Robotics Education for Middle School Students

An Interactive Qualifying Project Report
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Report Submitted to:

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ABSTRACT

With the constant growth of STEM (Science, Technology, Education, and Mathematics) in the United States, our group partnered with TRUE Robotics to work on implementing more STEM education in middle schools in Worcester, Massachusetts. Through this collaboration, our mission is to work on getting more robotics curriculums in middle schools in Massachusetts by writing a grant proposal to be submitted to funding opportunities. Our team also planned on writing a pilot program for the TRUE Robotics curriculum and robot kits to supply to schools as a trial of their program. This will allow the school to introduce the curriculum to their students and get the central office interested in buying it. For TRUE Robotics to sell its curriculum to more schools, we plan on providing a step-by-step process to get schools interested in their curriculum and get them to buy the product.

ACKNOWLEDGEMENTS

We acknowledge that with the support of many individuals, this project came to completion. Our thanks go out to our project advisor Professor Richard Sisson for making this project become a reality with our team going to him with this idea and making it possible by being our advisor. Through these seven weeks, he provided us with incomparable advice and guidance that made this project successful. Additionally, our team would like to thank TRUE Robotics, Anthony Galgano, and Kwasi Acheampong for accepting this project to work with them and having the same ambition to get STEM education into as many schools as possible.

We would also like to thank others willing to meet with us and give their advice to make our ambitions possible. The professionals responsible for extending their knowledge toward creating a pilot program are listed alphabetically below—a step-by-step process for selling curriculum and writing a grant proposal.

TRUE Robotics

- Kwasi Acheampong – Cofounder
- Anthony Galgano – Founder and President
- Emily Hajko – TRUE Robotics Teacher
- Vanessa Mahoney – TRUE Robotics Teacher

Worcester Polytechnic Institute

- Kathy Chen – Exec Director STEM Education
- Mia Dubosarsky – Director of Professional Development at the STEM Education Center
- Neil Heffernan – Learning Sciences and Technology
- Colleen Shaver – Director of the Robotics Resource Center
- Kenneth Stafford – Adjunct Teaching Professor

- Walter Towner – Associate Teaching Professor

Other Professionals in the Field

- Arlandis Hinton – Sales Representative for Curriculum Associates
- Anne Ludes – Mass Academy Principal

EXECUTIVE SUMMARY

Introduction

There has been an issue arising recently, where there is a struggle with the schools in various areas making STEM education available to students. The general areas where there are struggles with gaining access to a STEM curriculum are in places with low income, and the resources are not readily available to the students. There have been many efforts within the government to aid with the problem, whether by increasing governmental funding for schools or researching this issue. The government helps create a basis for the curriculum, but it is up to outside companies to take those standards and create a curriculum for it. The incoming college students are less likely to pursue studying a STEM topic, which is believed to result from a lack of exposure at a young age. The following steps are to find ways to give the students access to STEM education to see if they want to pursue them in future endeavors.

Background

The team needed to create some background research to gain a basis for the project and find the areas the team could improve and help on. For the project, we needed to ask questions to better understand the problem the team was facing: what is to know about STEM, how is it effective, and what is TRUE Robotics. With these questions, the team will gain a basis to go off of and improve the problem of the lack of STEM education accessibility.

When looking into what STEM consists of, the team needed first to define it; STEM is an acronym for science, technology, engineering, and mathematics, including computer science. STEM is an increasingly important aspect of learning and solutions to problems; this form of education allows students to learn and practice real-world problems and find answers. The educational process looks like students receive a problem; within a group, they find a solution

through various methods, either the engineering or the scientific process. These are what the professionals use when solving a problem. The team continues to ask about the need for STEM education and its impacts. Students are now less likely to be drawn to a discipline of STEM since there is a need for more exposure to it. This leaves out jobs that need to be filled and support in required fields. The team looks at what STEM looks like in the United States. The Department of Education has encouraged STEM education through increased funding and educators' support. The United States has been looking into how the nation has been moving towards automation in manufacturing, creating cleaner energy, and creating new technologies.

With the team looking into the curriculum portion, they need to examine how to ensure the education process is effective. The first steps are to educate ourselves on how is it that children learn. It is found that different types of learning help children comprehend the topics, visual, auditory, tactile, and kinesthetic. Each has its direction of helping the students. Visual learning consists of learning through seeing; the students pay close attention to body language and facial expressions. Auditory learners consume the information by listening and paying close attention to the words being said. Tactile learners get information through touch, like projects. Lastly, kinesthetic learners respond better to information when there is movement and activities to do.

What is TRUE Robotics? The team needed to understand the company to help best answer the question of how to gain more access to STEM for schools. TRUE Robotics is an educational STEM curriculum company that provides schools with a curriculum created by teachers to benefit the students and teachers best using it. They have made a portion of the curriculum to be supported by a robot kit that the students use to experience real-world technology like various sensors, programming, and engineering. The company’s strategy is to

have the students move, build, and learn by completing tasks, creating an immersive process for the students to engage in.

Methodology

The team created an objective list to pursue during this project to encourage the implementation of STEM in the most needed schools. There were six objectives that the team wanted to accomplish and create a plan to achieve; identifying what STEM education is in Massachusetts, identifying who the big players are in STEM education in Massachusetts, determining what schools want in purchasing a curriculum, developing standards on why schools purchase curriculums, create a pilot curriculum, Detailed step by step process on how to get people to buy and reach out to schools. Creating a background of what STEM education looks like in Massachusetts will help a sales representative develop different approaches to make the curriculum available to the schools and wanted by the schools. Looking at the big players of STEM education, the team will be able to understand what has been successful for the companies and where the company is struggling. In looking at large companies like Curriculum Associates, Savvas Learning, OpenSciED, Pearson, and Amplify Science, the team can look at the large scale the companies have been able to be successful at. To better the company's strategy, the team must fully understand which schools seek curriculums to benefit their needs best. With this, the schools can get the best-fitted curriculum, and the students can best help from it. Creating a standard on why schools purchase a curriculum will be essential to understand the process and best approach the schools. The team will continue to meet and interview individuals whose professions revolve around this topic. We wanted to create a pilot program to have the schools test out before committing. This will include a five-hour curriculum containing a differently designed robot, new programming, and scientific challenges. The team, from there,

will create a detailed process for the sales representatives to approach schools. This will consist of various outreach plans such as possible video messages, calling schools directly, and other ways to engage with the administrators with the product.

Results

Research, interviews, discussions, and trial and error allowed our team to produce the results that we concluded with. Our findings could be broken down into three main areas: funding, essential things to include in a curriculum, and resources provided when purchasing a curriculum. When meeting with teachers, sales representatives, principals, etc., they made common points with our team. Professor Heffernan, who is a professor at WPI and founder of AssistMENTS, Mia Dubosarsky, and Kathy Chen, who both work at the STEM education center at WPI, all made it clear that the more that you can provide for free the more schools that you will be able to better, which is why during our IQP we decided to focus on ways to go about funding TRUE Robotics to do just that. While meeting with TRUE Robotics teachers Emily Hajko and Vanessa Mahoney and principal at Mass Academy Anne Ludes as well as Arlandis Hinton, who is a sales representative, they touched on the importance of certain materials to include in the curriculum that all schools are looking for when buying curriculum. This was helpful for our team when creating our pilot curriculum that TRUE Robotics can use to get schools interested in buying their curriculum. While creating this curriculum, we aimed to touch on all the main things these people told us were essential to include. Along with that, they were all able to provide insight on what needs to be added to the curriculums that are out there, and the central point that our team wanted to focus on was the resources that come along with it. Our team took that insight and made sure when creating this curriculum that we made sure that

unique resources like easy access to experts in the field to help them along the process were accessible.

Deliverables

From our results, our team was able to develop deliverables that we would produce by the time our project was over. At the beginning of the project, our deliverables were very different than what they became. The main reason behind this was that we didn't have much research going into this project, and we hadn't met with anyone in the field yet besides Anthony and Kwasi, the founders of TRUE Robotics. When we met with some other professionals in this field, we were able to define the problems with getting more STEM education into schools. This was when our team decided to tailor our deliverables more towards those to make this project more successful and valuable for TRUE Robotics. Our deliverables changed to finding grant funding for TRUE Robotics to give the STEM curriculum to schools that are interested in using it in the classroom and to schools that are also underprivileged and cannot afford to get it in their classrooms. Another of our deliverables is to create a free piolet program with 5 hours' worth of curriculum and a separate robot that isn't in the usual curriculum that TRUE Robotics sells. This will allow schools to see how it works in the classroom for a week and get them interested in getting STEM education into their school if they don't have any. The last deliverable that our team developed was a step-by-step process on how to approach schools and get them interested in getting STEM education in their school. This will be useful material for the TRUE Robotics sales team when contacting schools and pitching their product.

Conclusion

Our team developed solid deliverables through this project to help TRUE Robotics tremendously. We put together our deliverables thoroughly and made them easily changeable for them to change them to their liking and to make them fit however they see fit. Our team would like to thank everyone who helped us along the way and gave us their insight. Without all these people, we would not have been able to put together and create this project without their help. Going into this project, our team didn't know the industry we were getting into, but we knew that there was a significant issue not just in Massachusetts but in the United States with STEM education. By being students at WPI and working with STEM education daily, we understand its importance. Hopefully, we can make a change and better the children in Massachusetts by getting STEM education in their schools.

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ABSTRACT	Harold Wotton	Colby Jones
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EXECUTIVE SUMMARY	Drafted by section	-
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Methodology	Colby Jones	Harold Wotton
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Recommendations	Harold Wotton	Colby Jones
Conclusion	Harold Wotton	Colby Jones
INTRODUCTION	Drafted by All	Harold Wotton
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2.1 What to Know About STEM	Drafted by All	Harold Wotton

2.2 What is STEM?	**Harold Wotton**	**Harold Wotton, Colby Jones**
2.1.2 Why Do We Need STEM?	**Harold Wotton**	**Colby Jones**
2.1.3 The Status of STEM in the United States	**Harold Wotton**	**Harold Wotton, Colby Jones**
2.2 How is it Effective?	**Colby Jones**	**Harold Wotton**
2.2.1 How Do Children Learn	**Colby Jones**	**Harold Wotton**
2.2.2 Project-Based Learning	**Colby Jones**	**Colby Jones, Harold Wotton**
2.2.3 Collaboration and Teamwork	**Colby Jones**	**Harold Wotton**
2.4 TRUE Robotics	**Harold Wotton**	**Colby Jones**
2.4.1 TRUE Robotics Market Research	**Harold Wotton**	**Colby Jones**
2.4.3 Curriculum	**Harold Wotton**	**Colby Jones, Harold Wotton**

2.4.4 Robots	**Harold Wotton**	**Colby Jones**
3.0 METHODOLOGY	**Drafted by Section**	**-**
Introduction	**Harold Wotton**	**Colby Jones**
3.1 Objective 1	**Colby Jones**	**Harold Wotton**
3.2 Objective 2	**Harold Wotton**	**Colby Jones**
3.3 Objective 3	**Colby Jones**	**Harold Wotton**
3.4 Objective 4	**Harold Wotton**	**Colby Jones**
3.5 Objective 5	**Colby Jones**	**Harold Wotton**
3.6 Objective 6	**Harold Wotton**	**Colby Jones**
4.0 RESULTS AND RECOMMENDATIONS	**Drafted by Section**	**-**
4.1 Results	**Harold Wotton**	**Colby Jones**
4.2 Recommendations	**Colby Jones**	**Harold Wotton**
5.0 DELIVERABLES	**Drafted by Section**	**-**
5.1 Developed Pilot Program	**Harold Wotton**	**Colby Jones**

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5.3 Step by Step Process	**Harold Wotton**	**Colby Jones**
6.0 CONCLUSION	**Colby Jones**	**Harold Wotton**
7.0 REFERENCES	**Harold Wotton**	**Colby Jones**
8.0 APPENDICES	**Harold Wotton, Colby Jones**	**Harold Wotton, Colby Jones**

TABLE OF CONTENTS

ABSTRACT.....2

ACKNOWLEDGEMENTS.....3

EXECUTIVE SUMMARY.....5

AUTHORSHIP.....11

LIST OF TABLES.....16

LIST OF FIGURES.....17

1.0 INTRODUCTION.....18

2.0 BACKGROUND.....19

2.1 What to Know About STEM.....20

2.1.1 What is STEM?.....20

2.1.2 Why Do We Need STEM?.....21

2.1.3 The Status of STEM in the United States.....21

2.2 How is it Effective?.....24

2.2.1 How do Children learn?.....24

2.2.2 Project-Based Learning.....25

2.2.3 Collaboration and Teamwork.....25

2.4 TRUE Robotics.....26

2.4.1 TRUE Robotics Market Research.....26

2.4.3 Curriculum.....27

2.4.4 Robots.....28

3.0 METHODOLOGY.....29

3.1 Objective 1: Identifying what STEM Education is in Massachusetts.....30

3.2 Objective 2: Identify Who the Big Players Are in STEM Education in Massachusetts.....31

3.3 Objective 3: Determine what schools want in purchasing a curriculum.....33

3.4 Objective 4: Develop the standards on why schools purchase curriculums.....33

3.5 Objective 5: Develop a pilot curriculum that comes with 5 hours' worth of material,.....34

which includes a building day, two programming days, and a simple science day.....34

3.6 Objective 6: Detailed step-by-step process on how to get people to buy and reach out to schools (How to approach schools) and how to get that initial meeting with schools.....35

4.0 RESULTS AND RECOMMENDATIONS.....36

4.1 RESULTS.....36

4.2 RECOMMENDATIONS.....41

5.0 DELIVERABLES..... 43
6.0 CONCLUSION..... 48
7.0 REFERENCES..... 49
8.0 APPENDICES..... 51

LIST OF TABLES

Table 1. Breakdown of 5 hours of pilot material

LIST OF FIGURES

Figure 1. Axle Robot Developed by TRUE Robotics

Figure 2. Pilot Robot our Team Developed for the Curriculum.

Figure 3. Swervy Robot that TRUE Robotics developed that was used in the Curriculum.

1.0 INTRODUCTION

This has been a significant initiative in getting STEM education into more nationwide schools in the past few years. The United States Department of Education has given hundreds of millions of dollars to different organizations to support STEM education in schools. Some of the organizations that receive this funding support schools financially to bring STEM curricula into their classrooms that they cannot afford within their budget. Other organizations exist for teachers to learn the material from experts in the field they will teach to their classes. This allows them to teach the material to the best of their ability, so the children leave the classroom retaining all the material they have learned. The next step is supporting children going to college and pursuing STEM degrees; other organizations help schools guide their children in the right direction. They provide them with all the materials they need to apply for college, along with counselors. Additionally, they assist underprivileged students in paying for college once they decide where to go.

The United States Department of Education has recognized the need for STEM Education in light of the direction in which today's society is moving. There is a low demand for students wanting to pursue an education in STEM. When students reach college, fewer than 20 percent of students enroll in STEM-related majors. This is a significant problem since STEM occupations in the workforce are projected to grow 10.8 percent in the next decade, while all other occupations are only projected to grow 4.9 percent (Barone, 2023).

2.0 BACKGROUND

In this section, we will discuss what STEM, Science, Technology, Engineering, and Mathematics are, and their importance today. With technology advancing daily, more people are using STEM and revolutionizing it. It is vital that more people start getting into STEM since it is scaling at an exponential rate, and the world needs more people to work in these fields, which are changing the world every day. Most importantly, we will discuss why we need STEM and how it is effective in the classroom, teaching students more than just STEM, but also real-life skills that will help them outside of school.

2.1 What to Know About STEM

The concepts of STEM are ubiquitous. Whether you are working in a cubicle or a warehouse, STEM surrounds you. The computer you use in your cubicle was engineered to perform the tasks you can do on it. In the warehouse, you have access to forklifts, packaging machines, and possibly robots, depending on the company you work for. These are just two examples of how STEM is present in our daily lives. By understanding this, we can delve deeper into why STEM education is crucial and why it needs to be taught to more children worldwide.

2.1.1 What is STEM?

As mentioned before, STEM is an acronym for science, technology, engineering, and mathematics, including computer science. While these are the five things included in STEM, there are many more disciplines that come with learning them. According to Wyatt Dalton, "At its core, STEM is a teaching philosophy that integrates all four disciplines into a single, cross-disciplinary program that offers instruction in real-world (as opposed to purely academic) applications and teaching methods" (Dalton, 4). Initially, STEM is very dense with math and science, and then it becomes very engineering and technology-heavy. This is because kids need a

strong foundation and background in math and science to understand how engineering and technology work. A significant part of learning math and science is not just learning math or science problems; it's about learning how to solve problems. While you do end up learning math and science problems through this skill, learning this skill is what helps you start thinking like an engineer and understanding technology.

2.1.2 Why Do We Need STEM?

STEM is a crucial aspect of teaching kids real-world concepts. While learning mathematics and science, they also learn to collaborate and think like scientists and engineers. This comes with hands-on experiences when working on projects and experiments in the classroom. To grasp these concepts, they must be introduced early, maximizing opportunities for the workforce and getting them interested in pursuing STEM as a career. The article "What is inquiry-based STEM education and why is it important?" expresses that "The future workforce will require skills and abilities that are often not part of the formal curriculum in traditional school programs. Social and emotional sensing, reasoning, flexibility, creativity, collaborative problem-solving, grit, and resilience will be increasingly important" (McKinsey Global Institute, 1). With the constantly evolving automation and robotics, this aspect is critical to introduce to kids. They need to become proficient at collaboration, an essential aspect of STEM. It will not only benefit their future careers but also greatly affect their personal lives, encouraging them to realize that they can accomplish great things and make a difference.

