanied by a facilitator manual that aims to guide educators delivering the lessons in a classroom setting.

CHAPTER 5
CONCLUSIONS

5.1 Summary of Findings
5.2 Deliverables
5.3 Recommendations
5.4 Reflections

5. Conclusion

This chapter presents the deliverables, recommendations, and reflections of the project. The goal of this project was to create an online educational robotics curriculum for use at P.A.Y., an after-school program for children in Katutura, Namibia who come from disadvantaged backgrounds. The objectives were to develop a hands-on robotics curriculum through an online platform and create a comprehensive toolkit for P.A.Y staff to support delivery of the provided information. These objectives were achieved by creating a website with 27 robotics lessons targeting students ages 6-18 and an extensive facilitator manual with supporting material and recommendations.

5.1 Summary of Findings

Throughout the course of the project, we made several decisions on equipment, created 27 robotics lessons, and received feedback on those lessons from both educators and students. In the early stages of the project, we decided to use VEX IQ kits for our curriculum based on the price, difficulty level, durability, and ease of use. We fundraised to be able to afford the kits, transportation of the kits, and other miscellaneous costs. We applied for and received a $2,500 grant from WPI Tinkerbox, a matching donation from the Robotics Education and Competition Foundation, and supplemental donations on a GoFundMe page. We then explored options for transportation of the kits to Namibia but realized that the final decision will have to be made at a later date when there are less variables in travel conditions. Lastly, we chose to use Wix as our online platform because it was best suited to our needs.

When building our curriculum, we utilized the lesson creation approach discussed in the methodology. In each lesson, we identified the objective to acknowledge the main idea, activated prior knowledge, introduced new material, and used guiding questions. Each topic was adjusted for the appropriate age group to ensure the right difficulty level and engagement of the students. In order to decide which material would be covered in the curriculum, we reviewed robotics resources from VEX IQ and WPI to understand the major concepts. We then established an outline for our curriculum including 27 lessons comprised of the following topics: introduction, programming, mechanical concepts, building, and testing. Finally, we compiled all of our additional recommendations into a facilitator manual. The manual includes supplementary guiding questions, lists of necessary materials, recommendations for delivery, vocabulary, and predicted duration for each lesson.

Lastly, we received feedback from educators and students in order to review and refine our curriculum. We sent our lessons to educators with varying backgrounds and asked for their feedback and any suggestions they may have. Their feedback consisted of four overarching themes: layout, age appropriateness, content, and engagement. In general, the comments on layout were positive and focused on consistency of format, eye-catching graphics, and ease of navigation. The comments on age appropriateness centered around the difficulty of the lessons and the type of language that we used. The suggestions that we received on content included the topics of pacing, accuracy, succinctness, and completeness. The last theme, engagement, concentrated on the activities that were included, avoiding content overload, and applicability to real life situations. We implemented the suggestions from the educators and began student trials in which we sent the curriculum to students with varying ages and experience levels. The students were asked to complete 2-3 lessons and answer a feedback survey asking how much they enjoyed the lessons and how hard they were. In general, the students greatly enjoyed the curriculum and expressed interest in learning more about robotics. These data supported the idea that our lessons were engaging and would be at the right difficulty level for learners at P.A.Y..

5.2 Deliverables

With the purpose of producing a practical and manageable curriculum for our sponsor, P.A.Y., to implement in their classrooms, we developed the online learning platform and a facilitator manual. These two deliverables serve as educational materials to support teaching educational robotics topics to students ages 6-18.

5.2.1 Online Learning Platform

The online learning platform was developed as a central hub for lessons and resources to guide and aid students' learning on the topic of robotics. Lessons were created for students ages 6-18, divided into three separate groups with suggested age groups: beginner for ages 6-10, intermediate for ages 11-14, and advanced for ages 15-18. Each age group encompassed two levels: level 1 assuming no prior experience with robotics and programming, and level 2 assuming some prior experience with robotics and programming, or prior completion of level 1. There were four lessons in each level, including topics in programming, hardware, building and testing. The concepts and pacing for the topics were determined using external resources from VEX IQ, the WPI Robotics department, and WPI summer programs.

5.2.2 Facilitator Manual

Supplemental materials were compiled in a facilitator manual that can be downloaded from the website to complement the collection of prepared lessons. With the intention of supporting the facilitators, the manual provides additional questions, lists of necessary materials, recommendations for delivery, vocabulary, and predicted duration for each lesson. The lesson specific information also includes notes on specific topics and helpful guidance for activities. This resource strived to provide clear instructions such that individuals with STEM or non-STEM backgrounds could facilitate the lessons with ease. The supporting information presented in the manual also provides the background information necessary to assist teachers and improve their confidence on the topics. Various student and educator resources were compiled to offer support material and a knowledge base for inexperienced facilitators of the lessons.

5.2.3 Summary

The lessons in the robotics curriculum were designed to provide enough information to standalone on the online platform for completion asynchronously and independently by students. This allows for this project to reach a wide audience of students in a variety of educational environments. In an effort to support the volunteers and educators at our sponsor, P.A.Y., an after-school program, the facilitator manual was developed to provide helpful resources and lesson details for delivery in a classroom setting.

5.3 Recommendations

After completing the project, recommendations were developed. These recommendations address feedback that we were unable to incorporate into the final product, further development of the platform that we did not have the time for, or anything else that we felt could be added to improve this curriculum in the future.

The recommendations are categorized as follows:

1. Recommendations for the staff and volunteers at Physically Active Youth
2. Recommendations for continuing and improving upon the project
3. Recommendations for other IQP sites around the globe
4. Recommendations for educators and programs similar to P.A.Y.

5.3.1 For P.A.Y.

Unfortunately, due to the Covid-19 pandemic, we were unable to travel to Namibia and directly interact with P.A.Y.'s staff and students. Despite this disruption to initial plans, we created an educational robotics website that we hope meets their needs. Since we could not deliver the lessons in person, the following are recommendations that we hope will help the staff and volunteers at P.A.Y. get the most out of the website. The recommendations are broken into these three categories: first steps, facilitator manual, and presentation.

First Steps:

The website contains a home page, pages containing the curriculum, resources, and an "About" page. Before beginning the curriculum, the students should find out which level they should start out n. This can be determined by clicking on the button on the homepage called "Which level?". Each level has a recommended age range, beginning with 6-10 year olds, then 11-14 year olds, and finally 15-18 year olds. Although these are the recommended age groups, a student may be ahead or behind their recommended age level. To accommodate this, we created an intro, level one, and level two within each overarching grouping. Students without any prior experience should start at the beginning, while students with some robotics experience could start at levels one or two. If the level that the student was placed in seems too challenging or too easy, simply direct the student to the previous or next level to find a better fit.

After finding the correct age level for students, there are a few more pages on the website that should be explored. Under resources, there are two sections: facilitator manual and VEX IQ info. The facilitator manual has general recommendations, as well as recommendations specific to each lesson from the website. The VEX IQ Info page contains instructions on how to download the VEXcode IQ Blocks software, how to set up a robot with the software, and links to helpful videos provided by VEX. Both of these resources should be looked over by the instructor in advance so that they can utilize them when teaching robotics in the classroom.

Facilitator Manual:

The facilitator manual is an important resource for instructors to use when teaching this curriculum. Robotics is taught best using hands-on, project-based activities. Although the website is entirely online, a facilitator can use the manual for suggestions on providing a more enriching and engaging experience for students in the classroom. Before beginning a lesson, facilitators should review the recommendations outlined for it and could also print out the page in the manual associated with that lesson.

Presentation:

For use at P.A.Y., the intention is that the curriculum will be taught in a classroom setting with a staff member or volunteer facilitating. The method of teaching is at the discretion of the facilitator, but ideally the lessons would be guided with the website curriculum and the facilitator manual would be used to provide a more enriching and engaging experience. In educational robotics students work in small teams, typically ranging from 2-4 students. This encourages the teamwork, communication, and problem-solving skills that learners would usually find in a robotics class. Therefore, the students at P.A.Y. should work either in pairs or groups of three when going through this curriculum. Being able to think out loud with a partner, discuss the best solutions, and cooperate when building a robot together is vital for a successful robotics program.

5.3.2 For Continuation and Improvement

If this project were to be continued, there are certain aspects of this project that we feel could be expanded upon with more time. One of the main areas of improvement is video creation. While we were able to create some videos for the website, we used sources like YouTube to find appropriate and engaging videos. The potential problem with them is that the original creator of the video could remove it from YouTube at any time. Therefore, we recommend that videos be made to replace any on the website that were found on the internet. Along with that, some new videos could be made to outline steps, activities, etc. that we were only able to present in text. These videos could explain concepts more clearly and be more entertaining for the learner than simply reading text. Aside from video creation, we recommend that a group continuing this project should make additional levels within the age groups to expand the amount of material being taught. Lessons new and old should also go more into depth, especially in the harder age levels, so that students can receive more challenging material if they so choose.

5.3.3 For Application at Different Global Projects Sites

With intentions that this project could be continued by another IQP group in the future, we provided recommendations for them specifically. We recommend that future teams work on expanding the curriculum both in the number of lessons and in more in-depth material. Since the website was designed to be shared with multiple audiences, project teams should use our curriculum as a resource. They should modify our lessons to best fit the culture and learning style of a new location by incorporating relevant real-world examples. Future teams will also need to account for adjusting the pace to fit the prior knowledge and skill level of the new learners.

5.3.4 For Educators and Programs Similar to P.A.Y.

One of the outcomes of developing our curriculum as a website was that it is easily shared and able to benefit many audiences. We created a facilitator manual with the purpose of guiding educators through our lessons whether they are experienced teachers or not. For other organizations using our curriculum, we recommended that they follow the facilitator guide, but also that they adjust the lessons to best fit their learners. This would include relating examples to their life and culture, adjusting the pacing based on their prior experience with robotics, and presenting the material in such a way that best engages students. It is also highly recommended that in a classroom setting, facilitators present the material to the class as a group when possible. Students should work on teams of 2-3 members and should discuss guiding questions and brainstorm ideas among themselves often.