2.1.3 The Status of STEM in the United States

The status of STEM has been growing exponentially in the United States due to the Department of Education. They have been dedicating millions of dollars every year since 2018 to fund STEM education in schools nationwide. The Biden-Harris Administration started a

coordinating conference in Washington, D.C. called YOU Belong in STEM. This conference is "designed to strengthen Science, Technology, Engineering, and Mathematics (STEM) education nationwide. This new Biden-Harris Administration initiative will help implement and scale equitable, high-quality STEM education for all students from PreK to higher education—regardless of background—to ensure their 21st-century career readiness and global competitiveness" (U.S Department of Education, 1). This is an excellent opportunity for schools to be introduced to this type of learning for their students to prepare them for the workforce. In today's day and age, they need to learn these skills. The world is moving more into automation and robotics every day, and for these kids to become more successful in life, they need to know how to work together and understand these concepts.

With this initiative, the Department of Education, in 2018, dedicated over $279 million in STEM discretionary funds. This was through the secretary's STEM discretionary grant priority, which was able to give out funding to programs like the Education Innovation and Research (EIR), Supporting Effective Educator Development (SEED), Teacher Quality Partnership (TQP), etc.

The EIR program is designed to support and create solutions to educational challenges and help expand many students. They provide funding to "create, develop, implement, replicate, or take to scale entrepreneurial, evidence-based, field-initiated innovations to improve student achievement and attainment for high-need students; and rigorously evaluate such innovations" (Education Innovation and Research, 1). Supporting Effective Educator Development is increasing the number of educators in this field and preparing them to teach the material. This is done through the program "by supporting the implementation of evidence-based practices that

prepare, develop, or enhance the skills of educators. This initiative allows eligible applicants to develop, expand, and evaluate practices that can serve as models to be sustained and disseminated" (Supporting Effective Educator Development Grant Program, 1). This program allows the teachers to be educated to spread their knowledge to other teachers, which helps this initiative grow.

The Teacher Quality Partnership provides for teachers to be trained by highly qualified individuals from different occupations to educate new and prospective teachers to improve classroom student achievement. In 2019, the Department of Education invested $540 million to increase STEM. Some of the programs that this grant money went to in 2019 include Gaining Early Awareness and Readiness for Undergraduate Programs (GEAR-UP), College Assistance Migrant Program (CAMP), and the other programs that were rewarded grant money in the year prior.

The GEAR-UP program is a grant program that provides capital to schools meant for low-income students to prepare them for the next chapter of their lives and introduce them to STEM. The program, "GEAR UP grantees serve an entire cohort of students beginning no later than the seventh grade and follow the cohort through high school. GEAR UP funds also provide college scholarships to low-income students (Gaining Early Awareness and Readiness for Undergraduate Programs, 1).

The other program that receives money from the Department of Education, CAMP, provides "outreach to eligible persons, counseling, tutoring, skills workshops, financial aid stipends, health services, and housing assistance to qualified students during their first year of college (College Assistance)

This is an excellent opportunity to get more children into college that can't afford it and gives them the tools that aren't offered at many schools to apply and get into college. Every year this program can help approximately 2,000 students. In the year 2020, they were able to award $141 million dollars in new grants along with $437 million dollars that were used to continue existing programs. Every year since 2018, they have been able to support more programs to help the increase in STEM, which has been essential in today's world.

2.2 How is it Effective?

In order for a team to understand how to make a curriculum more engaging for teachers and students, they need to understand how children learn and tactics to make the information more productive. Students absorb information in different ways that best suit them and retain that information differently. Through the use of project-based learning, students will be able to work on real-world applications and think like professionals. The foundational needs of the students come from collaboration and teamwork. Looking into the impact of these two topics can help mold the students' skills.

2.2.1 How do Children learn?

Children learn in many ways, but there are four core types of learning: visual, auditory, tactile, and kinesthetic (12). Visual learners respond well to learning through seeing. These children observe their peers' body language and facial expressions. While learning in school, they understand the content when it is demonstrated and described. Auditory learners take in information through listening. They do their best when it comes to discussions and talking about topics. Some tactile learners take in information through touch, with a preference for activities or projects. The main goal of this type of learning is to engage the senses. Kinesthetic learners connect best with children through movement and doing. This approach works best for kids who

struggle with sitting still and need movement. They respond well to hands-on learning. There are different ways to approach the various learning styles, such as giving presentations for auditory learners or having tactile learners engage in activities. The best way to serve children in the classroom is to incorporate a little of each learning type in the curriculum so that students can learn from various methods.

2.2.2 Project-Based Learning

Project-based learning involves working on real-world and meaningful projects to reinforce previously learned lessons or discover new ones. In Massachusetts, each grade level has specific standards for topics that must be covered, such as life sciences, physical science, and Earth's position in the universe, as set by the Massachusetts Department of Elementary and Secondary Education (11). When incorporating project-based learning into the curriculum, teachers must ensure that it aligns with these standards and engages students while they learn the subject matter.

By incorporating project-based learning, students are exposed to real-world problems and develop skills that will be useful in the future, including problem-solving, communication, and teamwork. These skills prepare them for any career path they choose, as they will need to communicate and collaborate with others to solve problems, regardless of the field.

2.2.3 Collaboration and Teamwork

There are essential attributes involved in collaboration and teamwork, and the skills learned while working in a group environment prepare children better for real-world experiences. The combination of group efforts develops skills that children will use in the future, teaching them about communication, problem-solving, and different perspectives on problems.

Through collaboration, children practice communication skills by discussing different solutions to a problem and coming together to decide on the best solution and why. They then have to present that solution to the teacher and the class in a clear and transparent manner that helps the audience understand the problem and the solution. The practice of these skills at a young age prepares them for various scenarios they will encounter, such as presenting ideas to a company or communicating with others effectively in social situations.

Teamwork projects also help children develop problem-solving skills as they are faced with issues during the project's solution. Adaptations and solutions will need to be made while working on the project, developing critical thinking skills that will help them in future projects in a learning environment with no real consequences.

Working in a team with individuals from different backgrounds also helps develop creative solutions by exposing members to different ways of thinking. Having the ability to think creatively and come up with the best solution is a valuable skill that will benefit them in many aspects of their lives.

2.4 TRUE Robotics

TRUE Robotics is a startup company founded by Anthony Galgano in August 2021. Anthony graduated from WPI in 2022 with a double major in Robotics Engineering and Electrical and Computer Engineering. The reason behind starting the company was to inspire and educate students about Science, Technology, Engineering, and Math (STEM), as Anthony didn't have the opportunity to be inspired to get into STEM while growing up. He was fortunate to be introduced to STEM outside of school and at after-school programs, which encouraged him to pursue it further.

2.4.1 TRUE Robotics Market Research

Anthony's goal of providing STEM education to schools has become a reality. He has developed a 45-day curriculum with the help of WPI students, alumni, professors, and 6th-grade teachers. The development of the curriculum was based on market research, which played a significant role in its creation. Through the I-CORPS program, they were able to interview 50 teachers, superintendents, and principals over four months to see what they wanted in a curriculum if they were to buy one or write their own. They found four important things that everyone looked for in a curriculum: curriculum materials, practical hands-on activities, access to expert training, and alignment with standards.

Teachers are often too busy to develop their own curriculum materials outside of the classroom and workday. Therefore, curriculum materials are a significant factor when buying a curriculum. Middle school students also need hands-on activities to stay engaged and communicate with other students, which teaches them valuable skills beyond the classroom. This is another major aspect teachers seek when buying a curriculum.

To teach a subject with a curriculum, teachers need to know the material very well. Access to expert training is essential for teachers to teach effectively and for students to learn the material. Additionally, curriculum alignment with standards is crucial since students need to learn specific material every year to prepare them for college and their future careers.

2.4.3 Curriculum

TRUE Robotics conducted market research to develop a 45-day curriculum and robots to support STEM education in schools. The curriculum was designed to address the key needs and concerns of teachers, based on feedback from 50 educators, including teachers, superintendents, and principals. The research identified four critical factors that teachers consider when selecting

a curriculum: curriculum materials, practical hands-on activities, access to expert training, and alignment with standards.

To meet these needs, TRUE Robotics' curriculum includes 45 lesson plans with time breakdowns, 45 active learning worksheets, 45 PowerPoints to project lesson information, five standard-based grading rubrics, and 20 instructional videos. The curriculum also includes entry and exit tickets, which help to engage students and assess their learning. All of these materials are editable, allowing teachers to customize the curriculum to meet the specific needs of their students.

The curriculum comes with 40 hours of professional development, providing teachers with access to expert training and support to help them deliver the material effectively. The curriculum is aligned with common core math and the Next Generation Science Standards (NGSS), ensuring that students learn what they need to in each school year. By providing a comprehensive curriculum that meets the needs of both teachers and students, TRUE Robotics aims to inspire and educate students about STEM and prepare them for success in their future careers.

2.4.4 Robots

TRUE Robotics has also developed a robot named Axle, which allows students to engage in hands-on, project-based learning in the classroom while also learning about mathematics, science, engineering, and technology. The robot can be assembled with a wrench, ruler, and screwdriver, which teaches kids how to use simple tools they will use outside of the classroom. In addition to learning how to use tools, students will develop communication skills while working in groups of 2-3. They will learn to take constructive criticism and listen to other people’s ideas. After the building process, they can learn how to code using a grab-and-drop

software called Scratch, which introduces them to coding and hopefully sparks their interest in learning more. They can program the robot to drive in a circle or rectangle, go through a maze, and move around using a controller. While getting hands-on experience, students learn math and science aligned with the standards throughout the curriculum.

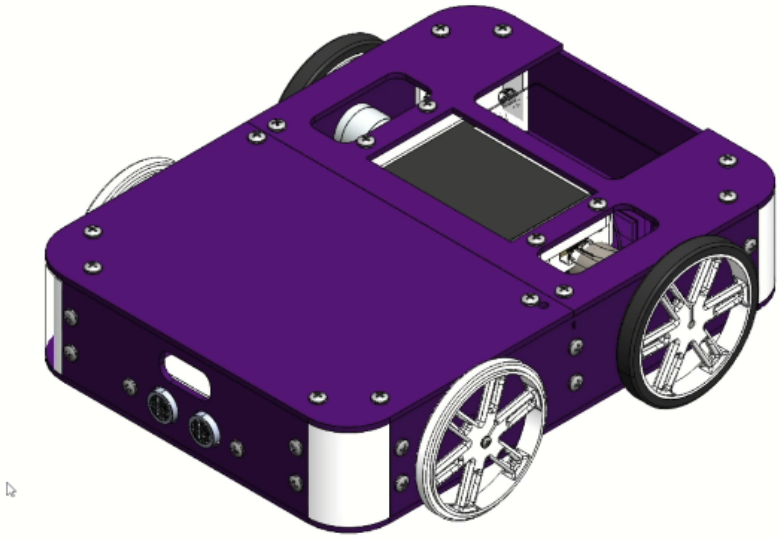


Figure 1. Axle Robot Developed by TRUE Robotics

3.0 METHODOLOGY

TRUE Robotics has initiated an effort to introduce STEM education to more schools and provide children with the opportunity to develop an interest in this field before it becomes too late to pursue it further. In line with this, we conducted research to gain insights into how schools in different districts in Massachusetts operate. Given the various roles involved in this project, we had to break it down into smaller components. Although TRUE Robotics only commenced operations in August 2021, we are working tirelessly to promote our initiative and find ways to provide every child with equal opportunities. Our project goals include implementing a pilot program and submitting a grant application to the National Science Foundation.

For the pilot program, our objective is to generate interest among schools to purchase the curriculum and witness the joy on children's faces as they build, program, and have fun while learning critical skills. To get the curriculum to low-income and less privileged schools that are interested in the TRUE Robotics curriculum but lack funding to purchase it, we will apply for a grant from the National Science Foundation. If we receive funding, we will distribute the robots and curriculum to middle schools for free, giving everyone an equal opportunity to benefit from STEM education. To achieve these objectives, we have developed the following goals:

Objective 1: Define what STEM education is in Massachusetts.

Objective 2: Identify the key players in STEM education in Massachusetts.

Objective 3: Determine what schools look for when purchasing a curriculum.

Objective 4: Develop standards for selecting curriculums.

Objective 5: Create a pilot curriculum that includes five hours of material, including a building day, two programming days, and a simple science day.

Objective 6: Develop a detailed step-by-step process on how to approach schools and initiate meetings with them to encourage them to purchase our curriculum.

Throughout this project, our team conducted extensive research and consulted with the right people to create the pilot program and write a grant application to the National Science Foundation. By having access to the original curriculum and robots, we can design a curriculum that includes five hours of material and one robot. Interviewing Professor Heffernan provided us with a better understanding of the grant application process and an excellent resource to review our proposal before submitting it. The Appendix provides a detailed timeline of our project. Below, we discuss each objective in further detail and our methods for achieving them.

3.1 Objective 1: Identifying what STEM Education is in Massachusetts

Our team's first objective was to research the current state of STEM education in Massachusetts before developing our deliverables and recommendations for TRUE Robotics. This research would inform us about the districts that have already implemented STEM programs and used curriculum or if the district is behind and needs improvement. This information would help in a few different ways. If the schools have a system in place, the sales representative would have a different approach to the customer than if the school is seeking a curriculum to teach the students about STEM. By understanding if STEM improvements are impacting schools in Massachusetts, the team can seek out the schools that need a new curriculum, especially since there is a governmental push on education that leads to grant money available to the schools.

3.2 Objective 2: Identify Who the Big Players Are in STEM Education in Massachusetts

Our team's second objective was to figure out which companies create STEM education curricula in Massachusetts. With some research, we could answer this task simply. For the most part, big companies in this space are in control all over the United States and even outside of the country. They have been around for a long time and have been able to develop their curricula more and cater to schools more. These companies have a large enough staff to send teachers all over the country to teach their product as well as sell it. The major curriculum companies that most schools are using in Massachusetts if they don't write their own are Curriculum Associates, Savvas Learning, OpenSciED, Pearson, and Amplify Science.

To develop research on Curriculum Associates, we interviewed a sales representative, Arlandis Hinton. Before the meeting, our group was able to research the company and develop questions that we would ask during our meeting with him. This gave us a good understanding of the company's initiative and allowed us to build off that to ask questions that would be beneficial to what our team is currently trying to accomplish. From these questions, he was able to give us information on how the company operates as well as advice on how to keep growing TRUE Robotics and get their name out there more. We learned through this meeting that the hardest part is getting your name known and having data to back up what you are doing. Arlandis gave a good, simple idea for us to use when reaching out to schools and getting them interested in buying TRUE Robotics, which will enhance the response rates from schools.

Savvas Learning, OpenSciED, and Amplify Science are curriculum companies that focus on every school's basic classes. This is not the realm that we are working in, but it is good to understand what they offer and what schools like about them to use them in their classrooms. Our team did research on each one of these companies to develop the main things that each one

of them all have in common. This gives us a good idea of what schools like in curriculums because these companies have had time to develop their packages to the style that schools like and include different things based on the feedback that they have received from schools using their curriculums.

Savvas Learning has curriculums for Literacy, Mathematics, Science, Social Studies, and World Languages. This company isn't focused on one subject, but they are trying to improve schools in all aspects and not just one area. While researching Savvas Learning, we learned that their main initiative is the "next generation learning company." This is their selling point to get schools interested because their material is editable by the teachers so they can change some of the questions, give more hints if the questions are too hard for their students, or make some of the questions harder if their students are more advanced.

OpenSciED provides elementary, middle, and high school science curriculums that are designed for the NGSS (Next Generation Science Standards). Their main initiative is to provide high-quality curriculums that are available to everyone. This is done by making their curriculums free to every school that wants to use them.

With this research, we will be able to develop recommendations to TRUE Robotics with ideas to help them grow and continue to provide STEM education in middle schools all around the country. Amplify Science has curriculums for ELA and Science courses for elementary and middle school students. Their initiative is to supply interactive digital tools that students can use and get away from the regular worksheet fill-in-the-blanks or taking notes on a presentation. This is a good way to move into the next generation of learning because, as we all know, the world is moving in the direction of technology, and that is why providing STEM education to more schools around the country is very important.

3.3 Objective 3: Determine what schools want in purchasing a curriculum.

During the interviews with teachers, it will be important to understand a few components, such as which schools are seeking updated STEM curricula, which schools have the financial resources to invest in them, and if there are schools that have possible grants that can be applied towards them. Finding the schools that have outdated STEM curricula will give them the possibility to keep up to date with the education system's efforts in introducing STEM to schools. There are also schools that have existing STEM programs, either through an after-school program or a class that teaches STEM to students. These are the two major types of schools to look for. There is also the aspect of the possibility of grant money being available to schools that have access to it. By finding this information, the company will be able to approach schools that have more flexibility with their spending in each department.