5.4 Reflections

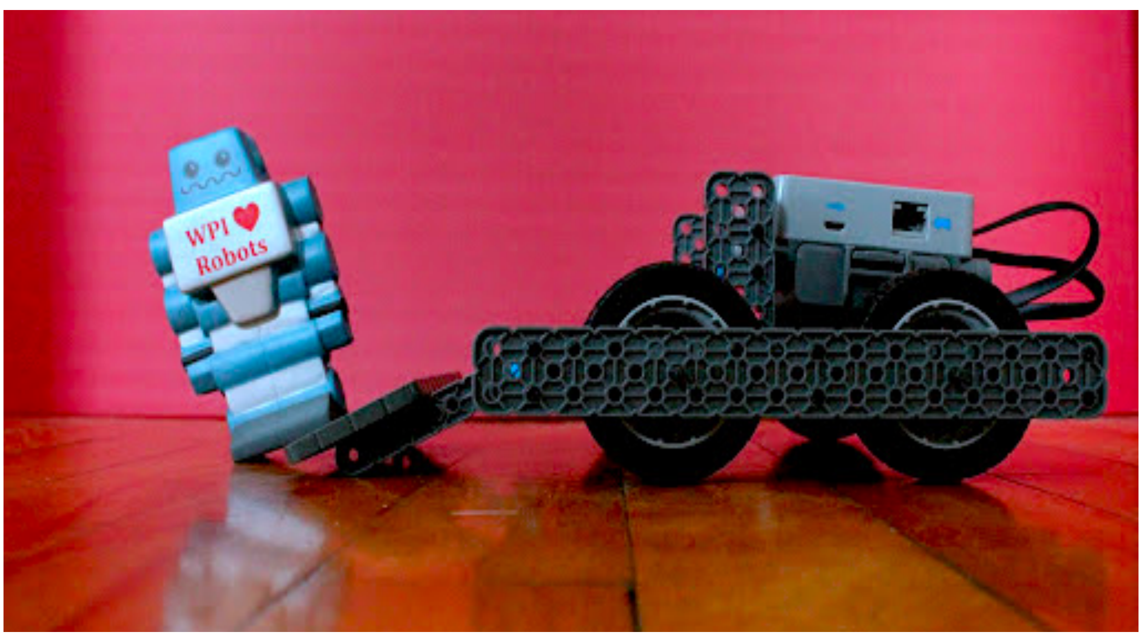
Covid-19 had a significant impact on the completion of our IQP, something that none of us could have anticipated. It came as a shock and certainly a disappointment that this project would be completed remotely, but overall, it was still an impactful experience. We were able to adjust the project in a way that allowed us to still collaborate with P.A.Y., our sponsor. P.A.Y. had requested a robotics curriculum and the resources necessary to implement it, and it was important that the modified project would address those same needs. We created a website that could be used in a classroom setting with the P.A.Y. learners. The material is presented in a way that makes it easy for students to understand and for educators to facilitate the lessons. Due to the fact that all the resources were compiled into a website, the project became something that could benefit more than just the target audience. We were excited to see that the website could have the potential to be impactful in many communities.

We experienced many limitations that came along with completing the project. One of the biggest drawbacks was that we would not be able to see how effective these lessons would be with P.A.Y. learners. We had hoped to do remote trials of the lessons with some of the P.A.Y. students to receive more specific feedback on how to adjust them. Unfortunately, we were unable to because P.A.Y. also switched to remote learning, and not all of the students had the resources to complete the lessons from home. This was a disappointment, but we ensured that the finished curriculum would be ready when P.A.Y. returns to normal operations. Another limitation was time. We created 27 lessons for the curriculum, which was much more than the original plan of 12, but still only introduced the material to students. With more time, we could have gone more in depth on concepts and given students a better understanding of the material. We also could have created our own videos to accompany lessons, instead of relying on outside sources.

At the completion of the project, we had the opportunity to review the deliverables in a meeting with our sponsor. We went over the website and facilitator guide, discussing the general information about the curriculum and suggested methods of implementation. Our sponsors were excited to see the finished product and expressed that they could not wait to begin implementing the lessons. One of our sponsors' initial reaction to the website is captured below in her statement:

> The website is catchy and child friendly, the colours work perfectly for the age group it serves. We love how interactive it is, and that it allows for work to be done even without the kit and also independently without the teacher. P.A.Y. upholds itself as a top of mind youth development NGO (Non-Governmental Organization) in Namibia. The partnership with WPI fosters and embodies everything we believe in, our value system and love for passion-enthused STEM focused education, and the work I saw today is beautifully done and really mind blowing. Super impressed, and a job well done. We are excited to test it out... (T. Sibanda, personal communication, May 11th, 2020).

Overall, the opportunity to develop extensive resources for P.A.Y. was a positive experience. We are excited that we were able to create an impactful project with the potential to benefit both P.A.Y students and many more communities that extend beyond Katutura, Namibia.



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Appendix A: Lesson Samples

Beginner Level 1 Lesson 1: What is programming?

WPI ROBOTICS EDUCATION

HOME BEGINNER INTERMEDIATE ADVANCED RESOURCES ABOUT

Beginner Level 1 Lesson 1

What is Programming?

Robots don't think like people, so how do we communicate with them? Let's find out by learning about programming!

Step 1: Watch this video to learn how engineers communicate with robots

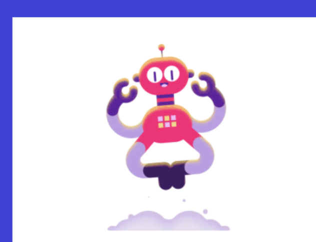
Programming is giving a series of instructions to a robot or computer. Robots don't have brains so they don't know what to do unless you tell them!

Step 2: Let's think about how a robot moves

You must give the robot very specific instructions!

For example, to make this robot dance, I must give it exact instructions:

1) Walk forward
2) Jump up
3) Spin



Step 3: Let's code our own dance!

1. Make up a dance with exact instructions for how to complete it.

2. Give a friend the instructions and see if they do the dance correctly.

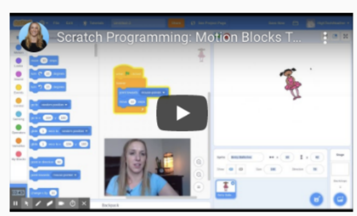
Giving your partner these instructions is how you must instruct a robot. In order for a robot to complete a task, you must tell it EXACTLY what to do.

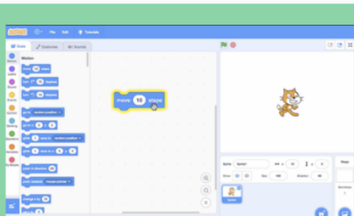
Step 4: We can try programming using Scratch!

Scratch is a programming language just for kids. When we say ***language***, we mean the way that we can talk to the robot!

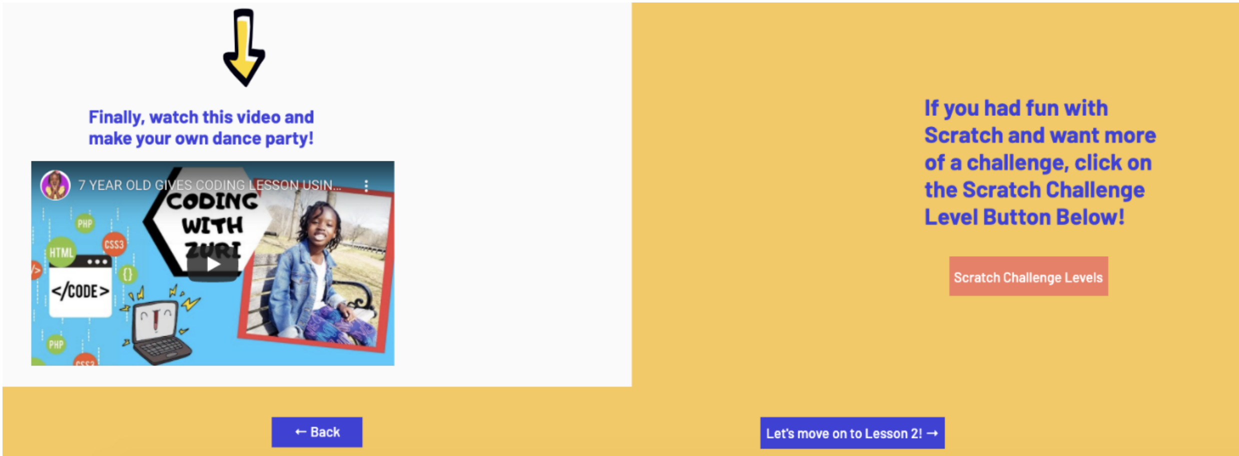
Click on the Scratch Icon below and watch the "Getting Started" tutorial

Watch this video to learn about the blue motion blocks!





Click on the different blue motion blocks to see how each one makes the cat sprite move.


Finally, watch this video and make your own dance party!
7 YEAR OLD GIVES CODING LESSON USIN...
CODING WITH ZURI
</CODE>
If you had fun with Scratch and want more of a challenge, click on the Scratch Challenge Level Button Below!
Scratch Challenge Levels
← Back
Let's move on to Lesson 2! →

Advanced Level 2 Lesson 3: Building Challenge

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Advanced Level 2 Lesson 3

Building Challenge

Time to put your skills to the test and build a robot that can navigate a competition field!