3.4 Objective 4: Develop the standards on why schools purchase curriculums

Developing standards for why schools purchase curricula is an important task our team is undertaking to provide recommendations to TRUE Robotics on what to include in their curricula and what to offer. We've been fulfilling this objective by meeting with superintendents, teachers, and principals in various Massachusetts schools. Each school goes about the process differently, so meeting with a diverse range of educators provides a good understanding of the different ways schools purchase curricula. We've identified the major criteria schools look for when making these purchases, despite the differences in their approaches. Defining what they all have in common will allow us to develop standards for TRUE Robotics. These standards will help TRUE Robotics improve their sales techniques and presentations to appeal to more schools and encourage more middle schools to purchase their curricula, bringing us closer to our goal of providing STEM education to more Massachusetts schools.

3.5 Objective 5: Develop a pilot curriculum that comes with 5 hours' worth of material, which includes a building day, two programming days, and a simple science day

The pilot program will consist of a new robot, and the curriculum will include building days, programming days, and a science-based day. The reason for introducing a new robot is to give teachers a glimpse of what it is like to build a robot while also getting them excited to work on a more complex robot design that comes with the kit. The new robot will have similar mechanical movements, programming steps, and components as the Axle robot to ensure a seamless transition.

The curriculum for the pilot program will introduce the major aspects of the Axle curriculum. The building day will provide instructions in the same format as Axle. Since the pilot robot is more straightforward, the first day will introduce how the programming software works. There will then be two dedicated programming days where students will learn how to complete simple tasks with the robot, and at the end of each day, there will be a challenge based on the knowledge they have gained.

Another aspect of the Axle curriculum is the science-based activities, where students work together to create a popsicle stick bridge. With the basics of the Axle program, the teachers can assess the benefits of bringing the main curriculum to the school, with the overarching objective of providing more STEM opportunities to students.

3.6 Objective 6: Detailed step-by-step process on how to get people to buy and reach out to schools (How to approach schools) and how to get that initial meeting with schools

To create a detailed, step-by-step process on how to get schools to buy the curriculum, we must interview people who sell curriculums, so they know how the market works and what we are trying to accomplish. They will also know the best ways to approach schools and get them

interested in setting up an initial meeting to explain the product in-depth to the teachers and facilities at the school. A major company in the curriculum industry that our team is going to meet with is Curriculum Associates. This company has been very successful at selling curriculums to schools not only in the United States but all around the world. By meeting and asking questions to sales representatives, we will be able to get a good understanding of how to reach out to schools where they will be responsive to either emails or phone calls. They will also be able to tell us how to explain to schools what our initiative is and what to mention in the initial meeting to get them interested in the product so they want to purchase it.

Along with interviewing sales representatives, we are also going to ask these questions to principals as well as superintendents. By asking these people, we will be able to get a good understanding of what they are looking to hear when they are looking to buy a curriculum and what makes them respond to emails they get from other curriculum companies. There are going to be key things that these people are looking to hear in the initial meetings, and what grabs their attention in emails that get them to read into them. Meeting with sales representatives, superintendents, and principals, we will be able to put together an extensive step-by-step process on how to reach out to schools and set up the initial meeting as well as getting them to buy the curriculum. We will then provide TRUE Robotics with this information as recommendations on what they should do moving forward.

4.0 RESULTS AND RECOMMENDATIONS

4.1 RESULTS

Through our team's interviews, we have gained knowledge on curriculums and how schools' central office runs through the process of buying curriculums. It's important to take into consideration that this process is different from school to school, depending on whether they are

a public or private school or depending on the state or federal funding they receive each year. In our interview with Professor Heffernan, he provided insight on how to get funding for schools that can't afford to buy STEM curriculums for their schools. Professor Heffernan started AssistMENTS, which is a student-facing software that provides real-time feedback for students and gives teachers data about what the students are learning well or what they are struggling with. He has written grant proposals for the past 20 years and has been awarded over 80 million dollars in grant funding. This funding has been able to provide this software to schools around the world for free. Professor Heffernan provided us with ideas on what TRUE Robotics should try to do, and one of the main things he touched on was to try to provide as much as they can to schools for free.

Schools around the country don't have leeway money that can be used outside of the regular classes that students need to take every year. It's hard for schools to allocate funds to STEM curriculums, which is why it's hard to get STEM education into schools when it isn't free. The way to go about this is to try to find grant funding from STEM foundations that are constantly working to provide funding to get STEM education into as many schools as possible in the United States. Professor Heffernan stated that if TRUE Robotics was able to get grant funding from a non-profit organization or foundation like the National Science Foundation, then they would be able to give out their STEM curriculum and robots to schools for free and build a network of teachers and schools to build a constant data stream. Once TRUE Robotics develops a solid data stream, schools will be more convinced to buy their curriculum.

Professor Heffernan made it very clear to our team that no school is willing to buy anything that isn't backed by data and proven to work in the classroom. Therefore, by being able to provide TRUE Robotics curriculum and robots to schools for free in the Massachusetts area

through grant funding, they will be able to create a bigger network and gather data to make their curriculum better based on feedback, as well as being able to get it into more schools since factual data backs it.

During our research, we gathered information on what schools look for when purchasing curriculums. An important factor to consider is that schools prefer digital materials that are easy to edit and modify. During our meeting with the TRUE Robotics teachers and Anne Ludes, they emphasized the significance of this point by highlighting the impact of COVID-19. With the transition to remote learning, it became challenging for children to retain information through a screen. Consequently, some children were able to keep up with the learning, while the majority struggled. As students return to the classroom, teachers are faced with the task of addressing the varying levels of understanding among their students. To accommodate these differences, teachers need to modify their lessons and provide simpler problems to help students catch up with their peers.

To improve their curriculum package, TRUE Robotics should focus on incorporating elements that schools deem essential. Anne Ludes and Arlandis Hinton advised our team to prioritize the following aspects: alignment with standards, provision of good teacher resources, professional development opportunities, digital copies of materials for customization, training from industry professionals, and culturally responsive material.

When schools purchase a curriculum, they ensure that it aligns with the standards. In Massachusetts, schools look for curriculums that align with the Massachusetts frameworks and Common Core Math standards. Aligning with these standards is crucial because it helps schools prepare their students for future grades. For STEM curriculums, it is essential to touch on the science, technology, engineering, and mathematics frameworks. While it may be challenging to

address all aspects, touching on the major points helps create a solid curriculum that teachers can use to prepare their students for the future.

During our interview with Anne Ludes, the principal of Mass Academy, she stressed the importance of aligning the curriculum with the standards and tying some of the questions to the Massachusetts MCAST testing. This comment stuck with our team because if the curriculum can provide knowledge that aligns with the standards and the types of questions that will be on the state test, then students will not be caught off guard on test day. This aspect is a good selling point to make to schools as it assures them that their students are being prepared adequately.

One thing that was made very clear to our team during our interviews is that teachers and the central office look for good teacher resources when purchasing curriculums. There are positives that come along with having good teacher resources, but some of the main things that teachers really like to see are lesson plans, presentations, answer keys, digital copies to modify at their own discretion, and professional development. Teachers are busy and don't have time to write their own materials, so being able to provide these materials makes their lives easier. In the lesson plans, some things that teachers are looking for include the learning objectives for that lesson, what materials they need for the class, and time breakdowns for everything they need to cover in that lesson. This allows them to keep the class on track and push the students to cover the material they need to learn to move on to future classes.

The presentations are also very helpful for teachers to teach the classroom. They keep the students interested with pictures and instructional videos that help them through each lesson. The lesson plans that go along with the presentations make the students pay attention to what they are learning. Some good things to include in these lesson plans are fill-in-the-blank questions so that students must actively listen to catch the answers to the questions. Another good thing to include

in the lesson plans is open-ended questions because this allows the students to come up with their own answers and think outside the box.

By including digital copies of all the materials, teachers can modify the questions to the pace of their class and alter some of the questions if they are too difficult for their students. This is an important thing to touch on during today's times due to COVID-19. When everyone was home doing online learning, it was hard for younger children to stare at a computer screen and stay focused. This caused learning gaps for the current middle schoolers, so by having the digital copies, teachers can tailor the work to where their students are currently at with the material. Lastly, teachers need to know the material very well to be able to teach it even better. For that to happen, there needs to be good professional development given by professionals in those fields. By getting professional development from experts in those fields, they are going to learn the material as best as they possibly can. This will prepare them to teach each lesson throughout the curriculum to the classroom and be able to answer any questions that are thrown at them by their students. Through our team's research, these are some major things that schools are looking for in curriculums when they are looking to purchase them.

4.2 RECOMMENDATIONS

Throughout the Interactive Qualifying Project, the team has gained much knowledge from interviews, discussions with the company, and the company's day-to-day operations. We have brainstormed some ideas for the company, including establishing a pilot program, acquiring a grant, and various sales tactics. These tactics will attract the attention of administrators and schools to implement STEM in their schools.

The idea behind implementing a pilot program is to have an accessible introduction program where teachers can experiment with the students to see if the curriculum works well with the school. The team designed a new basic robot with most of the attributes of the Axle Robot. The motion of the Pilot robot is the same as Axle, where two wheels powered by motors control it. The connection between the motors and the controller is one button for each motor, considered tank drive, the same as an Axle robot. We wanted the Pilot robot to be similar to Axle so the transition between the two curriculums is seamless. The robot and curriculum implement one sensor called an ultrasonic sensor, which sends and reads sound waves. It was necessary for both the curriculum and the robot to have exposure to the sensor since there are examples of sensors in robots in real-world applications. The Axle curriculum's objective is to teach applications, and in order to show what the Axle curriculum exposes students to, the Pilot curriculum needs a small portion of it. The students can code the robot just like the Axle Robot. The curriculum portion (see appendix 8.2-8.5) will walk through the steps of the assembly for the robot, have programming days, and have an essential science day. Each specific day gives a brief introduction to the Axle curriculum. For the programming days, it first gives an introduction to the software and then gives a challenge for the students to do. On the second day, the students will learn more advanced programming and give a more advanced challenge.

The team thinks that the best way to get into more schools in the future is by applying for a grant. The grant that is written up will be able to adapt to different grants. In order to get into schools, there have been issues surrounding the finances, and the schools cannot budget enough money to put aside money for the program.

When looking at the current sales tactics that the company has already put in place and talking to significant sales representatives, the team has concluded different sales ideas. The issues mainly arise when attempting to reach out to schools, and they are just receiving cold emails. This does not work whether it is sent to spam or the administrators think the emails are spam. To combat that, we suggest that the sales representatives are sending out emails with video pitches. This grabs the attention of the recipient because the email will be more personalized with a name tag for the recipient visible. Then videos are more personal than just written words. If the videos do not work, another way to contact schools is to call them and set up a meeting over the phone. When speaking over the phone, it is essential to ask questions about the school and the curriculums that are currently being used and how the company can best benefit the school.

5.0 DELIVERABLES

5.1 Develop a pilot program that is 5 hours' worth of material that includes entrance and exit tickets, Lesson Plans, Presentations, and Programming Challenges with Answer Keys.

Program Layout			
Day 01 Swervy Robot Buiding Day	Groups of 2-3 students working on building the Swervy Robot.	Lesson Plan included for the teachers to assist students throughout the lesson.	No other materials required.
Day 02 Introduction to Waves	45-60 minute lesson on understanding waves.	Lesson plan, powerpoint, active learning worksheet, and answer keys included.	Digital copies of all materials included for teachers to arrange or alter to their needs.
Day 03 Introduction to Programming	45-60 minute lesson on introduction to the TRUEbots software and movement challenges with the robot.	Lesson plan, powerpoint, instructional videos, and teacher copies included.	Digital copies of all materials included as well as programming challenge answer keys to assist students.
Day 04-05 Programming Challenges	45-60 minute lesson for more advanced programming challenges with the Swervy robot.	Lesson plan, powerpoint, instructional videos, and teacher copies all included.	Digital copies of all materials included as well as the programming challenges answer key.

Table 1. Breakdown of the 5 hours worth of pilot curriculum.

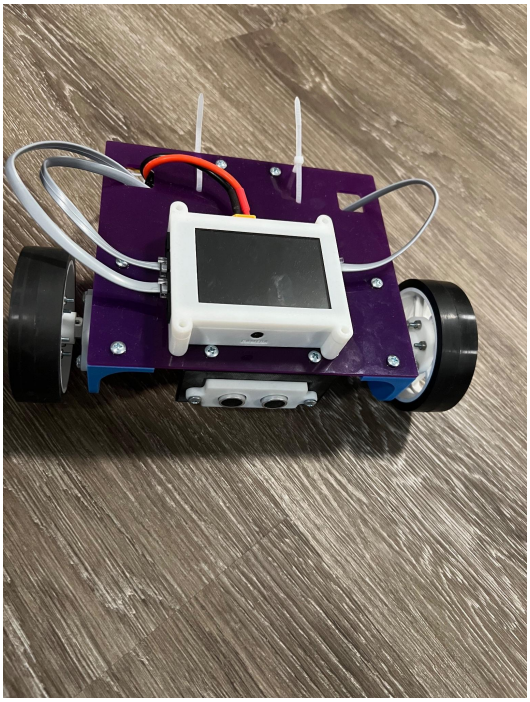


Figure 2. Pilot Robot our Team Developed for the Curriculum.

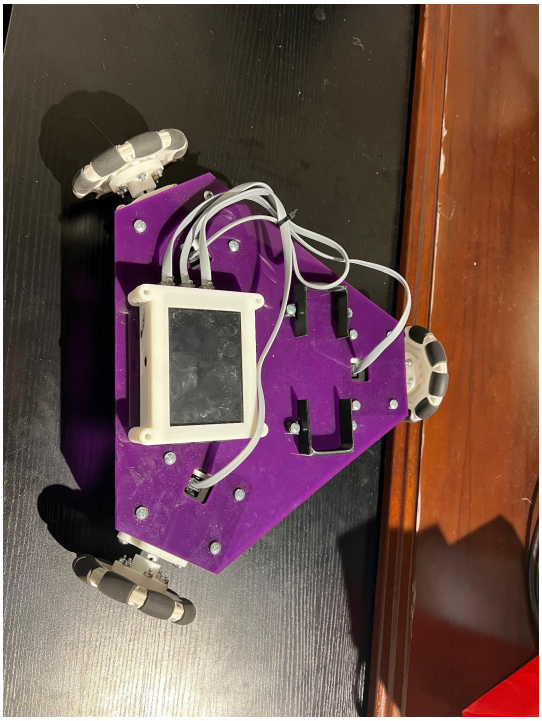


Figure 3. Swervy Robot that TRUE Robotics developed that was used in the Curriculum.

5.2 A grant proposal that can be submitted, and if the money is granted to TRUE Robotics they will give STEM education to schools of poverty.

The grant proposal (see appendix F) aims to create funding opportunities for schools that are less fortunate and have fewer resources than others. The proposal is written as a general format that can be adapted to apply for various other grants. This will help schools acquire the funding they need to purchase the curriculum provided by TRUE Robotics in the future. The grant proposal creates outreach opportunities for schools to benefit from the various findings that the government and other foundations can provide. Please let me know if you need any further assistance.

5.3 Step by Step process (How to approach schools) and (Get the interest of schools).

Through our interviews, we developed a step-by step process on how to approach schools and get them interested in buying TRUE Robotics curriculum and robot kits. This will be beneficial to TRUE Robotics sales teachers to try different routes to get in contact with schools and to use different techniques to get them interested in buying the curriculum. Below is a simple step-by-step guide on how to do so.

Step by step process:

- Start with phone calls, probe
    - Ask a lot of questions
    - Follow up with the email
    - Say in the subject line that you just called NEED TO MENTION THAT
- Try using Vidyard
    - Send them a video of you speaking to them
    - Have a whiteboard and the person's name written on it as the initial slide

(thumbnail)

    - 25-30 seconds at the most
- Check out the links below to the website.
- Call,, email, call email then email
- Or start with the video, then call
- Need to get ahead of the big companies
- Make the selling point no one else has a curriculum and robots built together
- Can't get discouraged when people don’t care and hang up on you
- Once you have the districts then itll get easier
- Offering things for free
    - Offer pilots
    - Pay for the robot and then we will give the curriculum for free
    - “I know you haven’t heard of us but we will let you try it for free for x amount of time”
    - Find a way to give something away for free
- Want to find schools with title one money

6.0 CONCLUSION

The team has identified a series of recommendations that will assist TRUE Robotics in implementing a strategy to add their curriculum to Worcester schools. They conducted interviews with individuals who have significant input in the robotic, teaching, or curriculum industries. With the ideas of a new pilot program, sales tactics, and grant proposal, the company can be implemented in more schools, and students will be exposed to STEM.

Through the Pilot Program, teachers will be able to gauge how well the curriculum fits into the school's current system and how it can engage students. The grant proposal the team wrote is adaptable to various grants, enabling them to approach less fortunate schools and provide an opportunity to bring STEM curriculum to the school. With the updated sales tactics, sales representatives can contact more schools, leading to more engagement and outreach to customers.

7.0 REFERENCES

(1). *Science, Technology, engineering, and math, including Computer Science*. Science, Technology, Engineering, and Math, including Computer Science | U.S. Department of Education. (n.d.). Retrieved May 2, 2023, from https://www.ed.gov/stem

(2). *What ithe s stem?* Online College Degree Programs for Students & Business. (n.d.). Retrieved May 2, 2023, from https://www.pearsonaccelerated.com/blog/stem/

(3). *The importance of STEM Education*. Mass.gov. (n.d.). Retrieved May 2, 2023, from https://www.mass.gov/service-details/the-importance-of-stem-education#:~:text=The%20need%20for%20STEM%20graduates,for%20Excellence%20in%20STEM%20Education

(4). StartingBlocks. (2022, July 27). *What is inquiry-based STEM education, and why is it important?* Starting Blocks. Retrieved May 2, 2023, from https://www.startingblocks.gov.au/other-resources/factsheets/what-is-inquiry-based-stem-education-and-why-is-it-important

(5). *January 2023 STEM newsletter*. U.S. Department of Education. (n.d.). Retrieved May 2, 2023, from https://content.govdelivery.com/accounts/USED/bulletins/3410f31

(6). *Education innovation and research*. Office of Elementary and Secondary Education. (2021, June 30). Retrieved May 2, 2023, from https://oese.ed.gov/offices/office-of-discretionary-grants-support-services/innovation-early-learning/education-innovation-and-research-eir/

(7). *Supporting effective educator development grant program*. Office of Elementary and Secondary Education. (2022, October 11). Retrieved May 2, 2023, from https://oese.ed.gov/offices/office-of-discretionary-grants-support-services/effective-educator-development-programs/supporting-effective-educator-development-grant-program/

(8). *Teacher Quality Partnership Program*. Office of Elementary and Secondary Education. (2022, February 17). Retrieved May 2, 2023, from https://oese.ed.gov/offices/office-of-discretionary-grants-support-services/effective-educator-development-programs/teacher-quality-partnership/

(9). US Department of Education (ED). (2022, July 28). *Gaining early awareness and readiness for Undergraduate Programs (Gear UP)*. Home. Retrieved May 2, 2023, from https://www2.ed.gov/programs/gearup/index.html

(10). *College assistance migrant program*. Office of Elementary and Secondary Education. (2020, November 16). Retrieved May 2, 2023, from https://oese.ed.gov/offices/office-of-migrant-education/college-assistance-migrant-program/

(11). Chester, M. D. (2016). (rep.). *Science and Technology/Engineering Framework - 2016*. Malden, Massachusetts: 2019 Massachusetts Department of Elementary and Secondary Education.

(12). AbilityPath. (2020, March 10). *Children's learning styles*. AbilityPath. Retrieved May 3, 2023, from https://abilitypath.org/ap-resources/childrens-learning-styles/

(13). Quesenberry, A. C., Mustian, A. L., & Clark-Bischke, C. (2016). Preschool and Kindergarten: Tuning in: Strategies for Incorporating Technology Into Social Skills Instruction in Preschool and Kindergarten. *YC Young Children*, *71*(1), 74–81. http://www.jstor.org/stable/ycyoungchildren.71.1.74

8.0 APPENDICES

8.1 Appendix A: Interview Information

Interview Questions for Professor Heffernan:

1. How did you start AssistMENTS and why did he feel like that was needed at the time?
2. How did you get the first few people to use ASSISTments?
3. What was your main selling point?
4. What did you do to set up the first meetings with schools, sending cold emails, phone calls, etc.
5. Why did you focus on middle school math and why not other subjects?
6. The teachers use their own curriculum but use AssistMENTS to get a better understanding of how their students are doing?
7. What advice could you give us for TRUE Robotics and how we can go about getting the curriculum in more schools?
8. What questions would you advise us to ask the other teachers that we will be interviewing?

Interview Questions for Arlandis Hinton:

1. Tell us a little about yourself and what you do?
2. Do curriculum associates sell all over the United States?
3. Can you walk us through your steps on approaching schools and how you get them interested?
    a. cold emails, known name, visiting them in person, etc.?
4. What is your top selling curriculum?
    a. Why is this the top selling curriculum?

5. Why do schools end up picking your curriculums over the other ones that are offered to them?
6. Can you explain to us the price breakdown of an average curriculum you sell?
7. Do you charge for your professional development?
    a. I saw on the website that your PD is offered on-site. Are those offered on certain days that you guys run them or are they flexible to the teachers PD days?
    b. Do you do them online as well?
8. What standards do your curriculums align to?

Interview Questions for Anne Ludes:

1. Can you tell us a little about yourself what you do as Mass Academy?
2. How did you end up at Mass Academy?
3. Does Mass Academy buy or write their curriculums?
4. When you are looking at curriculums to buy for say a math or science class how do you decided which one you want?
5. What are the main selling points that make you decide on that one?
6. How much does price play a role in choosing?
7. Do you try it first, a pilot, or just buy it after looking online or having a phone call with the company?
8. What gets students excited in math and science class that you have seen included in curriculums?

Interview Questions for Kathy Chen and Mia Dubosarsky:

1. Hello, can you guys tell us a little about yourselves and what you do at the WPI STEM center?
2. What does the STEM center do and what role does it play in Massachusetts?
3. What is one way your guys see schools getting STEM education into their classrooms?
4. How do you guys help provide STEM education into middle schools?
5. What are schools looking for in STEM curriculums?
6. What is your advice on getting more of TRUE Robotics curriculum into schools in Massachusetts?

8.2 Appendix B: Day 1 of Pilot Curriculum (Day 01 Swervy Building Day)

TRUE ROBOTICS

Day 01

Teacher Guide
Assemble Axle Robot kit

Learning Objectives

Students will . . .

- Collaborate with their team to assemble the Swervy robot kit.
- Apply knowledge of basic hand tools to using a screwdriver and wrench.
- Construct the Swervy robot kit.

Vocabulary

Swervy Robot, Screwdriver, Wrench

Materials

- Swervy Robot Kit
- Swervy Assembly Instructions

Lesson Overview

The Swervy robot kit is comprised of ___ pieces and can be programmed using Truebots Playground Software. The robot can be remotely controlled using a game controller or autonomously move from the pre-programmed instructions. The robot is powered by a rechargeable battery pack and has a built in _____.

Students will learn how to work as a team to assemble the Swervy robot kit. Students will be required to use a screwdriver and a wrench. Additionally, students will be required to follow instructions carefully to assemble the robot.

Recommended Lesson Activities (75-90 minutes)

1. Assign students in groups of 2-3 depending on how many robot kits are available.
2. Provide each group with an Axle robot kit.
3. Have each group follow the Assembly Instructions and build an Swervy robot.

References

1 https://www.truerobotics.org/robots

8.3 Appendix C: Day 2 of Piolet Program (Day 02 Introduction to Waves)

Teacher Guide:

TRUE ROBOTICS — Lesson Day 02

Teacher Guide
Introduction to Waves

Learning Objectives

Students will . . .

- ∀ Define wave and the various ways waves can be measured.
- ∀ Differentiate between mechanical waves and electromagnetic waves.
- ∀ Discover examples of waves that are a part of their everyday lives that they haven't realized yet.

Vocabulary

Wave, medium, amplitude, frequency, wavelength

Materials

- ∀ Active Learning Worksheet Day 02
- ∀ Presentation Day 02

Lesson Overview

Students will be introduced to types of waves. They will begin to understand how waves are measured using amplitude, wavelength, and frequency. In addition they will take time to think of examples of waves that they see or don't see in their every day life.

Recommended Lesson Activities

1. Day 02 Presentation and Active Learning Worksheet
   a. Distribute the Active Learning Worksheet to each student and instruct students to follow along with the presentation. Refer to presentation speaker notes and Active Learning Worksheet Day 02 Teacher Copy for the remainder of the lesson.
   b. The presentation includes the following material:
      i. Definitions of wave, medium (5 Minutes)
      ii. Measuring waves (amplitude, wavelength, frequency) (10 Minutes)
      iii. Two types of waves (10 Minutes)
      iv. Mechanical waves (5 Minutes)
      v. Electromagnetic waves (5 Minutes)
      vi. Exploration discussion questions (10 Minutes)
2. Reflection Questions (5 Minutes)

Additional Resources

1. Waves- Britannica Kids
2. Waves Video- PBS
3. Physics of Waves

Active Learning Worksheet:

Name: _____

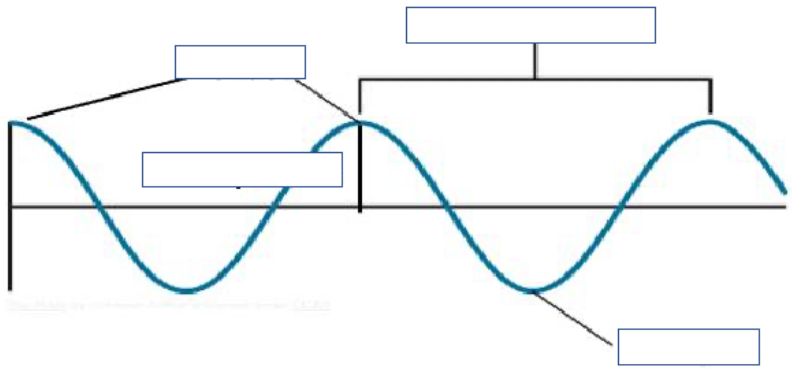
Date: _____

Active Learning Worksheet Day 02

Introduction to Waves

Directions: In this lesson, you will be learning about waves. Use the presentation to help you fill in the information below.

1. **Fill in the blank for the following definitions.**
   a. A disturbance or variation that transfers energy progressively from point to point in a medium is a _____.
   b. The material the wave travels through is called the _____.
2. **Answer the following questions about the mediums of waves.**
   a. If you are on a boat and the motor is making waves, what is the medium of those waves? _____.
   b. When you are playing outside with your friends and yelling across the lawn to each other was medium is your sound waves traveling in? _____.
3. **Label the amplitude, wavelength, crest, and trough on the wave below.**



4. Fill in the blanks about types of waves.

a. The type of wave that must travel through a medium is a _____. A(n) _____ wave can travel through a vacuum.

b. Two types of mechanical waves are _____ and _____.

c. Three types of electromagnetic waves are _____, _____, and _____.

5. Draw a picture of sounds waves traveling through space when you and your friend are having a conversation.

6. What do you think the most used waves are and why?

Active Learning Worksheet Teacher Copy:

Name: _____

Date: _____

Active Learning Worksheet Day 02 Answer Key

Introduction to Waves

Directions: In this lesson, you will be learning about waves. Use the presentation to help you fill in the information below.

1. Fill in the blank for the following definitions.

a. A disturbance or variation that transfers energy progressively from point to point in a medium is a ____wave ___.

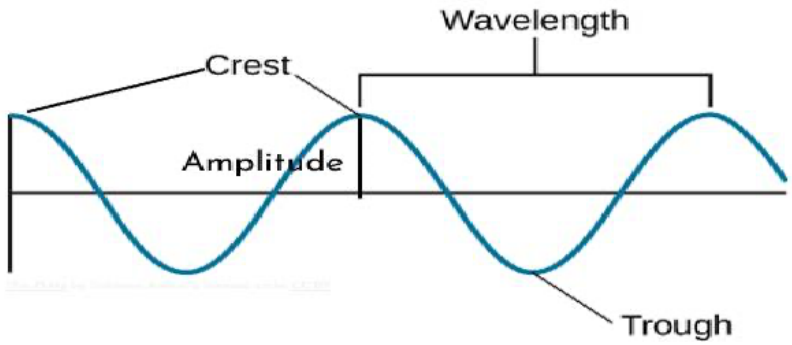
b. The material the wave travels through is called the _medium_____.

2. Answer the following questions about the mediums of waves.

a. If you are on a boat and the motor is making waves, what is the medium of those waves? ____the water_____

b. When you are playing outside with your friends and yelling across the lawn to each other was medium is your sound waves traveling in? ___the air_____

3. Label the amplitude, wavelength, crest, and trough on the wave below.



4. Fill in the blanks about types of waves.

a. The type of wave that must travel through a medium is a _mechanical wave_____. A(n) _electromagnetic____ wave can travel through a vacuum.

b. Two types of mechanical waves are __longitudinal_____ and ___transverse_____.

c. Three types of electromagnetic waves are _microwave_____, _infared_____, and __gamma rays _____. (Other answers could be microwave, ultraviolet, radio, visible light, and x-rays)

5. Draw a picture of sounds waves traveling through space when you and your friend are having a conversation.

Students answers may vary.

6. What do you think the most common waves are and why?

The most common waves are light, sound, and waves in the ocean. These are the most common waves due to the amount of them they are. Light and sound waves are around you every day and since the Earth is made up of mostly water waves in the ocean are another one that is common.

Presentation:

DAY 02

INTRODUCTION TO WAVES

1

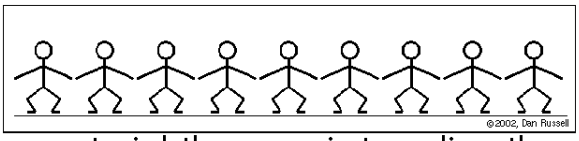
Entrance ticket

1. What is the definition of a wave?

2. How many different types of waves are there?

What is a wave?

A wave is a disturbance or variation that transfers energy progressively from point to point in a medium.



A medium is the material the wave is traveling through.

- When you are playing outside with your friends and yelling across the lawn to each other was medium is your sound waves traveling in?
- On a boat when the motor is making waves what medium are those traveling in?

TRUE ROBOTICS

TWO TYPES OF WAVES

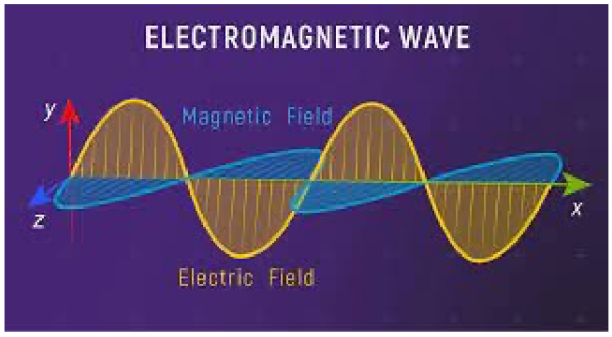
Mechanical Waves

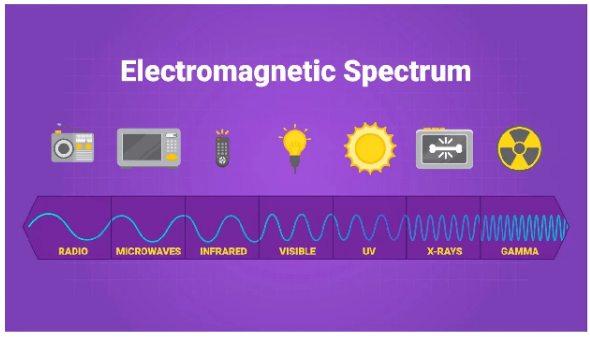
- Transfers energy through a medium.
- Examples include:
  - Sound waves
  - Water waves
  - Spring waves

Electromagnetic Waves

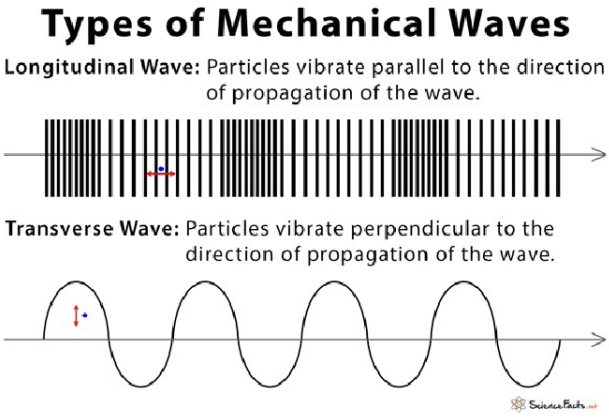
- Invisible forms of energy that travel though the universe.
- Examples include:
  - Gamma rays
  - Visible light
  - Microwaves

ELECTROMAGNETIC WAVES



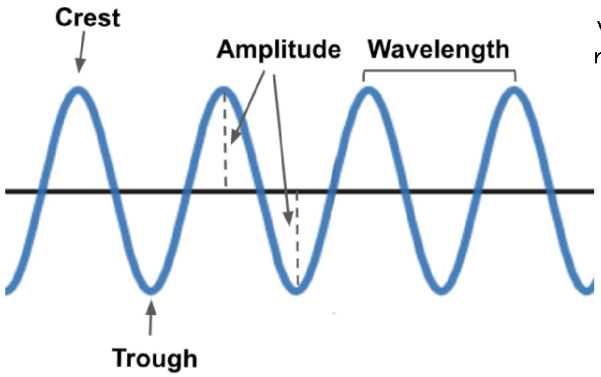


MECHANICAL WAVES



PROPERTIES OF WAVES

Crest is the highest point of the wave.



Amplitude is the maximum distance a wave can reach from its rest position. (positive or negative)

Trough is the lowest point of the wave.

Wavelength is the distance between the same spot on two sections of the wave.

HOW WAVES MOVE

- Transverse waves cause the medium to move perpendicular to the direction of the wave.

Examples Include:

- Microwaves
- Radio waves
- Seismic waves

- Longitudinal waves cause the medium to move parallel to the direction of the wave.