The Challenge:

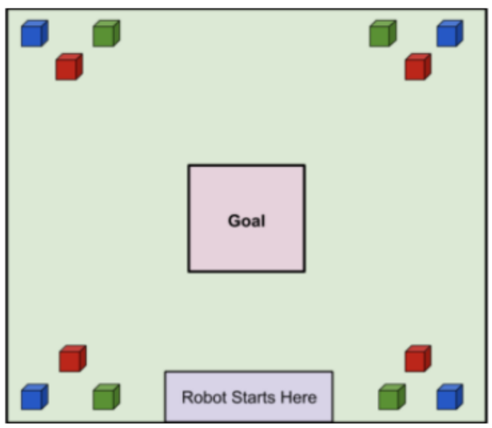
You have one minute on the clock! Your robot needs place as many cubes as it can in the goal before the minute is over. However, you have a few design constraints that your robot must meet.

What are Design Constraints?

Design constraints are specific limitations or requirements that your robot has to meet. Robot engineers need to meet those requirements when they build robots for their customers.

The Field

The field is a square that is 1 meter wide and 1 meter long. There is a goal in the center that the robot must place the cubes into. The robot starts in the center of the bottom edge of the field. Three cubes are placed in each corner of the field, one of each color (red, green, and blue) at the start.



Your Design Constraints:

1. Your robot must have at least one sensor that can let it know when it gets close to something (a distance sensor or a bump sensor)
2. Your robot must have an appendage that allows it to lift up objects on the field
3. Program the remote control to move your robot around the field

Helpful Hints:

- Brainstorm possible solutions in your engineering design notebook
- For help with programming with the controller, review it in Intermediate Level 2 Lesson 4, or go to the VEX IQ Info Page
- Review the different types of manipulation to think about the design for your appendage

← Back

Let's move on to Lesson 3! →

Appendix B: Facilitator Manual Samples

Beginner Level 1 Lesson 1: What is programming?

<table>
<tr><th colspan="4">BEGINNER</th></tr>
<tr><td>Level</td><td>1</td><td>Lesson</td><td>1</td></tr>
<tr><td>Topic</td><td colspan="3">Programming</td></tr>
<tr><td>Lesson Title</td><td colspan="3">What is programming?</td></tr>
<tr><td>Predicted Duration</td><td colspan="3">1-2 hours</td></tr>
<tr><th colspan="4">Lesson Objectives</th></tr>
<tr><td colspan="4">Understand what programming is
Practice the basics of programming through an interactive activity
Begin using Scratch</td></tr>
<tr><th colspan="4">Recommendations</th></tr>
<tr><td colspan="4">If possible, play the videos on the projector so that the group can watch them together
After each video, discuss the main concepts as a group
In step 3: if the students can write, have them write down their instructions for the dance
If the step 3 activity takes a long time, you may want to begin step 4 on a second day
If some students complete the activities quicker than others, have them complete the Scratch Challenge Levels</td></tr>
<tr><th colspan="4">Materials/ Equipment</th></tr>
<tr><td colspan="4">Projector
Paper and pencils (for step 3 activity)
Computer</td></tr>
<tr><th colspan="4">Vocabulary</th></tr>
<tr><td colspan="4">Programming: giving a series of instructions to a robot or computer</td></tr>
<tr><th colspan="4">References</th></tr>
<tr><td colspan="4">Programming for Kids
Scratch Programming: Motion Blocks
Dance Party</td></tr>
</table>

Advanced Level 2 Lesson 3: Building Challenge

ADVANCED			
Level	2	**Lesson**	3
Topic	Building		
Lesson Title	Building with Design Constraints		
Predicted Duration	1-3 hours		

Lesson Objectives

- Design and build a robot to complete the challenge
- Adhere to the given design constraints

Recommendations

- Set up the field using tape, blocks, etc. that can outline the 1m by 1m square
- Colored blocks from VEX should be used, but can be substituted with any type of object as long as they are all uniform in shape and size
- Have students brainstorm and design in their engineering notebook
- Encourage working in teams of 2-3 students
- Review the sensors and manipulation methods
    - Have students discuss which would be best for this situation
- Adjust the field or design constraints to what fits best for the students and the space

Materials/ Equipment

- VEX IQ Robotics Kit
- Computer with VEX Code Blocks software
- Engineering notebook
- Tape, blocks, etc. for outlining the field
- Objects (preferably blocks from VEX) of same shape and size

Vocabulary

- Design Constraints: specific limitations or requirements that the robot has to meet

References

- N/A

Appendix B: Educator Feedback Responses

Educator A

How many years have you been teaching? 26+ yrs, ages 8-30

What subjects have you taught? Aerospace History, Sailing, Statics, Technical Communication, Robotics, Aerial Navigation

One a scale of 1-5 how comfortable are you with online learning (1-never used it, 5-use it all the time)? 4

Would you consider yourself a STEM or non-STEM educator? STEM

On a scale of 1-5, what would you consider your proficiency with robotics in the classroom (1-never used them, 5-could create your own curriculum)? 5

Please write your comments and feedback in the corresponding box:

Which section are you providing feedback for (Beginner, Intermediate, Advanced)?

Lesson		Comments
Introduction		The first video seems a bit advanced for this age group. The rest are fine but if the intent is for all of these to be shown sequentially during the first session, it is perhaps too much.
Level 1	Lesson 1	Step 1 video is confusing due to the foreign script (what language?) shown on the narrative-to-code slide. How long do you expect this lesson to be? I really love Steps 2 and 3 of this lesson! I went through the scratch tutorials and one of the challenges and it took me well over an hour. This appears to be more than a single session of effort.
	Lesson 2	Step 2 has you build a pendulum which most folks do not consider a simple machine (and was not covered in the video). This lesson appears right-sized for a single session, although the actual building of the "simple" machines will take longer than you expect...
	Lesson 3	Parts Checklist: "B: Brain batter"? Assembly pix: lighter background would make pix easier to see. You don't show attaching the brain battery or the need to have the controller in your Parts Checklist. Why end this lesson with powering

		up...but not moving it?
	Lesson 4	You start by saying you have a “working robot”, but that has not been demonstrated yet…”completed robot”? Think you need to include some guidance on how to make the arm move (which control?). I kept trying to “click” on the Challenges until I figured out that they were just questions.
Level 2	Lesson 1	In Step 3, would be better to include a wait (~1 sec) after each move command--otherwise students don’t see the movement as the steps are run...happens too fast (at least on my computer).
	Lesson 2	I hate the fact that the Step 1 video keeps saying how “force” is affected by gears! We all know that it is unaffected! Torque is what is affected. The forces transferred through gearing are always equal. The bike you show in Step 2 has NO gears! Your Step 3 picture collage has 2 robots that have NO gears displayed--please, do not mislead students to think that gears and sprockets are identical. Perhaps you could mention the similarities between gears and sprockets early on. You need to be very careful not to spread misconceptions about physical elements in Step 4. It is a challenge to define torque, but better (and correct!) if you said something like measures how much twisting effort an axle provides. Then in your gearing up/down, substitute power with torque. (Power is UNAFFECTED by perfect gears!) After going through this lesson entirely, I think an early explanation that gears and sprockets, while technically different (explain), produce similar effects, are both used on robots, and are commonly considered equivalent, may be your best solution.
	Lesson 3	I like this assembly set better than the Level 1 instructions. Combining a statement or two makes the steps more understandable. Although you seem to have never put the arm motor back on (took it off in Step 3?). Again you really need to explain how to control the arm motor.
	Lesson 4	This lesson seems incomplete. Think you need more guided increments on developing the actual robot code. The VEX tutorial driveline video is good but doesn’t address operating the arm.
Comments on:	Layout	Overall quite attractive. A “back button” on the left bottom would be useful--I found myself having to use the browser back arrow several times. The format (a WiX feature?) doesn’t allow great scaling, ie, shrinking window truncates

		display rather than more conveniently reducing font sizes.
	Age Appropriateness	All the sequential videos in the Intro may be questionable for the earlier learners. I believe they need interaction to stay engaged for more than about 15 minutes. Suggest some related activity between each vid.
	Potential Engagement and Interactiveness (will the kids get bored?)	The intro to Scratch is a bit challenging for one session, and then there seems to be no connection to the rest of the level 1 lessons. I really believe in "no-promises" pedagogy when possible: rather than say "trust me, you'll need this in later lessons", reinforce by example/need in each lesson. Be careful with your video-heavy lessons, kids of this age really need tactile engagement to stay engaged.
Miscellaneous Feedback		REALLY important not to develop misconceptions early on. Be very careful with terms to make sure they are age-appropriate yet accurate (eg gears vs sprockets, forces vs torque, torque vs power). Will these imported videos remain available as long as the site exists? Some of the pages seem to mix teacher guidance with student directions--in general I think it would be useful to provide more detailed teacher guidance (eg: timing for each activity, questions to ask, etc. Will there be an accompanying lesson plan for each lesson?

Which section are you providing feedback for (Beginner, Intermediate, Advanced)?

<u>Lesson</u>		<u>Comments</u>
Introduction		Your definition of robot seems a bit limited/incomplete… think you should at least include the inclusion of sensors and processors to perform tasks.
Level 1	Lesson 1	Not clear how to return to lesson after checking out Vocab tab in Step 1. Step 4, Challenge 1 same as in Beginner lesson? Step 4 backdrop download procedure not obvious to target students...took me some time to do it! Step 5: if you do the "Loops Review", not an easy path back to lesson (couple clicks and some scrolling required). Step 5 quite challenging--will absorb a lot of time.