Examples Include:

- Sound waves
- Tsunami waves
- Ultrasound waves

SOUND WAVES

- Sound waves are vibrating forms of energy that are made of molecules and look like waves.

Examples Include:

- Ringing cell phone
- Talking to a friend
- Listening to music

Reflection Questions

1. How do you think waves will relate to the robot?
2. Draw a picture of the most common wave you see everyday?

8.4 Appendix D: Day 03 of Pilot Curriculum (Day 03 Introduction to Programming)

Lesson Plan:

TRUE ROBOTICS

Day 03

Teacher Guide
Introduction to Programming

Learning Objectives

Students will . . .

- Understand the fundamentals of programming.
- Understand how to use the Trubots Playground Software.
- Apply their knowledge of the Trubots Playground Software to program Swervy to move at different speeds.

Vocabulary

Programming, Drag-and-Drop

Materials

- Swervy Robot Kit
- Trubots Playground Software
- Active Learning Worksheet Day 03
- Entrance Ticket & Reflection Questions Day 03
- Presentation Day 03

Lesson Overview

The Trubots Playground Software is a drag-and-drop software used to program Swervy. The software will teach students different programming concepts. The purpose of this lesson is to teach students the fundamentals of programming. Students will learn how to program Swervy to drive in different directions and speeds.

***** Note: If a Mac or Chromebook is being used, computer drivers do not need to be installed. If a Windows 10/11 Computer is being used, drivers need to be installed.**

Recommended Lesson Activities

1. Entrance ticket (5 minutes)
2. Day 03 Presentation and Robot Challenges
   a. Have each student log onto a computer and open the Trubots Playground Software and instruct students to follow along with the presentation. Refer to presentation speaker notes.
   b. The presentation includes the following material:
      i. Trubots Playground environment. (5 minutes)
      ii. Save and load programs (3 minutes)
      iii. Block Groups (3 minutes)
      iv. Upload a Program (3 minutes)
      v. Movement Lessons (10 minutes)
      vi. Driving Challenge (10 minutes)
3. Reflection Questions (10 minutes)

Additional Resources

1. Videos in the Day 2 Presentation.

2. Program Answer Files

Programming Answer Key:

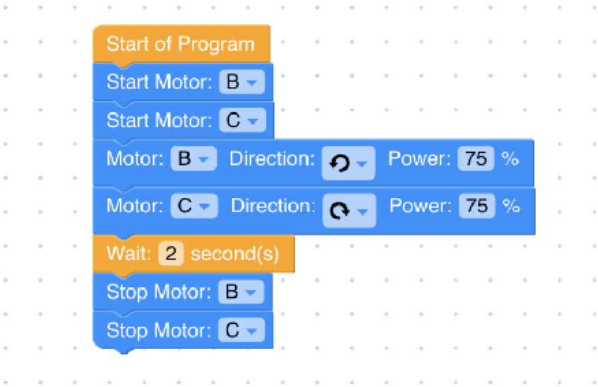
TRUE ROBOTICS

Day 03

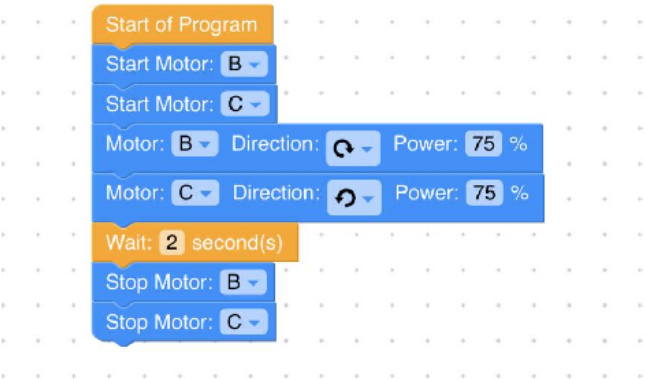
Answer Key Programming Challenges

Note: The time and angles set in each challenge can vary and yield similar results.

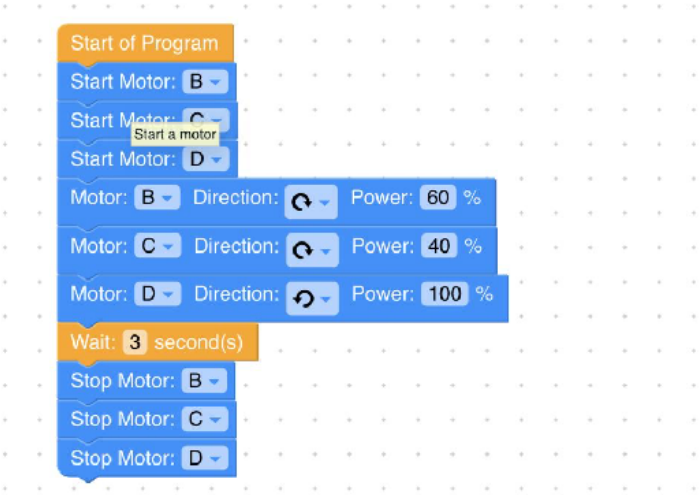
Challenge 1: Drive Forward Motor and Event Blocks



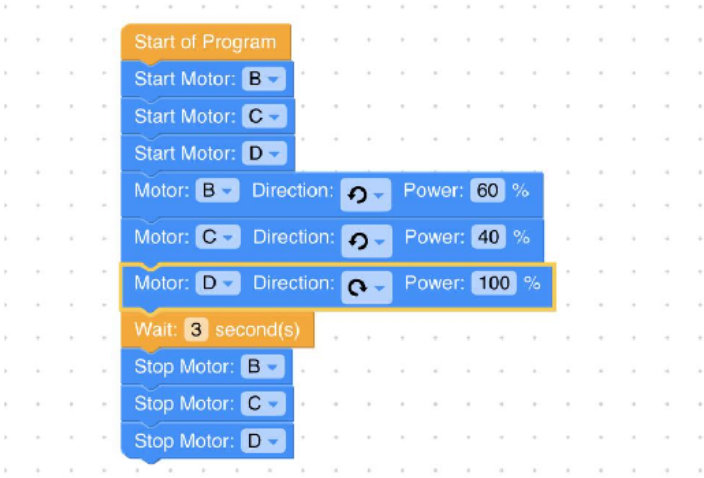
Challenge 2: Drive Backward Motor and Event Blocks



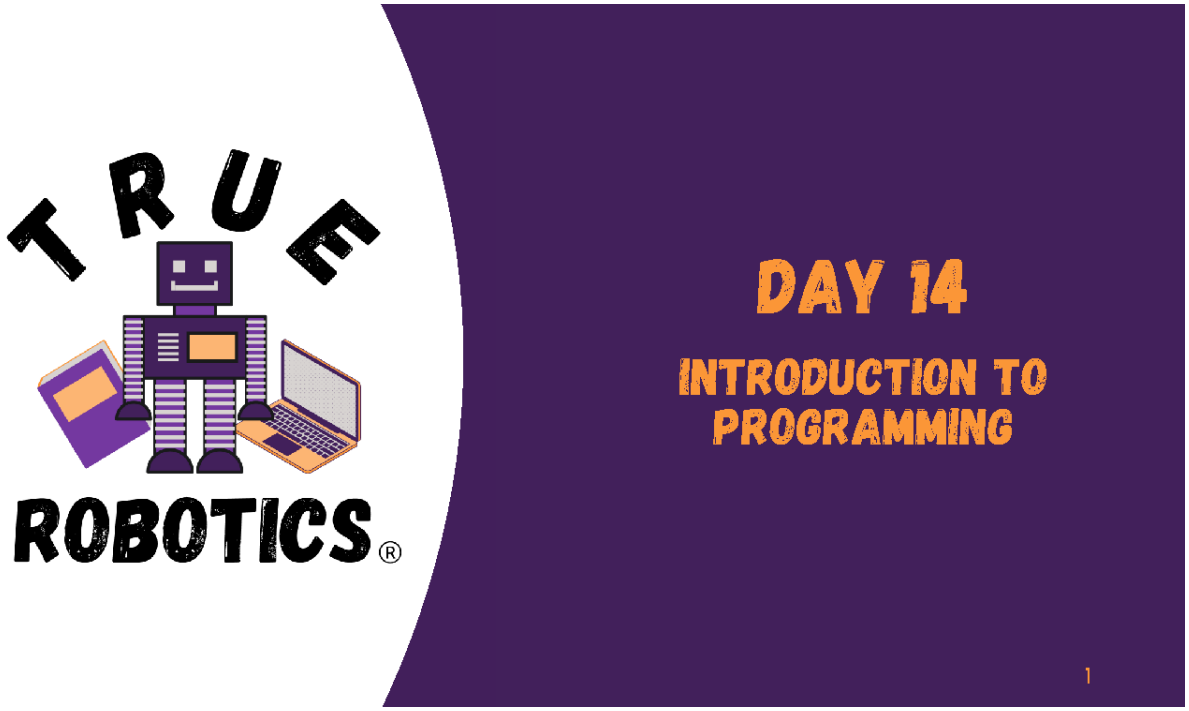
Challenge 3: Drive to the Left Motor and Event Blocks



Challenge 3: Drive to the Right Motor and Event Blocks



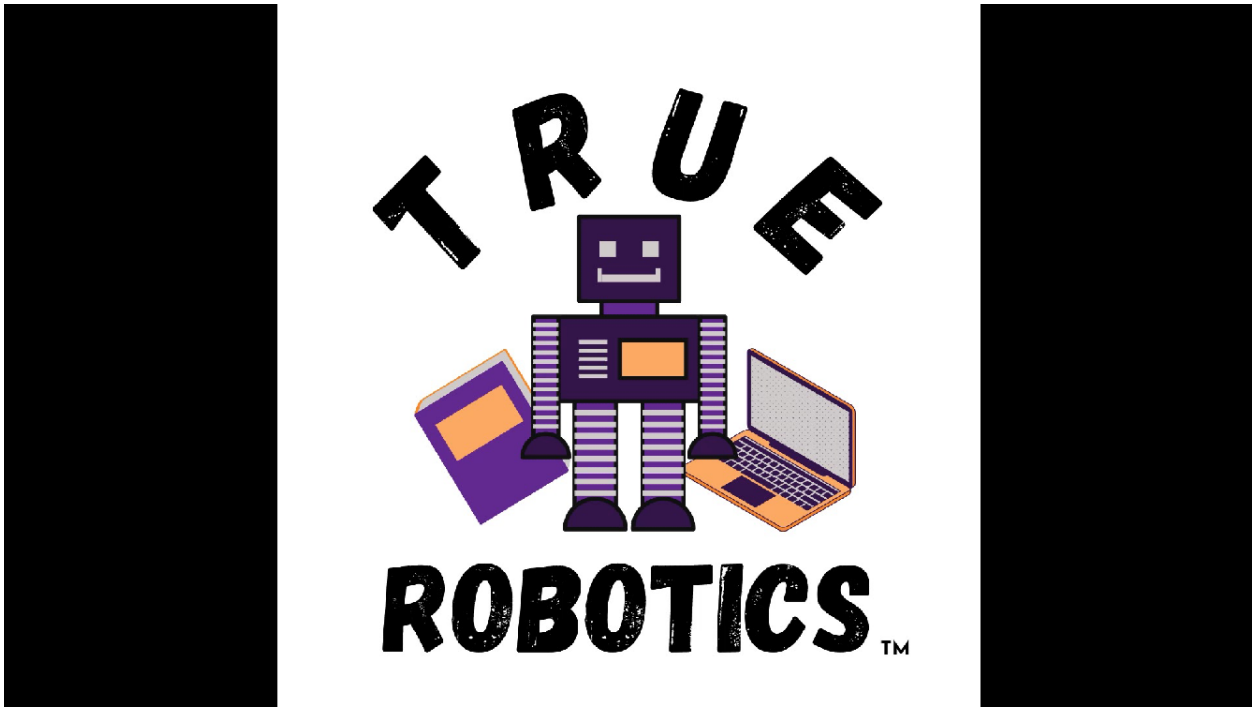
Presentation:



Login to your computer and
open the Trubots Playground Software.
https://app.truerobotics.org/

INSTALL WINDOWS DRIVERS

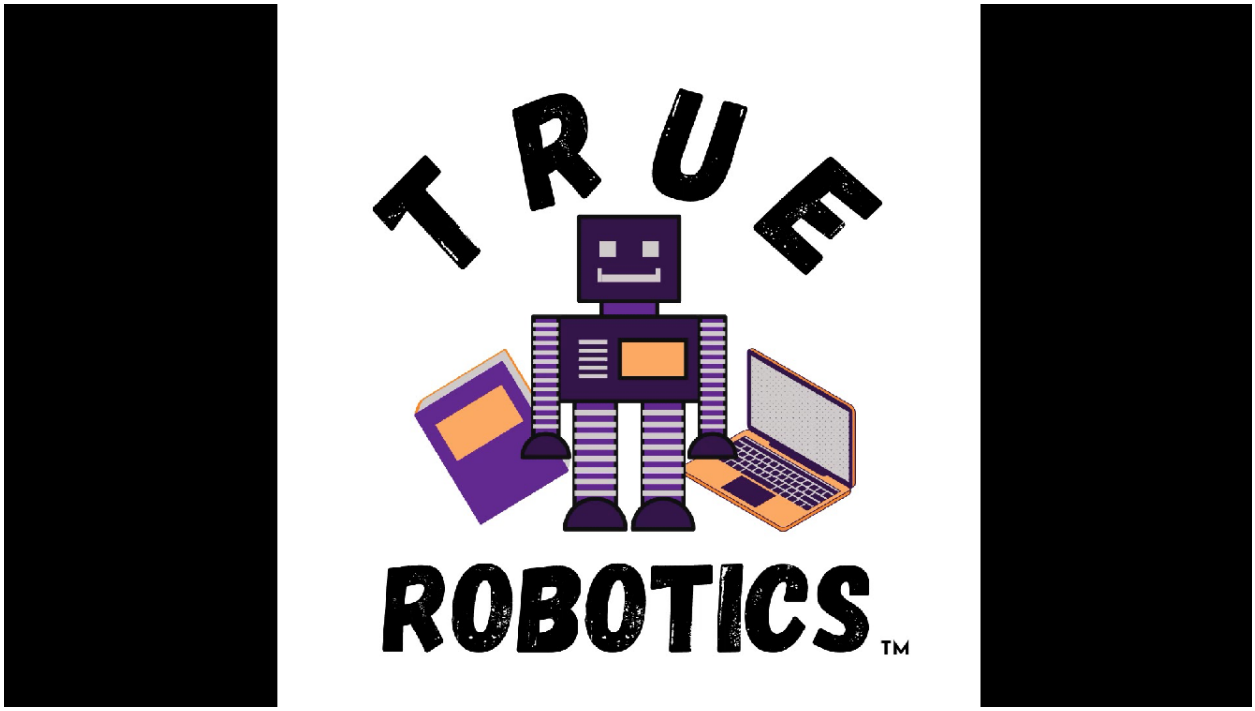
3



In this slide we made an instructional video on how to install the driver on your windows computer.

INTRODUCTION TO THE TRUBOTS PLAYGROUND

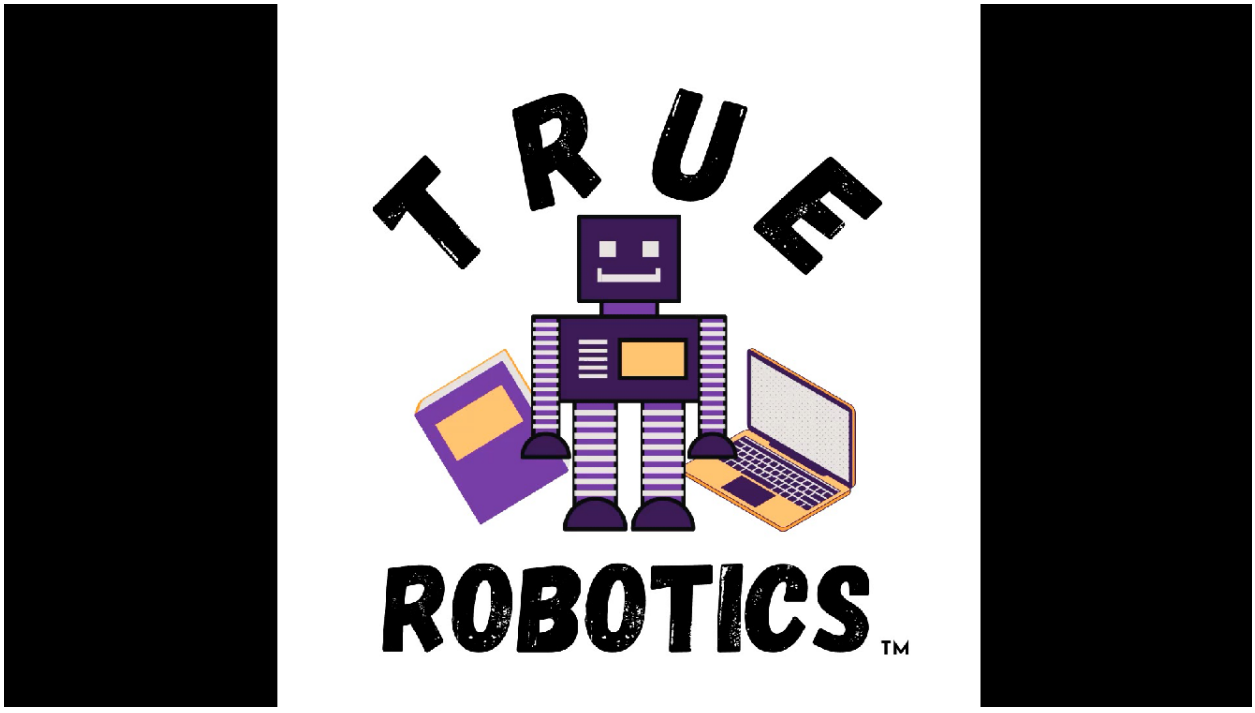
5



In this slide we made an instruction video as an introduction to the TRUEbots Playground software.

HOW TO SAVE AND LOAD A PROGRAM

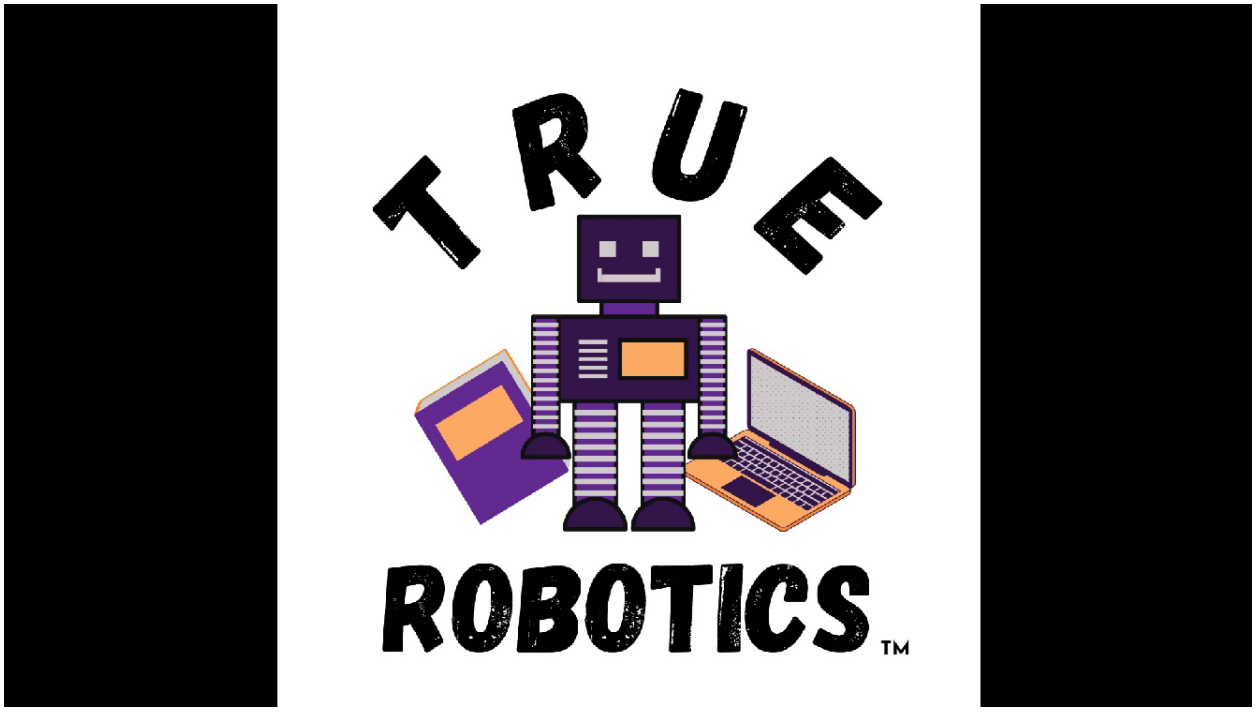
7



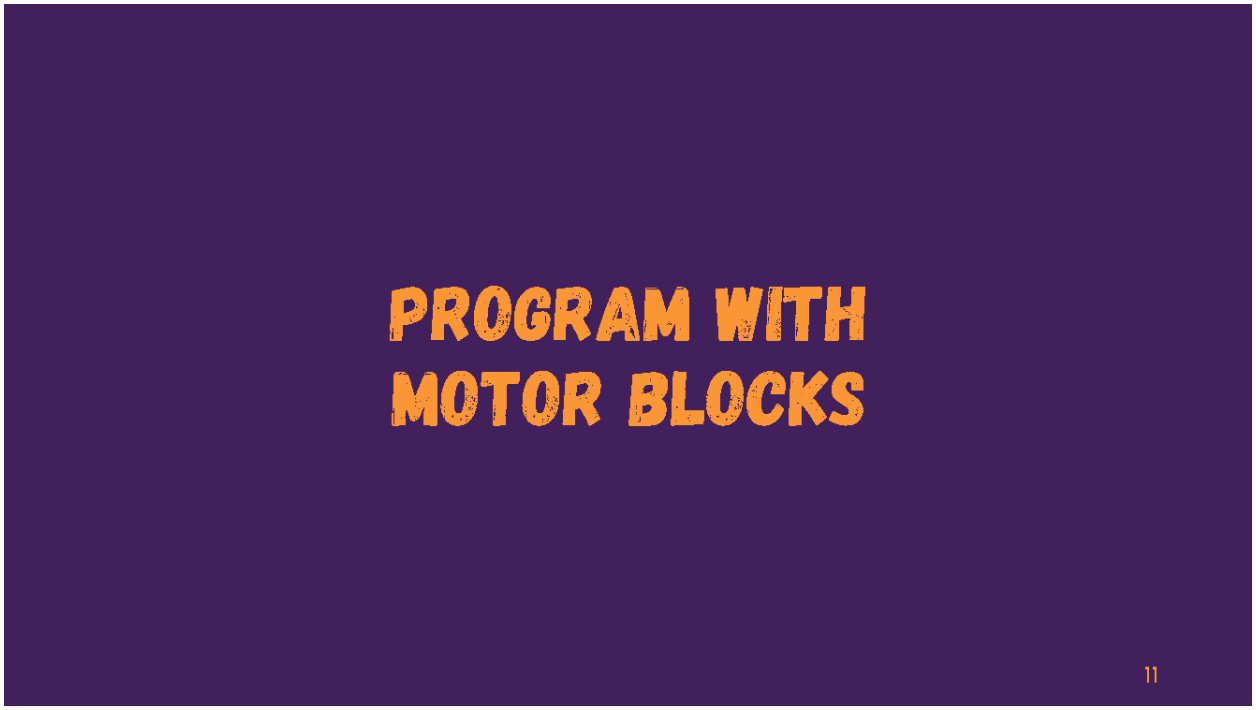
In this slide above there is an instruction video to teach the children how to save and load a program into the TRUEbots playground software.

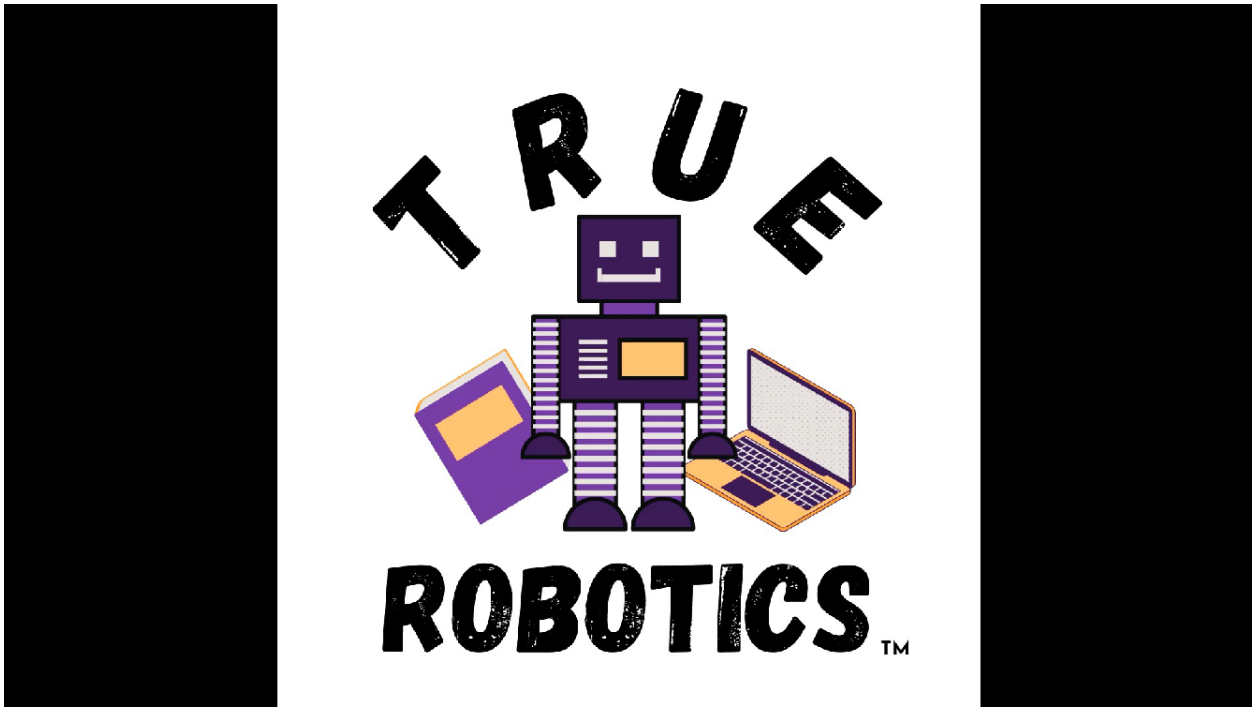
HOW TO UPLOAD A PROGRAM

9

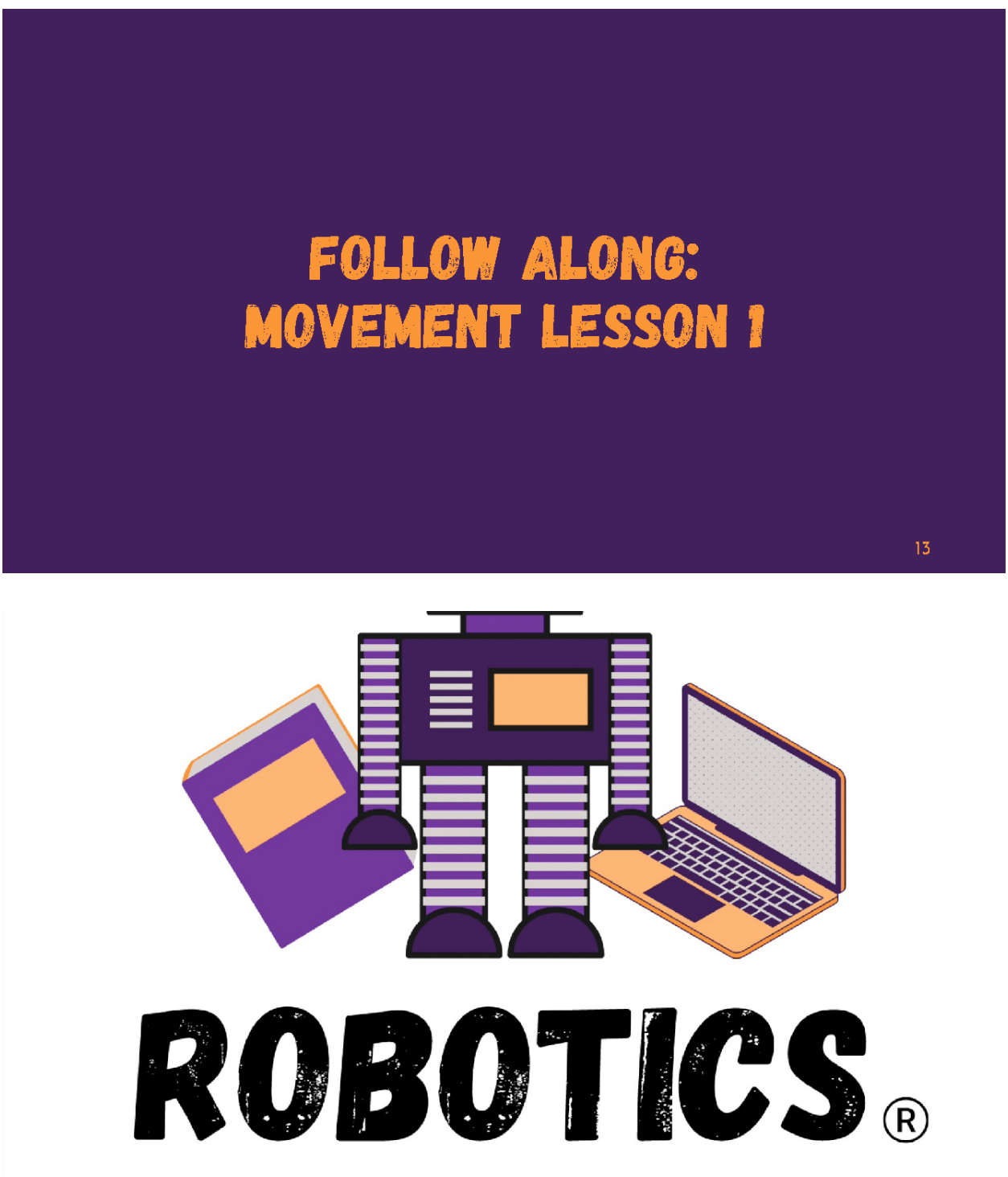


In the slide above our team made an instructional video for the classroom to follow along and learn how to upload one of their saved programs.





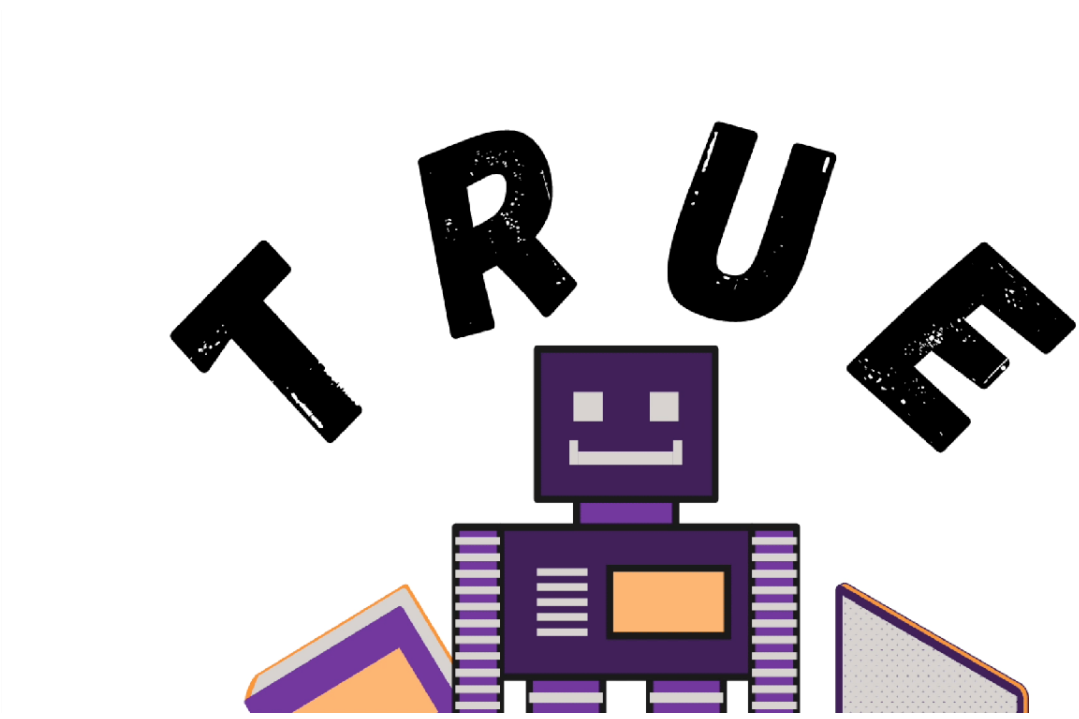
In the slide above our team made an instructional video to teach the children in the class how to program using motor blocks in the TRUEbots Playground software.



In the slide above our team made an instructional video for the children to follow along with a movement challenge. In this movement challenge they will make the robot drive forward for X number of seconds.

FOLLOW ALONG: MOVEMENT LESSON 2

15



In the slide above our team made an instructional video for the children to follow along with a movement challenge. In this movement challenge they will make the robot drive backwards for X number of seconds.

Challenge 1: Drive

- Using only Motor (Blue) and Event blocks:
  - Drive forward for 1 second.
  - Drive backward for 1 second.
  - Drive left for 1 second
  - Drive right for 1 second

*** Be sure to save each program.

TRUE ROBOTICS

Reflection questions

1. How many motors can the blue blocks control at once?

2. In plain words, how do you make Axle drive forward with blue blocks?

3. Why is it important to save programs?

TRUE ROBOTICS

8.5 Appendix E: Days 04-05 of the Piolet Program (Day 04-05 Programming Challenges)

Lesson Plan:

TRUE ROBOTICS

Lesson Days 04-05

Teacher Guide
Ultrasonic Sensor Programming

Learning Objectives

Students will . . .