	Lesson 2	This is a very short lesson. Seems imbalanced to the rest of this level. In Step 2, you would only feel “turning scrub” if you were trying to push a toy car around a turn. What you feel when pushing forward isn’t that.
	Lesson 3	In step 2, would be better to have Robbie describe his problem more completely or show a sketch of what he is trying to move. Otherwise very difficult to brainstorm. Also rather confusing to have the Engr Des Process “Steps” look just like the lesson steps. Perhaps “phases” or something other than steps? Step 3 assumes a pretty big leap from programming Scratch to programming your robot.
	Lesson 4	Ok, I see now that you have not downloaded the program yet. My assumption was that “building” the robot included downloading the program...and that “testing” begins when you hit go/on. And again, I find calling these engr phases “steps” confusing (especially when Lesson 4 begins with “step 4”). Whoops you move from Intermediate Level 1 to Beginner Level 2??
Level 2	Lesson 1	Why does your intro to Int Level 2 have the same narrative as on Beginner Level 1? Broken link on Step 2: “**Whoops! Our server is Scratch'ing its head**
	Lesson 2	Like in previous lesson, you should be clearer in your definition of Torque. Also Gear Ratio is not the arrangement, it is the measure of the arrangement. In Step 5 don’t you mean bike’s “lower gear” vs “lighter gear”? And PLEASE do not proliferate the thinking that gearing intrinsically changes power--it does not! (You mean torque for biking up a hill.) “Gearing up” generally means the opposite of what you say. It means shifting to faster gears (eg shifting from 4th to 5th). Btw, you have it correct in the scenarios! PLEASE don’t say “torque power”...that is tantamount to saying this is an “apple orange”...they are different physical quantities, one does not describe the

		other. You can have more torque, you cannot have more powerful torque.
	Lesson 3	Again, might be better to be a bit more specific about the type of debris to more (does it need to be carried or just shoved?).
	Lesson 4	
Comments on:	Layout	Attractive. Thanks for putting in "Back" buttons. Please do note the comments on organization (ie lesson steps vs design steps).
	Age Appropriateness	Seems ok to me. The one video with the really young narrator may be slightly too young for middle-schoolers.
	Potential Engagement and Interactiveness (will the kids get bored?)	I think the Scratch sessions will be particularly well-received. The Brainstorming sessions need more details to get folks to generate any worthy ideas.
Miscellaneous Feedback		There seems to be a big step between programming in Scratch and driving your robot via rc. Suggest some intermediate guided lessons would be useful. EG: perhaps programming your robot to duplicate some Scratch exercize (eg: drive in a square).

Which section are you providing feedback for (Beginner, Intermediate, Advanced)?

Lesson	Comments
Introduction	Quite a good STEM video--too bad the statistics given seem to be just for Australia...

Level 1	Lesson 1	Oh man...an advertising video? For HIT?
	Lesson 2	Your bike friction example isn't great. The friction at the surface is what makes the bike go forward--not retarding it! Air friction and bearing friction slow it down, The bumpy surface difficulty is not caused by friction (unless the wheels start spinning), but rather by the normal force being inclined to the rear..adding to air friction. Better example would be walking up a dry surface vs a wet, slippery slope. Whoa, I think your balance example is inverted: tall, high CG items are actually easier to balance than ones with lower CGs (unless the CG coincides with your finger, in which case it is totally stable). The reason for the ease of balance is actually a dynamic, inertial effect. The very thing that makes robots tippy and unstable (ie high CG) makes finger-tip balancing easier. Does your CG pix of the armed VEX IQ robot represent the entire robot (can't be) or just the arm (which doesn't look right either)? Trying to illustrate the potential for tipping has more to do with the CG and "polygon of contact" of the robot, than the arm geometry...
	Lesson 3	Will PAY students understand "inches"?
	Lesson 4	Why start with "Step 2"? And why 2 Step 2s and then direct to Step 4? Spelling error in step 4.
Level 2	Lesson 1	Color-specific should be hyphenated.
	Lesson 2	
	Lesson 3	You specifically challenge them with picking **UP** cubes and placing them **IN** the goal...this means a plow would not work. This is a *really* tough challenge.

	Lesson 4	This challenge seems to be a very large leap from previous lessons. Quite a step from avoiding obstacles and random motion to locating obstacles, maneuvering to get the manipulator in position, operating the manipulator (without experience with potentiometers), and then, critically, finding the goal zone and delivering the cargo.
Comments on:	Layout	I like it.
	Age Appropriateness	These videos are a significant step up from previous younger audience lessons...I'd say they were appropriate. The leaps in required understanding of the Level 2 lessons may be slightly too much for this age group.
	Potential Engagement and Interactiveness (will the kids get bored?)	I think there may be some frustration in Lesson 4. You show some rather complex mechanisms (eg: reverse 4-bar; multi DOF arm). Then you have them design something for autonomous control but provide them with insufficient sensor knowledge to do it. While I appreciate your building-block pedagogy, I think you skipped a step or 2 in the ending challenge.
Miscellaneous Feedback		Overall, I like this age-advanced section, but feel you are trying to get them to a level of proficiency beyond what can be expected in a 4-lesson set. You talk about lifting mechanisms, but almost nothing about collection devices (eg: how can I get an object into my scoop arm...autonomously?). Suggest you should reduce the complexity.

Educator B

How many years have you been teaching? 2 years in a classroom, 5 years in education

What subjects have you taught? 3rd grade, all subjects at an elementary level

One a scale of 1-5 how comfortable are you with online learning (1-never used it, 5-use it all the time)? 2-3

Would you consider yourself a STEM or non-STEM educator? non-STEM, but district is moving in the direction of implementing more STEM into curriculum

On a scale of 1-5, what would you consider your proficiency with robotics in the classroom (1-never used them, 5-could create your own curriculum)? 2

Please write your comments and feedback in the corresponding box:

Which section are you providing feedback for (Beginner, Intermediate, Advanced)? Beginner

Lesson		Comments
Introduction		• Intro page is easy to navigate for students who can read- I would assume students who cannot read are being guided by a teacher? • The first video is more suitable for upper age groups, younger students may not understand the meaning of STEM after watching. • The other 3 videos are engaging- the length is good, any longer and you might lose the younger students
Level 1	Lesson 1	• Step 3 - might need more child friendly language / more simple direction. Younger students will need more specific words, and less is more with the younger students. Be direct in what you want them to do. • Step 4 does a great job of using simple direction to guide students. I think they should be able to follow these steps without problem.
	Lesson 2	• Step 2- again, may need more child friendly language. Students in the upper age levels will understand, but the younger students will not- and might not even read it. • Step 3- looks great! The pictures and simple definitions will benefit all students.
	Lesson 3	• I like that you didn’t include any words with the images of building the robot. I think this keeps the project more open ended and allows students to figure it out using problem solving. • As with the other lessons, I would assume that the younger students are assisted with this lesson? If not, they might have a hard time following step by step directions simply because there are a lot of steps to follow.

	Lesson 4	• The challenges are fun, easy and engaging for students- I think they will have a lot of fun searching for items around the room and trying them!
Level 2	Lesson 1	• Step 3- do they add those steps from top to bottom, or bottom to top? • This lesson I would think might take quite a bit of time to play around with, trial and error, etc.
	Lesson 2	• Most children have a bike, or have seen a bike in real life or on TV, so I think they can relate to this lesson and think more about how an object like a bike really works.
	Lesson 3	• Simple instructions that seem easy to follow independently with older students. Younger students will need guidance with the terminology of the parts.
	Lesson 4	• I like that you provided hints. Hints are always helpful when trying something new, whether you're 6 years old or 60.
Comments on:	Layout	• Easy to navigate • Consistent color scheme, bright and appealing • The arrows when used are helpful • The simplicity of it is beneficial. There's no question of where to go next.
	Age Appropriateness	• Some students will need help with reading and navigating, especially if they are not familiar with technology • The age group of 6-10 contains a vast amount of developmental differences. Thinking 1st grade to 5th grade… but one thing that is consistent among children in general is that less is more, and simple is best. Kids tend to skip the reading and go straight to the videos. • The child friendly sites are great- the scratch site with the cat is fun and engaging for all ages.
	Potential Engagement and Interactiveness (will the kids get bored?)	• I think the way you keep the layout consistent with the videos is important. This will help to ease any confusion. With younger students, some kind of a fun graphic or pictures might be helpful to keep engagement, but overall I think they will do just fine.

Miscellaneous Feedback	• Overall, I think the website is fun and easy to navigate. I think that younger students will have a hard time with this program if they are working by themselves due to the fact that there are a lot of steps to follow and specific directions. If they are working with an adult and it is appropriately paced, I think it will work fine. • Do you provide a pacing guide with this? For example- on Day 1 do lessons x, y, z. Day 2 do lessons a, b, c. Something to think about- children might run out of stamina trying to do too much in one sitting.

Educator C

How many years have you been teaching? 16

What subjects have you taught? K, 1, 3, 4, (Language arts, Math, Science, Social Studies)

One a scale of 1-5 how comfortable are you with online learning (1-never used it, 5-use it all the time)? 3

Would you consider yourself a STEM or non-STEM educator? STEM (actually STEAM, arts included)

On a scale of 1-5, what would you consider your proficiency with robotics in the classroom (1-never used them, 5-could create your own curriculum)? 1

Please write your comments and feedback in the corresponding box:

Which section are you providing feedback for (Beginner, Intermediate, Advanced)? Beginner

Lesson	Comments
Introduction	• Video - Stem, What is it and Why is it Important - Great introduction • Video - What is an Engineer? - Crash Course Kids videos are better for 6th grade and middle school - the narrator talks too fast (that is her thing- to give you a lot of information quickly) but kids can't absorb it. I showed a Crash Course video to my 4th graders this year about the phases of the moon (or something similar) and they were really lost. Especially English Language Learners and Students

		With Disabilities need slower media and explanations of academic vocabulary. ● Video - Real Life Robotics- Sci-Sho Kids - goes fast too, but good, teachers would have to stop it frequently to recap ● Video - Ready, Set, Robot, Crash Course Kids - This one is probably more accessible to kids. The beginning is good, it gets confusing at the chart with variables and fixed variables - few grade schoolers will be familiar with that (maybe 5th and 6th graders would have heard these terms) and it is a difficult concept which would need separate lessons. It's still a worthwhile video
Level 1	Lesson 1	● Scratch video, What is Programming? The voice is difficult to understand - I wasn't sure if it was a genuine accent or a silly character voice. My Tamil-speaking students would be super-excited to see the Tamil script though! Any connection to student's home culture makes things much more relevant and interesting to them. ● Step 2 - very clear - specific instructions for the robot that kids can understand ● Step 3 - most kids will love this!! They will be laughing at how hard it is to give your friend step-by-step dance instructions. K-1 may have difficulty with this - you can't really have them write instructions for a friend - they could do it verbally. Great to get everyone up, out of their seats! ● Step 4 - Video - Try Programming Using Scratch - This is a great video - short so they don't lose track of what's going on or what the point is. ● Motion Blocks video with Heather is also very good and easy for kids to follow ● Watch This Video and Make Your own Dance Party - Best video!!! This video pulls it altogether and goes at a perfect pace for young kids. ● In general, I would show the videos whole group on the Smartboard, as opposed to having kids watch them individually at their own computers. This allows the teacher to monitor for understanding and to stop the videos to clarify or emphasize things.
	Lesson 2	● Step 1Simple Machines for Kids - Clarendon Learning - Great video that goes at a good pace for kids and is interesting ● Step 2 Build 3 Simple Machines with Vex - Teacher should show and go over how to read and use this kind of instructions. Kids who build Lego or similar

		kits will know how to read them - other students will be lost. Teachers will need to point out things like, first they show you teh pieces you need and how many you need of each piece is indicated by the “times” sign, or X. This would be a good lesson to call on a couple parent volunteers to help pairs or small groups of students. Kids will LOVE doing this! ● Step 3 - Find some simple machines in robots - Wheel and axle picture doesn’t show the axle clearly. Wedge - change wording?? A plow is a wedge on the front of a truck or robot. Lever - change wording?? A lever, such as a robot’s arm, can be used to lift things. ● Step 4 - Good, call on a few students to share, then show examples ot have students look at them on their own computers
	Lesson 3	● Checklist - clear ● Part 1 -Build a base - clear ● Part 2 Build the lift - clear ● Part 3 - clear, great step-by-step pictures ● Part 4 - ok, kids who don’t read well will need support ● Great brainstorm and discussion questions ● In general Lesson is too difficult for students lower than grade 3 to follow independently. Grades K-2, and possibly 3, will need an adult with each pair of students
	Lesson 4	● Step 1 - Fabulous!! This is going to get kids so excited about robotics! Teachers of younger kids will want to read these instructions to the whole group before setting kids loose! ● Step 2 - Let’s Talk to Robbie...May want to do this whole group and definitely read Testing is Important to the class to make sure everyone read it!
Level 2	Lesson 1	● Step 1 - video on loops and accompanying text - as clear as possible for a difficult concept. Tricky vocabulary - function, syntax Can connect to what students know about patterns in math - they study repeating patterns, with a core or base, starting in K ● Step 2 - missing? ● Step 3 - Scratch - Put a Loop in Our Code - This is too hard for third grade and below to read. At least third grade could follow step-by-step whole group - with teacher modeling what to do on the Smartboard

	Lesson 2	• Step 1 - How Does It Work video from Houston Children's Museum - clear for kids third grade and up to understand Gear up/gear down difficult concept btu later definitions and videos make it clear • Step 2 - Let's think about where we find gears - Just pictures - Maybe make it into a discussion question or go visit the school custodian to look at her ride-on mower or other place in the school where kids can look at real gears - egg beater? • Step 3 - Look at gears in robots - maybe combine with step 2? • Step 4 - How Can we use Gears? - Good definitions except for torque - kids don't know what force is - Is there a practical situation you could give as an example to explain torque? • Step 5 - Bike Gears - Good bike gear video! Are there real model gears kids can use (like the ones pictured in the Houston Children's Museum video so they can really see and learn the concept of gearing up/down. I think this lesson needs a hands-on component for kids to understand these concepts.
	Lesson 3	• Part 1 and 2 - Good to link to previous instructions • Part 3 - Make some changes - In step 1, remove the base of the lift, it's unclear to me why it says: 2X10 beams - I'm not sure if students are adding these or removing them or what. The rest of the directions are clear, but I think will be tough for kids grade 3 and below. • This would be another lesson to have parent volunteers to offer kids support
	Lesson 4	• Step 1 - Loops - Can you link the instructional videos on Loops from the original Loops lesson in case they forgot the steps? • Step 2 - Change image of female robot - those breasts are going to make all genders of young kids uncomfortable!! • Great lesson!!! Lots of hands-on!
Comments on:	Layout	• The layout and colors of these lessons are beautiful • The slides with arrows are easy to follow
	Age Appropriateness	I incorporated comments about age-appropriateness as I went along. Overall, I think the lessons would be too challenging for an average class of k-1, or even 2nd grade students. I think the sweet spot for these lessons is 4-6th

		grade.
	Potential Engagement and Interactiveness (will the kids get bored?)	The kids will absolutely not get bored!! Level 2/ Lesson 2 could use a hands-on component - I made suggestions for that in the actual lesson.
Miscellaneous Feedback		These are great lesson plans! I actually learned a lot. I felt that I could implement them even though I don't have any experience with robotics or programming. I would love to share these with the STEAM teacher at my school!

Educator D

How many years have you been teaching? 2 years

What subjects have you taught? Science and Social Studies

One a scale of 1-5 how comfortable are you with online learning (1-never used it, 5-use it all the time)? 5

Would you consider yourself a STEM or non-STEM educator? STEM educator

On a scale of 1-5, what would you consider your proficiency with robotics in the classroom (1-never used them, 5-could create your own curriculum)? 4

Please write your comments and feedback in the corresponding box:

Which section are you providing feedback for (Beginner, Intermediate, Advanced)? Beginner

Lesson	Comments
Introduction	Informative videos to introduce the general topic of STEM before breaking down to robotics. I noticed the last video (about the Engineering Process) has subtitles not in English. Was this on purpose? Showing English subtitles are helpful to expose students to the spelling of content specific vocabulary words: increase exposure and familiarity of words they will be using. These

		subtitles (unless in their native language) may be distracting from the content of the video. The breakdown of the introduction is very simple to follow!
Level 1	Lesson 1	The dance steps activity is great to connect movement with the concept of coding. It is very relatable for all students regardless of learning challenges. The dance visual is helpful to get ideas flowing. Including the "code" to make the robot dance is key supporting your visual learnings and for students to explicitly see what you are describing. *_The yellow font is difficult to read, perhaps switching to the orange tone you are using on the page may be a deep enough contrast against the white to better read the words._ For the directions "Click on the different blue motion blocks to see how each one makes the cat sprite move." The font color for the word "blue", is difficult to read in contrast to the color of the background. Adding the optional challenge is very enticing to try! I found this entire page user friendly, relevant to the content, and challenge appropriate with options.
	Lesson 2	Great start by showing students how simple machines are used in their daily life. Great image and definition of the vocabulary words. Interactive display of additional examples of simple machines. Very engaging!

	Lesson 3	Including pictures of the pieces is visually supportive. You should include the letter of each piece to help guide students. Is it possible to include a video with how you assembled each step? Imagine how would you teach these steps to students in a class. You would model it aloud (speaking each step), then having students try on their own following a written copy of the steps. By including a video, students will be able to rewind to listen again when needed. By including written, visually based students who need additional explicit steps. Also, for visual consistancy, the numbers of each step in a phase should be in the same place (i.e. all upper left corner or lower left corner, etc.). Part 4 is very thoroughly explained by displaying the visual with the red circle to see what to click in addition to written directions.
	Lesson 4	The conversation between Robbie the Robot and his friends is helpful to understand the importance of testing to help improve your work. It is cute to include a badge for completing the first level! :)
Level 2	Lesson 1	The recap at the beginning is a useful refresher for the students. However, I would recommend reformatting because the statements are too close together making it difficult to read. Either add another space between each new thoughts or change the font size for each thought to be only one line. Love the addition of the link back to the “Beginner Level 1” for students who need support.
	Lesson 2	For step 4, I agree it is important to define important features of each use of the gears. However the display of content for this step is very overwhelming and distracting from the purpose behind it. From my understanding, at PAY they refer to bicycles as cycles with a specific coach. To be personal with PAY you could use these terms. Is it possible to get a video of someone from PAY using their cycle? If so, you could show the new video with the caption of “See how coach is using gears every day with his cycle”.

	Lesson 3	Part 3, Step 1: rephrase what 2x10 beams means "Remove the base of the lift, these are the 2x 10 beams." This page may benefit from a video of how to do each step in addition to the explanation you have already included. This addition would help teachers, who may have little experience with engineering, supporting students too.
	Lesson 4	Including
Comments on:	Layout	The website is very easy to navigate with clear directions and visual aids for support. Visually appealing with color coordination and images. Suggestion: if the site is used for students, it is common practice to display words with fonts which model the correct way to write letters. It is especially important for developing writers to be exposed to the properly written letters. I tend to use Comic Sans or Short Stack.
	Age Appropriateness	Would students aged 6-10 be recommended to complete all of the Beginners Levels? If so, the concepts are engaging. And the younger students will be eager to participate. However the content is too much to completely independently. If these lessons were completed in a STEM class, I would want students to complete the coding activities after watching me model, then we will do as a class, followed by a partner before they are able to complete independently. These are the scaffolding stages. The inclusion of a page dedicated to vocabulary may be an asset to support English Language Learning individuals.
	Potential Engagement and Interactiveness (will the kids get bored?)	Add a check in quiz (multiple choice) for students to respond to based on what they learned in the videos.