- Learn how to program the ultrasonic sensor.
- Learn how to use If-Else programming logic with loops.
- Understand how programs work in sequential order.

Vocabulary

Ultrasonic Sensor, If-Then, Loops

Materials

- Boxes
- Swervy Robot Kit
- Trubots Playground Software
- Entrance Ticket & Reflection Questions Days 04-05
- Presentation Days 04-05

Lesson Overview

Students will be introduced to how to program the ultrasonic sensor. Students will learn that the sensor can be programmed to display distances on the robot. Students will also learn how to use If-Then blocks. These blocks will allow Swervy to check if one condition is true, then do something. These blocks will use basic operations such as greater than and less than.

Recommended Lesson Activities

1. Entrance Ticket (30-45 Minutes)
2. Days 04-05 Presentation
   a. Instruct students to follow along with the presentation. Refer to presentation speaker notes for the remainder of the lesson.
   b. The presentation includes the following material:
      i. Ultrasonic Sensor Introduction Review
      ii. How to Display Sensor on Screen
      iii. How to use the If-Else
      iv. Basic object detection
3. Reflection Questions (10 Minutes)

Additional Resources

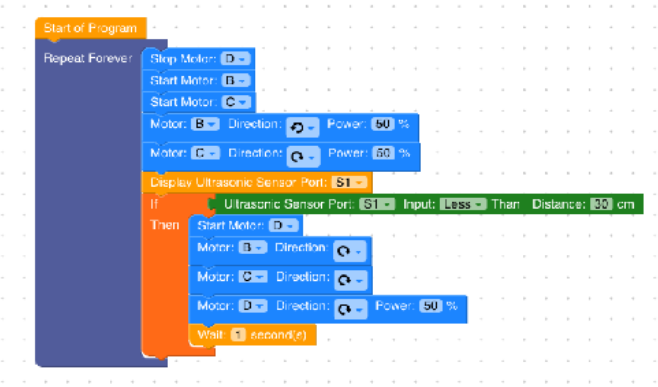
1. Additional Videos

Programming Challenges Answer Key

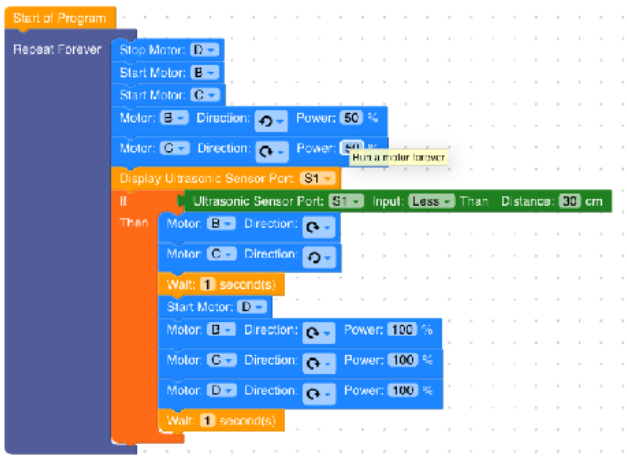
Answer Key Programming Challenges

Note: The time and angles set in each challenge can vary and yield similar results.

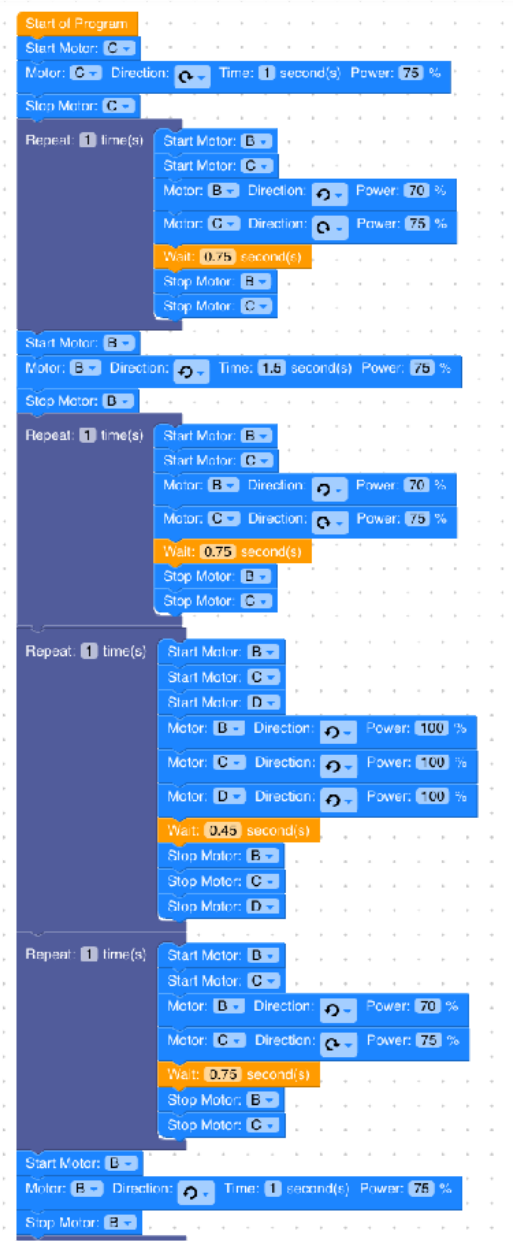
Challenge 1: Stay Inside Area

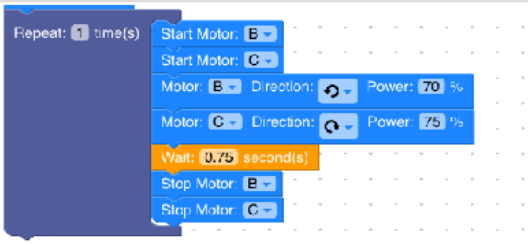


Challenge 2: Stay Inside Area but Back up Before Turning (Advanced)



Challenge 3: Drive in a Diamond





Presentation

DAY 04-05

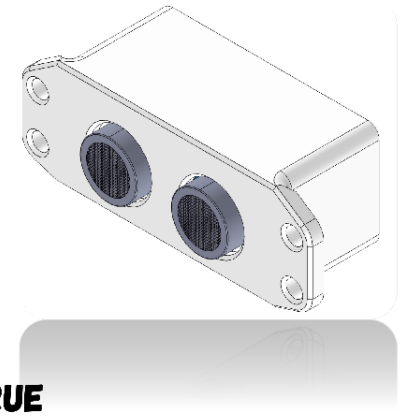
ULTRASONIC SENSOR PROGRAMMING

1

Entrance ticket

Login to your computer and
open the Trubots Playground Software.
https://app.truerobotics.org

Ultrasonic Sensor

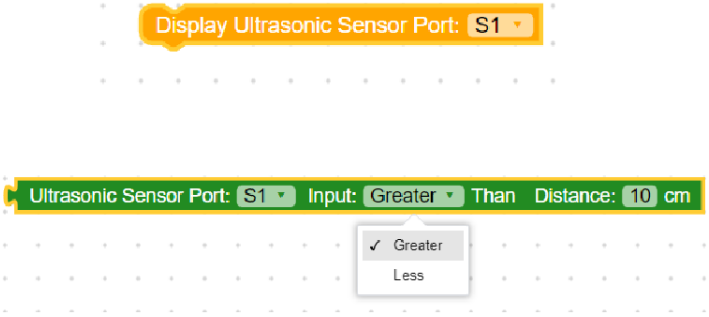


Axle can use the ultrasonic sensor to detect objects.

TRUE ROBOTICS

Programming the ultrasonic

The ultrasonic sensor can directly be controlled by these two blocks.



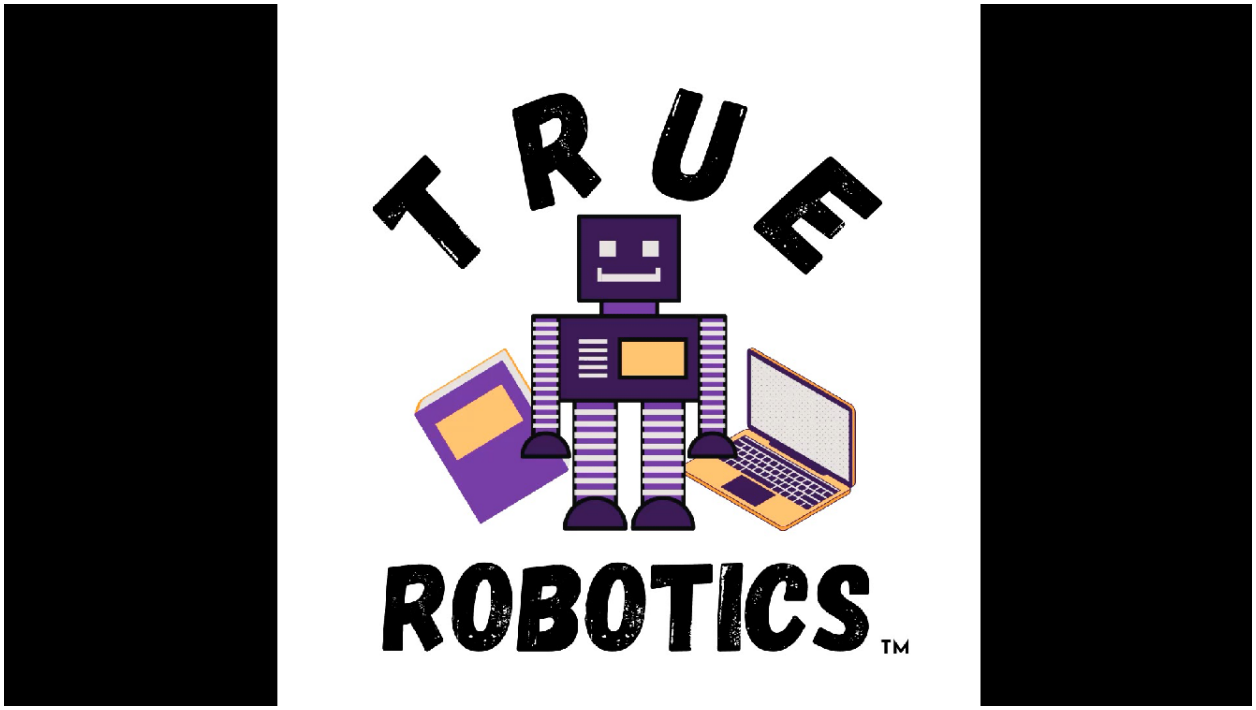
TRUE ROBOTICS

Programming the Ultrasonic

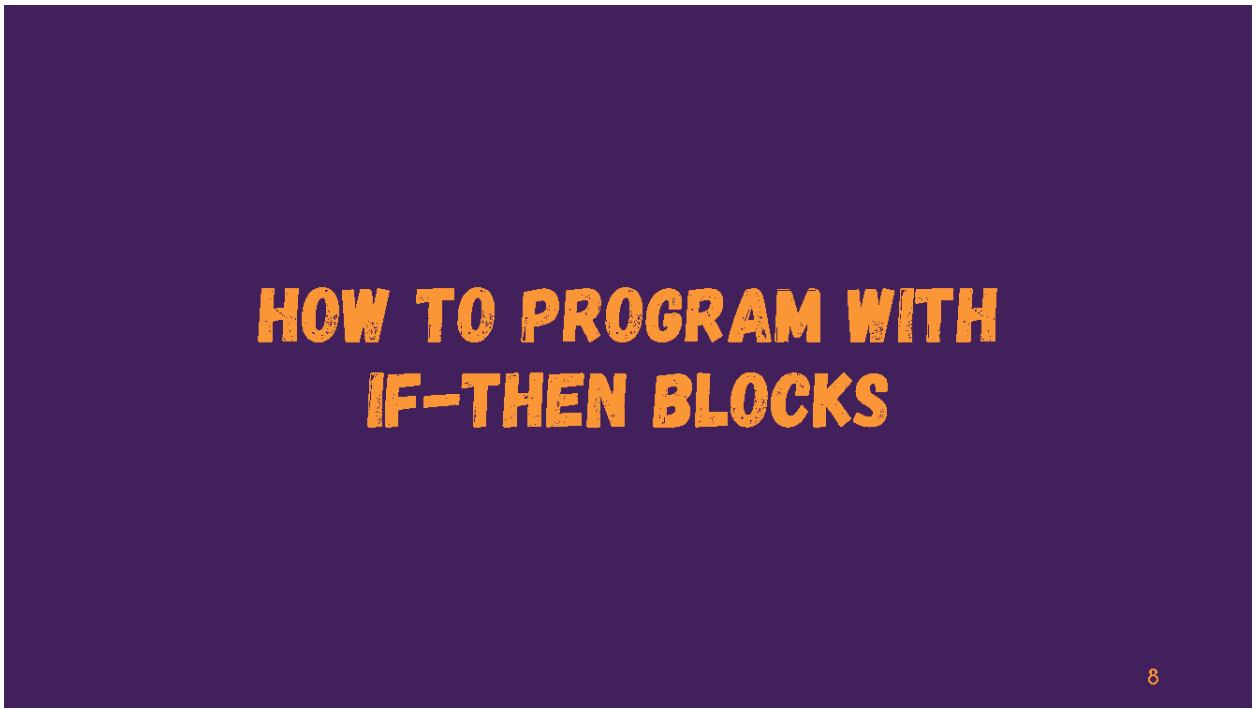
The **If-Then** block and **Repeat Forever** block are also both used to help program the ultrasonic sensor.