Miscellaneous Feedback	Is this website made specifically for P.A.Y.? If so, will it be a private site where P.A.Y. will have to access it with a password? To keep students engaged with content, you want to make the content relatable. A beneficial way to do this is by showing videos with people, places, and things these students can personally connect with. For example, pictures of students working should look like the students who will be accessing the website. Would students be accessing this website? Will this website serve as a teacher resource when planning lessons on robotics? Or will it serve as a supplemental resource/activity during lessons? I appreciate adding the teacher perspective on this work to review for content accessibility and review of facts. Have you thought about having the WPI students who worked with P.A.Y. last year to provide a personal touch based on their experience with the students and the demeanour of the program.

This website shows a great amount of research and effort! Truly remarkable!! Please let me know how I can assist moving forward. :)

Educator E

How many years have you been teaching? 8 yrs

What subjects have you taught? CAD, Engineering, Architecture

One a scale of 1-5 how comfortable are you with online learning (1-never used it, 5-use it all the time)? 5

Would you consider yourself a STEM or non-STEM educator? STEM

On a scale of 1-5, what would you consider your proficiency with robotics in the classroom (1-never used them, 5-could create your own curriculum)? 5

Please write your comments and feedback in the corresponding box:

Which section are you providing feedback for (Beginner, Intermediate, Advanced)?

INTERMEDIATE

Lesson		Comments
Introduction		The image for the Engineering Design Process could be better - it looks like an image for a math class.
Level 1	Lesson 1	-BrainPop video is GREAT! -Maybe the "programming Vocab" link could be more of an interactive quiz to check for understanding rather than simply a list? -Step3: It may be a stretch to assume that the participants will be able to jump from Step 2 to Step 3 without a little more instructions. Maybe you could use Google Screencastify to create a follow-along video (or maybe the instructional video already exists made by scratch) so that participants know how to create code in Scratch and change backgrounds. -Step 4: Again, a set of instructions (ideally a video) would be very helpful if you want participants to be able to get through the entire activity. If kids get stuck, they won't be able to continue. If you don't want to do videos, maybe you could have the answer key somewhere, which consists of an image of the code needed to complete the challenge. -Step5 - Loops - I clicked on this and felt a little lost. There was some content in here that probably should've been placed under Steps 3 & 4. I guess I'm also confused because it seems that you now want the participants to use the Loop commands within scratch, but you wanted them to simply use move and turn commands before this? But then the activities under "Step 5: Loops" are the same as steps 3 & 4 prior to step 5. Basically the loops part of Lesson 1 seems to be somewhat lost because it seems that steps 2-4 were more important since they were large rows on the site but Step 5 was a half of a row.
	Lesson 2	Seems much easier and has no active participant steps, while Lesson 1 was packed with activities.
	Lesson 3	Under Step 1, you reference the engineering notebook. You may want to link to the same set of instructions on how to make an engineering notebook as was under the intro section, since not everyone probably clicked on that. -Under step 2, you say that Robbie "isn't strong enough" to move a heavy object, so I am right now under the impression that I need to worry about how strong my

		drivetrain will be, but I am guessing that all the participants need to design is some kind of attachment in the front that acts like a bulldozer. It would help to know what type of object we have to move so that we can design the attachment properly (is it something small or large?). If you are letting them choose, say that so that they aren't wondering.
	Lesson 4	I don't remember seeing a step where you had participants actually write a program for the VEX robot? - Actually I went back and found it under step3, bullet 3. All it says is "Program your robot to move forward", but do participants already know how to program their VEX robots? All I have seen so far is programming using Scratch. Step 4 - test the model: #3 says "Press the checkmark button" - would it help to have an image of the checkmark button? Or maybe you are assuming participants already know VEX well enough? Step 5: Record - you may want to give an example of what someone would record for this. Say something like "the robot moved forward until it hit the obstacle and then it's wheels spun in place" in handwritten font
Level 2	Lesson 1	Step2: Let's head over to scratch… the link didn't work properly. It took me to Scratch but then scratch said "Whoops! Our server is scratching its head". Maybe the program has to be public?
	Lesson 2	Step 2 - Do you want them to do the gear simulator in the VEX video? I'm guessing not since Step 2 says "Watch" the video, but the video says to do the work. You just may want to make sure it's clear if you want them to do it. -I like the blank boxes at the end that reveal the answers. Better than simply telling participants the info!
	Lesson 3	Like Level 1, I think it would help if you told participants what the debris is - is there a lot of it so they'll have to either move a lot or make a lot of trips? Is it heavy, is it large, etc? If this lesson is about conditional statements, then maybe you need to make it clear that the robot will be looking to see if there is any debris still left, if so then run the program again, if not, then it can stop?
	Lesson 4	OK, I just got to lesson 4 and now I see the answers to the question I asked above. These parameters should be in lesson 3 where you asked participants to brainstorm and then make a model. Also, is there a sensor that the VEX robots will be using? If so, do participants know how to use a sensor?

Comments on:	Layout	-I really like the overall design of the website with the colors and blobs and animations, etc. Great look to the site! -As I said earlier, the layout for Level 1, Lesson 1 gets a bit confusing. I thought I was stuck in a loop myself at first! -Logically laid out to navigate to and from different lessons. It was easy for me to go back if I wanted to reread something.
	Age Appropriateness	Seems perfect - not too elementary, but still engaging. You offer up a lot of vocabulary, maybe you need some more 'checks for understanding" in some form of a quiz or even those blocks that change from blank to the answer (like Level 2, lesson 2)
	Potential Engagement and Interactiveness (will the kids get bored?)	-Some sections (such as level 1, lesson 2) have no engagement and it's all simply reading the info. Some other sections have a lot of engagement. -Also, there seemed to be a lot of steps in Level 1, Lesson 1, but then not so much later on, even though the concepts get harder. Maybe they should revisit the same scratch program as they progress through. So for example, you have the cat walk through a maze. Maybe they could learn about lops and conditional statements so that as the cat moves autonomously through the maze, it is checking if it touches the black maze wall, if so it then backs up and turns 90deg and then proceeds straight again. This would then help participants with your final debris challenge since the VEX robot in your challenge also had to stay inside boundaries. Therefore it's the same type of movements required
Miscellaneous Feedback		-It seems that you spent more time on explaining lesson 1 in level 1 than the rest (there are 5 steps, each requiring completion of some activity) -I really like how you've broken up the levels into two distinct goals (loops and conditional statements) as well as broken up each level into programming-mechanical-challenge steps. It makes it easy to follow. -Was the goal for level 1 to learn loops? If so, it seems that your VEX challenge doesn't require a loop. Maybe you could have the robot drive in a square with the obstacle and end up where it started to force them to use a loop in VEX. -I think you need to describe the two VEX challenges in more detail so that participants know what their robot has to do. -Sorry if there seems to be a lot of items to be fixed. It looks great overall, but I just wanted you to know where I felt confused so that hopefully it's clearer for your participants. Great job overall!

<u>Educator F</u>

How many years have you been teaching? 15

What subjects have you taught? Intro to Programming, Media Literacy, AP Computer Science Principles

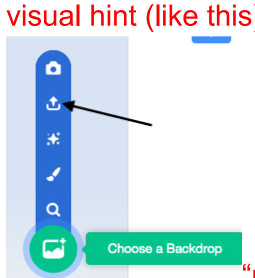
One a scale of 1-5 how comfortable are you with online learning (1-never used it, 5-use it all the time)? 5

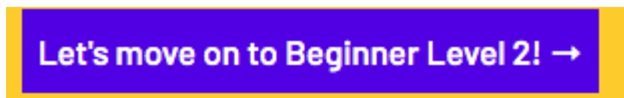
Would you consider yourself a STEM or non-STEM educator? STEM

On a scale of 1-5, what would you consider your proficiency with robotics in the classroom (1-never used them, 5-could create your own curriculum)? 5

Please write your comments and feedback in the corresponding box:

Which section are you providing feedback for (Beginner, Intermediate, Advanced)?

Lesson		Comments
Introduction		
Level 1	Lesson 1	RE: Step 1: It would be helpful to add a “back” button to return to the Lesson page from Vocab. RE: Step 4: Because the racetrack images actually need to be saved and then uploaded as a backdrop, it might be helpful if instructions were a bit more specific -- at least for a beginner. A Scratch beginner might find it helpful to see a visual hint (like this) as to where to find the  “upload” icon. Same for “Challenge 2”
	Lesson 2	No comments

	Lesson 3	No comments
	Lesson 4	Correct "build" to "built" "Now that you have build a robot" RE: Step 4: Recommend repeating a positive test a few times to be sure it's not a fluke -- Just as you would run several trials on a "first time fail" (maybe the failure was due to an obstruction in robot's path, loose mechanism, etc.) it's good practice to run several trials on a "first time success" to establish a confidence factor. RE: Step 5: Correct button to read "Let's move on to Intermediate Level 2" as opposed to: 
Level 2	Lesson 1	RE: Step 2: It appears that the link is broken: 
	Lesson 2	RE: Step 5: Scenarios are very effective. Perhaps add one more for one-to-one ratio - 3 gear ratios/3 scenarios
	Lesson 3	RE: Step 3: The nature of the debris is a consideration for the design of the attachment. The nature of the debris isn't revealed until Lesson 4, after the initial design and build phases have been completed. Should we design a plow-type, scooper or grabber arm? Some direction as to the shape or weight of the "debris" would be helpful; i.e., round, long and thin, round and heavy, irregularly-shaped, etc.
	Lesson 4	No comments

Comments on:	Layout	You have admirably designed for a wide range of ages 6-18. To my eye, the visual presentation of the site tends to cater to the younger ages. Web designers suggest a 60-30-10 rule - 60% of the website should be one color; utilize 30% of a different color for headings, sections, etc.; and 10% for highlighting. Maybe cater to the audience somewhere in the mid-range versus the elementary level?
	Age Appropriateness	See above
	Potential Engagement and Interactiveness (will the kids get bored?)	In my experience, the more hands-on demonstrations included, the better students grasp the concept. If you have the ability to add to Steps, perhaps a couple of instructions to make a change on their robot; i.e., the size of the drive gear (for example), run it, observe what happens? Maybe a “Try It” in Lesson 2, Step 3; or anywhere else it seems appropriate to have the student demonstrate to themselves the concept. This would also break-up the amount of straight reading from the screen.
Miscellaneous Feedback		The Virtual Robotics Curriculum is creative and very well-done. I am curious as to what the classroom environment would be. It seems that a moderator or facilitator would be needed especially in the final construction site debris exercise. The mention of “team” and the instruction to observe other robots implies a classroom set up, but a virtual environment would not <u>necessarily</u> provide for these things. Supplemental documentation to this Curriculum would most likely include guidelines for delivery. Best of luck with the project!

<u>Educator G</u>

How many years have you been teaching? 21

What subjects have you taught? English, Civics, U.S. History

One a scale of 1-5 how comfortable are you with online learning (1-never used it, 5-use it all the time)? 4

Would you consider yourself a STEM or non-STEM educator? Non-STEM educator

On a scale of 1-5, what would you consider your proficiency with robotics in the classroom (1-never used them, 5-could create your own curriculum)? 1

Please write your comments and feedback in the corresponding box:

Which section are you providing feedback for (Beginner, Intermediate, Advanced)? Intermediate

Lesson		Comments
Introduction		I like the intro section. I think it is well organized and I liked the linked video. It is a good length- not too long.
Level 1	Lesson 1	Good idea to have the video and vocab. Once you open the vocab you do not have a back button to access- may want to add that so it makes site navigation easier I liked that there were a lot of opportunities to try different programming challenges. The links to important vocabulary with videos are very helpful The lesson is well organized and easy to follow
	Lesson 2	Good review of vocabulary and link to video refresher Clear directions and good use of visuals Easy link to next lesson at bottom of page
	Lesson 3	Easy to click on link for pages in manual I like the ideas for the design process journal entries Good link at end to lesson 4
	Lesson 4	Easy to follow steps I like the link for downloading help Link at end to level 2 is helpful
Level 2	Lesson 1	Informational video is helpful Practice opportunities are good to reinforce new concepts Good link to lesson 2 at bottom
	Lesson 2	Helpful review video at beginning of lesson I like the scenarios for students to discuss with a partner I like how the kids are able to check their answers afterwards Link to lesson 3 at bottom is helpful

	Lesson 3	Good links to the build guide at start of lesson Organized and easy to follow Link to lesson 4 included
	Lesson 4	Helpful instructional video Good discussion questions for students to do with teammates Nice journal entry ideas Link to Advanced level at the end
Comments on:	Layout	I really liked the layout. I like how all the lessons are formatted in a similar way that will be easy for students to follow. I like that most lessons include short informational videos.
	Age Appropriateness	This is definitely age appropriate for intermediate students.
	Potential Engagement and Interactiveness (will the kids get bored?)	Since this is a very hands-on lesson for kids, I think it is of high interest. I like the practice activities, video links, partner discussion questions It is doubtful that students will get bored
Miscellaneous Feedback		I think this is a very organized program. You use the same formatting for each of the lessons which is very helpful for students. I think this will help teach students in an age appropriate way. You included a lot of resources such as video links, vocabulary review, and practice activities. Well done!!!

Educator H

How many years have you been teaching? 26 years

What subjects have you taught? Programming, software engineering, web design, systems analysis, database administration and various business courses

One a scale of 1-5 how comfortable are you with online learning (1-never used it, 5-use it all the time)? 5

Would you consider yourself a STEM or non-STEM educator? both

On a scale of 1-5, what would you consider your proficiency with robotics in the classroom (1-never used them, 5-could create your own curriculum)? 2

Please write your comments and feedback in the corresponding box:

Which section are you providing feedback for (Beginner, Intermediate, Advanced)?

Lesson		Comments
Introduction		Good intro video; where does software engineering fit? Should WPI be spelled out under the What is Robotics video? Can't assume everyone knows who you are.
Level 1	Lesson 1	Flow of steps should be consistent visually. Step 2 at the same margin as Step 1, etc. and really should be consistent . I like the look of Step 2 and 3. Step 1 should follow the same format. Isn't there really a 4th step? The section that starts "..now that you understand how the sensors work, …"
	Lesson 2	Great use of mini-question for self-assessment of content understanding with the "Think About It" mouse-over. Recommendation: Reword to reinforce topic in Lesson 2: "Why are Mechanical Forces important for robotics?"
	Lesson 3	No issues / suggestions here
	Lesson 4	Where is Step 1? Step 3? Typo: Step 4 #2 "challenge"
Level 2	Lesson 1	Your steps start out visually consistent, then Step 4 is over to the right. Stay consistent with Steps. Summarize with debugging at the bottom for better flow.
	Lesson 2	No issues - love all the videos!

	Lesson 3	No issues
	Lesson 4	No issues
Comments on:	Layout	Some work needed for consistent flow especially when lessons have numbered steps
	Age Appropriateness	Yes. I also like references given for refreshers on coding.
	Potential Engagement and Interactiveness (will the kids get bored?)	I do not believe so for your Advanced group. Great pace of content with excellent use of videos to support concepts.
Miscellaneous Feedback		Very impressive. Congrats to your group on a well-constructed project. Keep up the great work.

Educator I

How many years have you been teaching? 23 years

What subjects have you taught? Math, Physics, Engineering

One a scale of 1-5 how comfortable are you with online learning (1-never used it, 5-use it all the time)? 5

Would you consider yourself a STEM or non-STEM educator? STEM

On a scale of 1-5, what would you consider your proficiency with robotics in the classroom (1-never used them, 5-could create your own curriculum)? 5

Please write your comments and feedback in the corresponding box:

Which section are you providing feedback for (Beginner, Intermediate, Advanced)?

Lesson		Comments
Introduction		The front page does not indicate that there are pull down menus for each level. You might think about changing the color to show that there is more there. There is no back button when you view the engineering notebook page. Make sure that there is a back button in each location that is accessed off of the main page.
Level 1	Lesson 1	Everywhere the student needs to write something down in their engineering notebook should be a distinctive color. Make sure that they are writing something down in each section about what they learned including any definitions, drawings, etc. An engineering journal should be an instructional guide for anyone to be able to repeat the design…. Also a way to make students think about what they learned in each lesson/day.
	Lesson 2	
	Lesson 3	Fix the handwritten dimensions on the cube.
	Lesson 4	
Level 2	Lesson 1	
	Lesson 2	Assume that students should just watch the gear introduction video...not as a "refresher" They should be writing down definitions in their notebook. Step 5 you might want to give them a little more practice with gear ratios Step 6 need an example Scenario #1 - remind students to scroll over answers after the question (the instructions are above the area where the questions are located and the student might have missed

		that part)
	Lesson 3	Step 3...what are you trying to do here? Do the questions on the left flow into each other, or are you expecting them to pick from the ones on the right? Step 3 - Make a model… should this be numbered?
	Lesson 4	Test your robot. Do you want them to create an area with stuff on it? If so, tell them that. At the end of this page, you are asked to click to advanced and it takes you back to the home page?
Comments on:	Layout	Good layout, but why does it scroll back rather than clicking to the top of the next page. Be sure to highlight any area where the engineering notebook is required….actually they should be writing in it at the end of every level, so a reminder would be good before they move onto the next level.
	Age Appropriateness	As long as they have the equipment this will be level appropriate, but you should offer more advanced topics for students who want to do more. You should also supply examples of code that they can use to start the robot (or provide this to the instructor so that they can guide the students for each step of the process)
	Potential Engagement and Interactiveness (will the kids get bored?)	
Miscellaneous Feedback		I think that the picture of the VEX robot on the main page should be at the end, not as a roll-over before you get to the lessons. The "About Us" should be at the bottom of the page, not the first thing that a student sees. Learn more about Age groups here button does not take you anywhere….did you want to include a separate page to indicate ability levels?... if not just take it out… HOME PAGE - Advanced button does not work. WHICH LEVEL - Does not go anywhere… did you intend this to be another link?

Educator J

How many years have you been teaching?

Six
What subjects have you taught?
Chemistry
One a scale of 1-5 how comfortable are you with online learning (1-never used it, 5-use it all the time)?
4
Would you consider yourself a STEM or non-STEM educator?
STEM
On a scale of 1-5, what would you consider your proficiency with robotics in the classroom (1-never used them, 5-could create your own curriculum)?
1

Please write your comments and feedback in the corresponding box:

Which section are you providing feedback for (Beginner, Intermediate, Advanced)?

Lesson		Comments
Introduction		Solid overview of topics to be covered. Consider expanding on engineering notebook so that participants know how to apply it to the lessons they will be engaging in.
Level 1	Lesson 1	Turn "Conditional Statements" and "Loops" to hyperlink to automatically return students to those sections. The Scratch tool is very fun and engaging.
	Lesson 2	This lesson is very well structured but it could use some form of activity to organize all the information in the lesson. Perhaps a graphic organizer or Google form of some sort could be useful.
	Lesson 3	The interactive nature of this lesson is fully appropriate to support the previous lessons. Good
	Lesson 4	Consider making an Engineering Notebook as a shareable e-document. The process is what is being taught so there should be some kind of way to assess the process as well as the final result.
Level 2	Lesson 1	Good use of the software (Scratch) to teach and support its use.