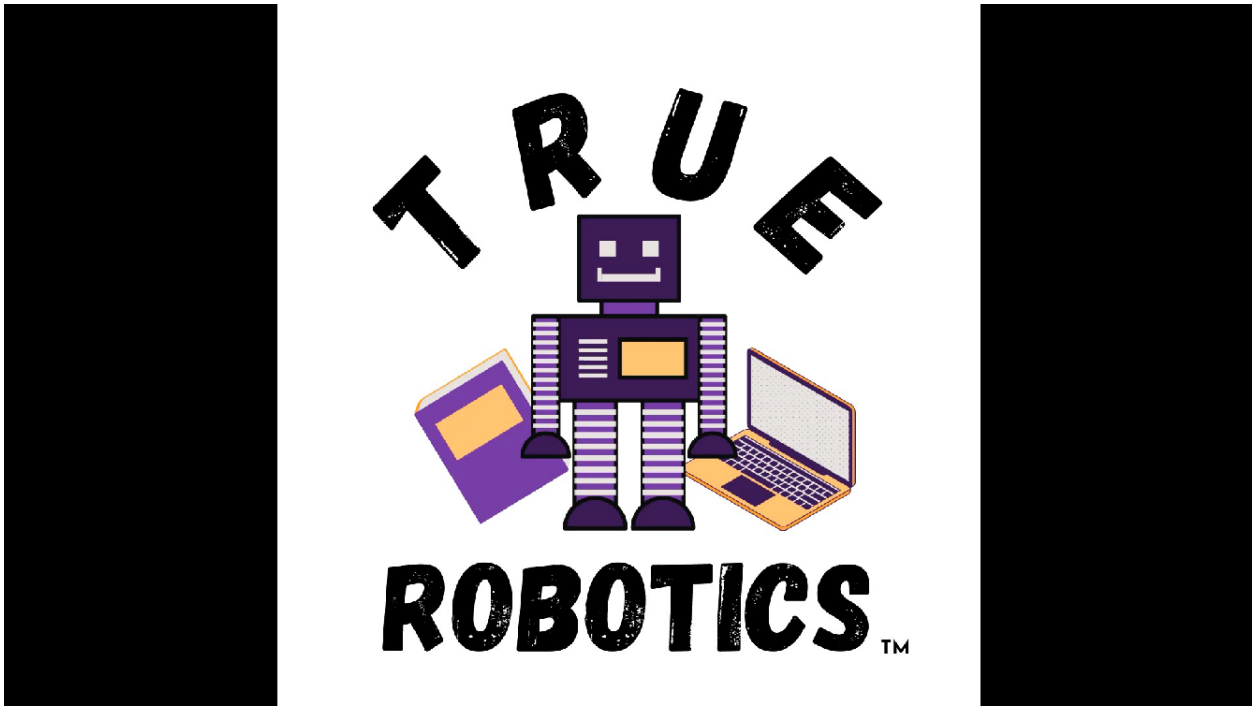
TRUE ROBOTICS

HOW TO PROGRAM WITH LOOP BLOCKS

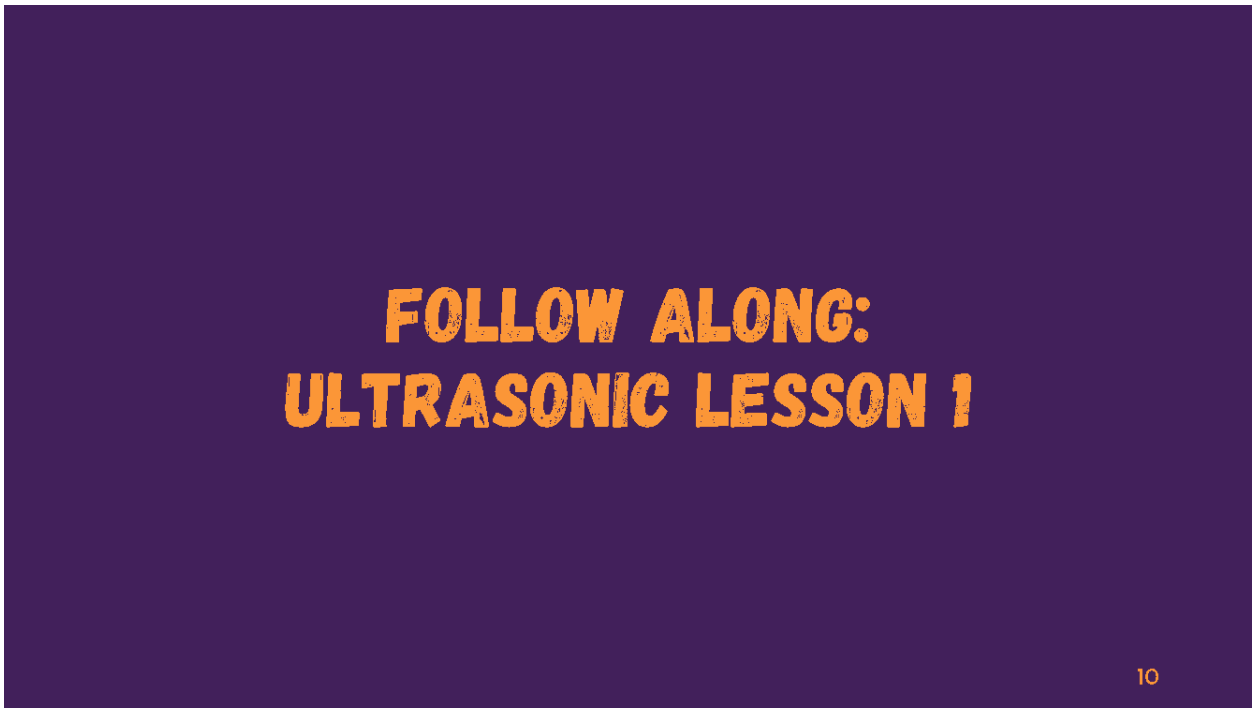


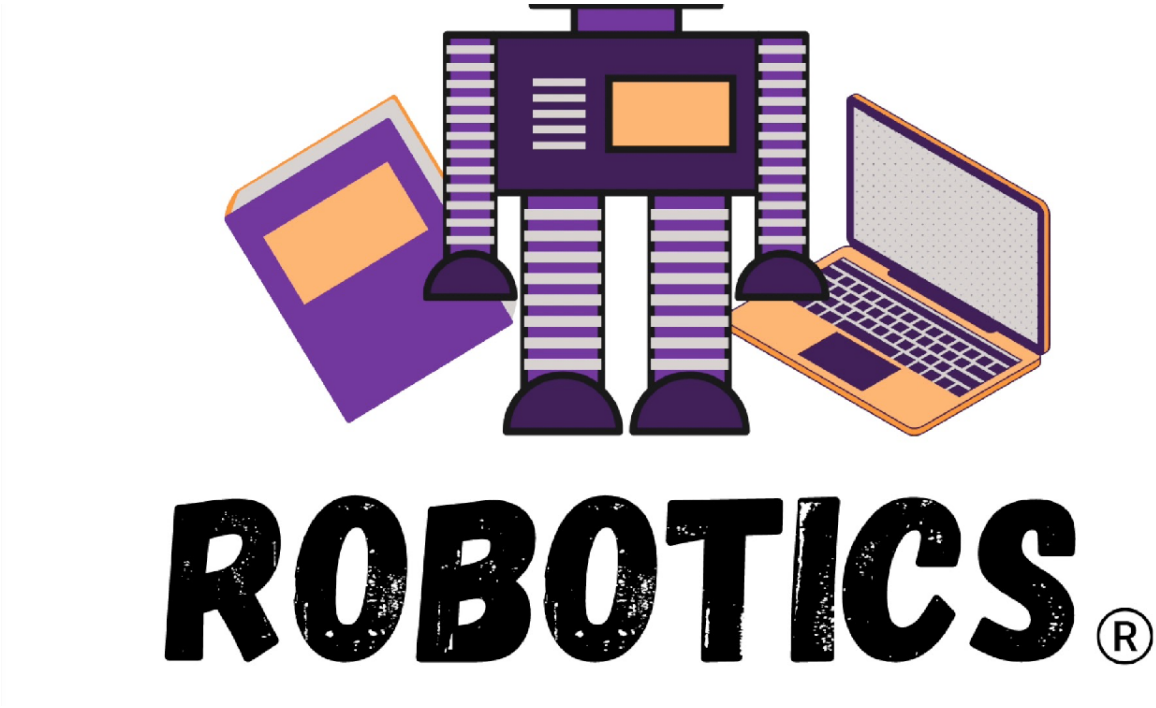
In the slide above our team made an instruction video on how to program in the TRUEbots playground software using the loop blocks.



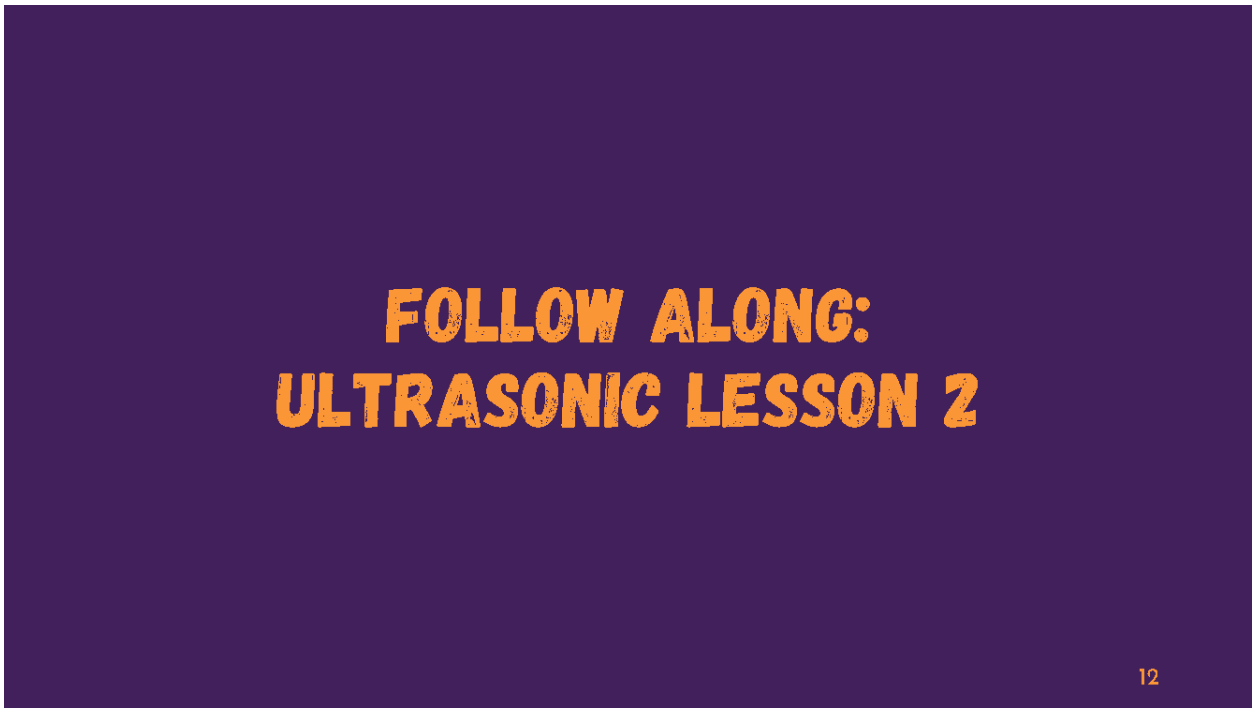


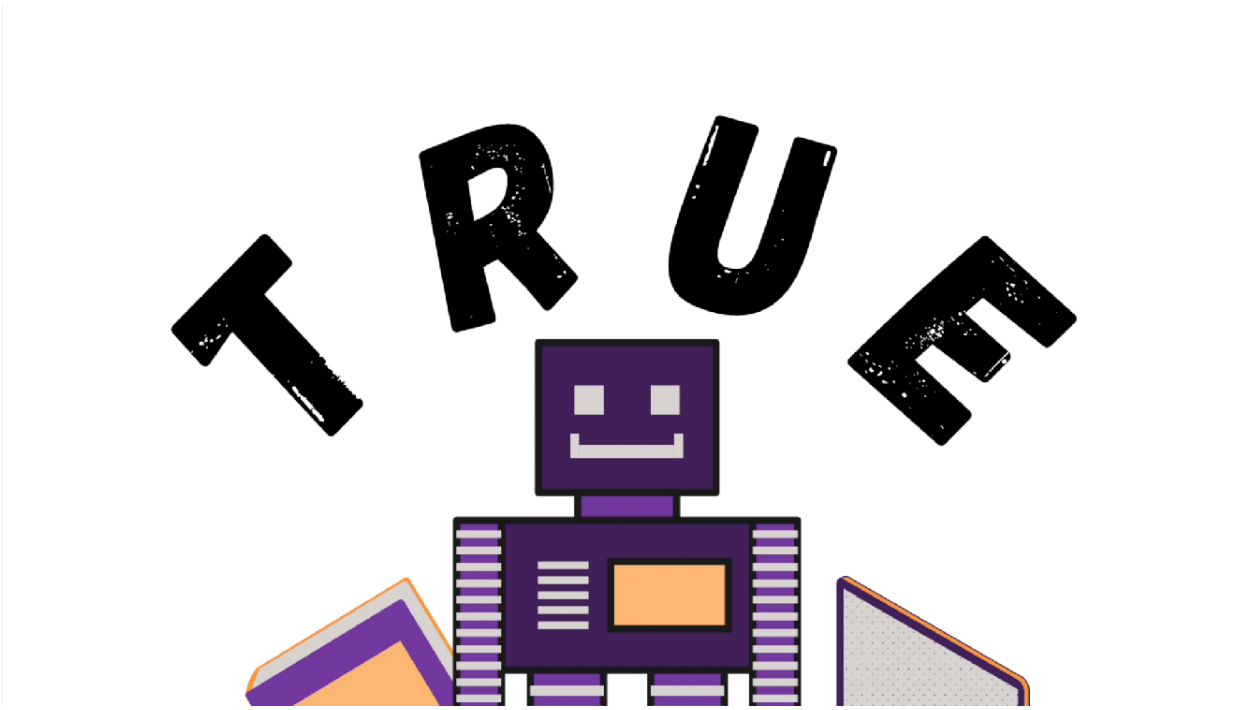
In the slide above our team made an instructional video to teach the classroom how to program with if-then blocks in the TRUEbots Playground software.





In the slide above our team made an instructional video where the students will make a program while following along with the instructor in the video. In this program they will make the robot Swervy stay inside an area.





In the slide above our team made an instructional video for the students to follow along and make a program. In this program the students will make the robot stay inside an area but is more advanced than the previous one.

Reflection questions

1. What two blocks are used to program the ultrasonic sensor?
2. How does the If-Else block works?
3. Why does the ultrasonic sensor need the Loop block?

Appendix F: TRUE Robotics Grant Proposal Template

Dear [Grant Committee],

I am writing to submit a grant proposal on behalf of [School Name] to acquire multiple classroom packages of robotics resources. We wish to purchase the TRUE Robotics middle school Introduction to Robotics Classroom Package. TRUE Robotics is a company that designs and sells educational Science, Technology, Engineering, and Math (STEM) robotics kits and services. students in grades five through eight, equipping them with the tools and skills to explore the latest technologies and engage in exciting, real-world problem-solving challenges. The purpose of their purchase is to provide students and teachers with access to the latest technology, increase student grades and test scores, and to have students design, build, and program robots in a hands-on environment.

Need Statement

The need for robotics education in schools has become increasingly evident due to the demand for STEM skills in the workforce. According to the Bureau of Labor Statistics, STEM jobs are projected to grow by 8.8% between 2018 and 2028, compared to 5.0% growth for non-STEM jobs (Bureau of Labor Statistics, 2019). However, studies show that there is currently a significant shortage of workers with STEM skills, and this gap is projected to grow over the next ten years. The National Science Board reports that the United States faces a shortfall of nearly 2.4 million workers with STEM skills by 2028 (National Science Board, 2020).

By providing the school with robot kits, students will have the opportunity to gain hands-on experience with coding, robotics, and problem-solving skills, which will prepare them for future careers in STEM fields. Research suggests that integrating technology into the classroom can improve student engagement, motivation, and academic performance. According to a study by

the National Math and Science Initiative, students who take robotics classes have higher math and science scores and are more likely to attend college and pursue STEM degrees (Fegely, 2019).

Moreover, robotics education can help students develop important 21st-century skills such as critical thinking, creativity, collaboration, and communication. These skills are essential for success in the modern workforce and are highly valued by employers. According to a survey conducted by the National Association of Colleges and Employers, 91% of employers consider critical thinking, communication, and problem-solving skills to be essential when hiring new employees (National Association of Colleges and Employers, 2021).

Overall, the need for robotics education in schools is clear. Providing students with access to robot kits will not only prepare them for future careers in STEM fields but also help them develop important skills that are essential for success in the modern workforce.

Proposed Solution

TRUE Robotics has developed a high quality, evidence-based curriculum, and instructional materials. The curriculum is designed for grades five through eight and is directly aligned with Next Generation Science Standards (NGSS) and Common Core Math Standards. The curriculum contains 60 hours worth of classroom materials and includes a curriculum map to outline the student learning goals, grading rubrics, suggestions for student evaluation, daily lesson plans, active learning worksheets, presentations, entry and exit prompting questions, and instructional videos.

TRUE Robotics has also developed an interactive professional development training service for teachers. The training can be offered online or in person and provides personalized

guidance on how to grade and evaluate students, perform experiments, use the programming software, create additional exercises and challenges, and use the robot kits.

The curriculum and training have been developed in tandem with a 250-piece robot kit called “Axle.” Axle is a hands-on reusable robot kit that students must put together using real world tools such as screwdrivers, wrenches, and rulers. The kit is designed to allow groups of two to three students to work as a team to assemble and program the Axle robot. The team of students is required to complete a series of programming challenges using a drag-and-drop software tool based on the Scratch programming language. The robot kit will introduce students to real world design concepts used by engineers every day. For example, students will learn about sensors, motors, batteries, and how basic electronics work.

The purpose of the classroom package is to improve students’ grades and test scores in Science and Math. The curriculum is designed to be project-based, forcing students to work in teams and think critically. The robot kit is designed to teach students teamwork, improve their basic motor skills, brainstorm, and solve problems in a hands-on environment. Additionally, TRUE Robotics has seen students’ interest in STEM increase as a result from learning robotics.

Cost

The cost structure is designed to be sold in a per-class format. This means for a standard classroom of approximately twenty-five students, the package would include twelve Axle robot kits, all curriculum resources, and the training service for a single teacher. The standard package is priced at $15,000 upfront or $6,000 per year for three years. Additionally, a $750 subscription fee is required to ensure continued access to the curriculum, training portal, and robot software updates.

Proposal

We are requesting funding to purchase TRUE Robotics' classroom package for [Number of] classrooms at [School Name]. This package would include robot kits, curriculum resources, and professional development for teachers. We believe that this package would greatly benefit our students by providing them with hands-on experience in STEM subjects, increasing their interest in robotics, and improving their grades and test scores in Science and Math.

We are requesting a grant of [Amount] to cover the cost of purchasing this package. We believe that this investment in our students' education will have a significant impact on their future success in STEM fields. We are committed to providing our students with the latest technology and resources to help them achieve their full.

Conclusion

In conclusion, the acquisition of a robotics classroom package would be a valuable investment for [School Name] and its students. The need for robotics education in schools has become increasingly evident due to the demand for STEM skills in the workforce. By providing students with access to robotics resources, they will have the opportunity to gain hands-on experience with coding, robotics, and problem-solving skills, which will prepare them for future careers in STEM fields. Additionally, the curriculum and resources provided by TRUE Robotics are designed to improve students' grades and test scores in Science and Math, while also developing important 21st-century skills such as critical thinking, creativity, collaboration, and communication. We are committed to providing our students with the latest technology and resources to help them achieve their full potential, and we believe that this grant will have a significant impact on their future success.

Bibliography

Bureau of Labor Statistics. (2019). Employment Projections - 2018-2028. U.S. Bureau of Labor Statistics. https://www.bls.gov/news.release/ecopro.nr0.htm

Fegely, A., Winslow, J., Lee, C.-Y., & Rubbo, L. J. (2019). The Effects of Robotics Professional Development on Science and Mathematics Teaching Performance and Student Achievement in Underserved Middle Schools. Contemporary Issues in Technology and Teacher Education, 21(4). https://citejournal.org/volume-21/issue-4-21/mathematics/the-effects-of-robotics-professional-development-on-science-and-mathematics-teaching-performance-and-student-achievement-in-underserved-middle-schools/

National Science Board. (2020). Science & Engineering Indicators 2020: Chapter 3: Science and Technology Labor Force. National Science Foundation. https://ncses.nsf.gov/pubs/nsb20201

National Association of Colleges and Employers. (2021). Job Outlook 2021 Spring Update. National Association of Colleges and Employers. https://www.naceweb.org/job-outlook/2021-full-report.pdf