	Lesson 2	If it's possible bring in previous learning from the topic on gears and ask specific questions about the gears they build. The scenarios are great but a way for you to collect and monitor responses may be useful.
	Lesson 3	Maybe have students brainstorm solutions as opposed to simply giving them. This would make the activity more interactive and less about simply reading.
	Lesson 4	On the testing pages it may be helpful to create a simple FAQ of issues that may arise to help them if they are completely stuck.
Comments on:	Layout	The layout was super. It was very well organized which made it very easy to navigate and bounce around from topic to topic.
	Age Appropriateness	This is certainly age appropriate for a motivated and engaged group of students. There is an appropriate amount of independent work time so it's important that your participants are inquisitive and active participants.
	Potential Engagement and Interactiveness (will the kids get bored?)	I don't think they will get bored at all. I would say they would potentially be more frustrated than anything (at the creation process, not the presentation).
Miscellaneous Feedback		Admittedly, I don't know all of the details of how student success will be measured, if at all, but the one thing that appears to be conspicuously absent in the lessons is assessment. Assessing work is really important, and it's not just about grades, but also gives a lot of really useful information to both teacher and student. Informal assessments can help you provide feedback to students as well as help you evaluate the strengths and weaknesses of your program. I'm not saying that you have to give high stakes tests but evaluating student answers to questions can save you a lot of trouble in the end. Overall though you kids did a super job. Your lack of pedagogical education is not evident.

Appendix C: Student Background Survey

Background Knowledge Survey

* Required

Background

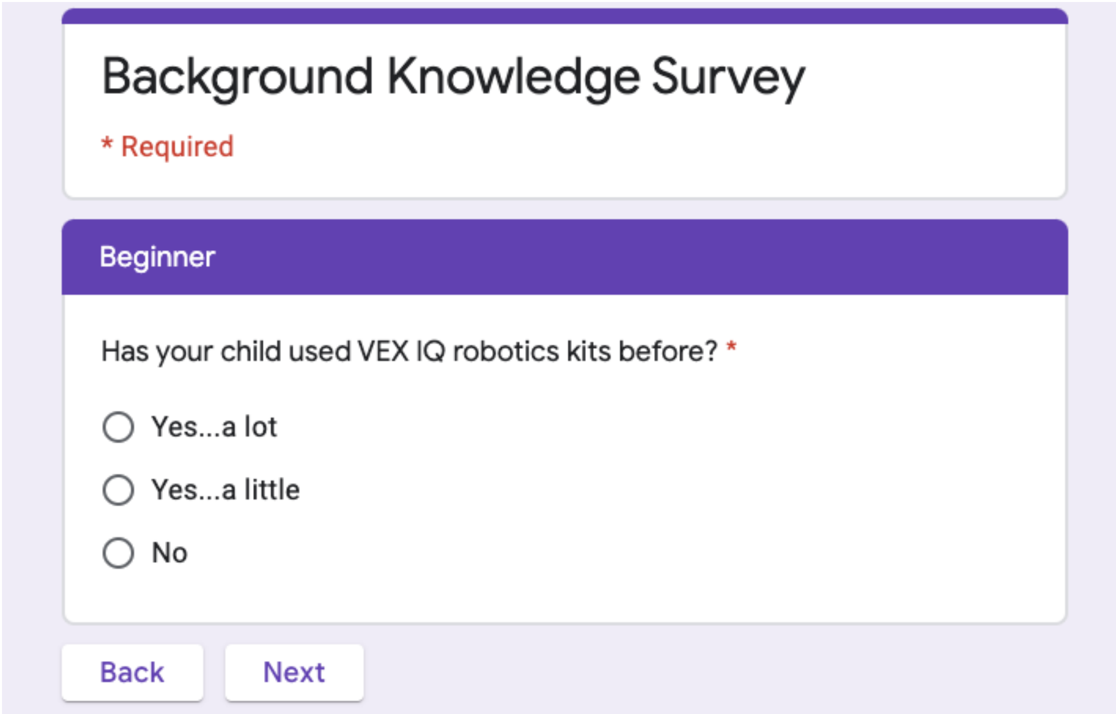
Type the student's first name *

Your answer

What is your child's age? *

- ◯ 6 years old
- ◯ 7 years old
- ◯ 8 years old
- ◯ 9 years old
- ◯ 10 years old
- ◯ 11 years old
- ◯ 12 years old
- ◯ 13 years old
- ◯ 14 years old
- ◯ 15 years old
- ◯ 16 years old
- ◯ 17 years old
- ◯ 18 years old

Back Next



Background Knowledge Survey

* Required

Beginner

Has your child used VEX IQ robotics kits before? *

- Yes...a lot
- Yes...a little
- No

Back Next

Appendix D: Student Background Survey Responses

Type the student's first name	What is your child's age?	Has your child used VEX IQ robotics kits before?
	10 years old	Yes...a lot
	10 years old	Yes...a little
	12 years old	Yes...a little
	10 years old	Yes...a lot
	12 years old	Yes...a lot
	10 years old	No
	10 years old	No
	13 years old	No
	12 years old	Yes...a little
	15 years old	No
	13 years old	Yes...a lot
	12 years old	No
	18 years old	No
	14 years old	Yes...a lot
	17 years old	No

Appendix E: Student Feedback Survey

Feedback Form

Please assist your child in filling out this form after they have completed a few activities! Thank you!

* Required

Type your first name *

Your answer

Which section did you complete? *

- [ ] Beginner
- [ ] Intermediate
- [ ] Advanced

Which lessons did you complete? *

- [ ] Level 1 Lesson 1
- [ ] Level 1 Lesson 2
- [ ] Level 1 Lesson 3
- [ ] Level 1 Lesson 4
- [ ] Level 2 Lesson 1
- [ ] Level 2 Lesson 2
- [ ] Level 2 Lesson 3
- [ ] Level 2 Lesson 4

On a scale of 1-5, how much did you enjoy the lessons?

	1	2	3	4	5	
Did not enjoy it.	○	○	○	○	○	LOVED IT!

On a scale of 1-5, how difficult were the lessons?

	1	2	3	4	5	
SO easy- I breezed through it.	○	○	○	○	○	Too difficult and I could not complete some of the activities.

On a scale of 1-5, how often did you need help from an adult?

	1	2	3	4	5	
I did the entire thing by myself.	○	○	○	○	○	An adult helped me with the entire thing.

Did these lessons make you interested in learning more about robotics?

○ Yes

○ No

What was your favorite part about the lessons?

Your answer

What was your least favorite part about the lessons?

Your answer

Do you have any other comments?

Your answer

Next

Feedback Form

Facilitator Feedback

If you helped your child with the lessons, please fill out this section with your feedback.

How straightforward were the lessons?

	1	2	3	4	5	
It was impossible to follow and understand the activities/material	○	○	○	○	○	The lessons were very easy to follow with no problems

Was there anything you had difficulty assisting your child with?

Your answer

Would this be something you would like to help your child with again?

- ○ Yes
- ○ No
- ○ Other: ____

Do you have any comments on the layout, user friendliness, or age appropriateness?

Your answer

Do you have any additional feedback?

Your answer

Back Submit

Appendix F: Student Feedback Survey Responses

Type your first name	Which section did you complete?	Which lessons did you complete?	On a scale of 1-5, how much did you enjoy the lessons?	On a scale of 1-5, how difficult were the lessons?	On a scale of 1-5, how often did you need help from an adult?	Did these lessons make you interested in learning more about robotics?	What was your favorite part about the lessons?	What was your least favorite part about the lessons?	Do you have any other comments?
	beginner	L1L1, L1L2, L2L1, L2L2	5	2	2	Yes	The walkthroughs and instructions on the lessons.	I can't think of anything except maybe a more detailed survey on placement points.	No, thank you
	beginner	L2L1, L2L2, L2L3, L2L4	3	3	3	No	The programming aspects.	I felt like I already knew about gears and didn't really enjoy that part of the build lesson.	I'd like to learn more about building different structures and adjusting the robot to handle certain tasks. Things like lift mechanisms, picking up objects, drive trains, etc.
		L1L1, L2L1	5	3	1	Yes	Getting to do the conditional coding game in Scratch	That I didn't have the things to do the other lessons	No, I loved it :)
	intermediate	L1L1, L1L2, L2L1, L2L2	5	2	1	Yes	The steps were very clear and simple to understand.	Somethings I already knew.	No, it was great.
	Beginner	L1L2	5	2	5	Yes	Would like to try building a robot.	I didn't have the parts to keep working on it	
	Intermediate	L1L1, L1L2, L1L3	5	3	1	Yes	Everything.	Having to stop because I did not have the VEX IQ kit.	No
	Beginner	L1L1, L1L2, L1L3, L1L4	4	4	3	Yes	scratch	nothing	no
	Intermediate	L1 L1, L1L2, L1L3, L1L4, L2L1, L2L2, L2L3, L2L4	4	3	2	Yes	brain pop	hurting my hands with the plastic tbh, otherwise very nice	website looks very cute 10/10
	Intermediate, Advanced	L1 L1, L1 L2	4	2	1	Yes	learning the diffrent types of engineering and seeing what each type of engineering is for.		no

How straightforward were the lessons?	Was there anything you had difficulty assisting your child with?	Would this be something you would like to help your child with again?	Do you have any comments on the layout, user friendliness, or age appropriateness?	Do you have any additional feedback?
5				
4	No, although he wasn't keen on building the robot because he had done it before.	Yes	Keeping in mind that some kids have already built robots in the past and are struggling with advancing beyond the basics. Scratch was a great addition. He really enjoys programming.	Any detail you could provide upfront on how long to expect the lessons to take would be helpful for a facilitator.
5				
5	Would like to have tried to go further.	Yes	Videos are a good idea.... kids like them! The STEM video was great to have kids do the explanation . The scratch app looked like fun and we'd like to try it!	
4	No	Yes	No.	This was fun, and he'd like to do more.
5	Timing his interest alongside homeschooling	Yes	Well thought out and very age appropriate	We would like to revisit this and finish the lessons.
4	No	Yes	The layout was easy to follow	no