Low-Budget, Variable-Length, Arduino-Based Robotics Professional Development Program

by

Jonah Lerner

A Thesis Presented in Partial Fulfillment
of the Requirements for the Degree
Masters of Science

Approved April 2020 by the
Graduate Supervisory Committee:

Adam Carberry, Chair
Molina Walters
Shawn Jordan

ARIZONA STATE UNIVERSITY

May 2020

ABSTRACT

This graduate thesis explains and discusses the background, methods, limitations, and future work of developing a low-budget, variable-length, Arduino-based robotics professional development program (PDP) for middle school or high school classrooms. This graduate thesis builds on prior undergraduate thesis work and conclusions. The main conclusions from the undergraduate thesis work focused on reaching a larger teacher population along with providing a more robust robot design and construction. The end goal of this graduate thesis is to develop a PDP that reaches multiple teachers, involves a more robust robot design, and lasts beyond this developmental year. There have been many similar research studies and PDPs that have been tested and analyzed but do not fit the requirements of this graduate thesis. These programs provide some guidance in the creation of a new PDP. The overall method of the graduate thesis comes in four main phases: 1) setup, 2) pre-PDP phase, 3) PDP phase, and 4) post PDP phase. The setup focused primarily on funding, IRB approval, research, timeline development, and research question creation. The pre-PDP phase focused primarily on the development of new tailored-to-teacher content, a more robust robot design, and recruitment of participants. The PDP phase primarily focused on how the teachers perform and participate in the PDP. Lastly, the post PDP phase involved data analysis along with a resource development plan. The last post-PDP step is to consolidate all of the findings in a clear, concise, and coherent format for future work.

TABLE OF CONTENTS

Page

LIST OF TABLES

Table Page

LIST OF FIGURES

Figure Page

INTRODUCTION

This graduate thesis had a few main motivations driving its completion. The first is the extension of work done in a prior undergraduate Honors thesis. Second is a personal motivation as a mentor for a high school robotics team which is always looking for new members to join. Introducing students to robotics in their classes is one way to potentially increase the amount of students interested in joining the team, or program as a whole. Building this interest involves reaching more students through their teachers. Third is a personal interest to see robotics in middle and high school classrooms. Developing a Professional Development Program (PDP) would allow middle school and high school teachers to learn and teach their students about robotics.

Robotics is a subject that should be taught in middle and high school classrooms as a platform to apply science and math. Physics, computer science, and math are utilized greatly when working on a robot. Robotics can also enhance valuable life skills, including teamwork, communication, interpersonal, and problem-solving. This is because most robotics tasks involve working on a robot with a team, or group, since there are many different subsystems and components to integrate together. The overall goals of this graduate thesis are to develop a PDP that reaches multiple teachers, involves a robust robot design, and is shown to be an effective way of preparing teachers to teach robotics. Success of the PDP will require that the content and resources be self-sustaining following my graduation, since I may not have the ability to answer any questions regarding the unit and robot design beyond this study. A delicate balance between being very hands-on with the unit and robot design (e.g., making custom parts for the robot) and being very hands-off (e.g., purchasing a premade kit and not answering troubleshooting questions) is something I aimed to achieve as part of this project.

BACKGROUND

Undergraduate Honors Thesis

The topic of the undergraduate honors thesis was "Creating a Low-Budget, Variable-Length, Arduino-Based Robotics Unit for a 5th-7th grade classroom." This topic was based-on a brief research period and thesis committee feedback. The Low-Budget aspect was included to make the activities affordable for as many teachers as possible to be able to use the materials developed. The Variable-Length descriptor highlights the flexibility of the unit to be inserted by a teacher as a one, two, or three-week unit into their existing curriculum. Lastly, the Arduino-Based descriptor describes the open source, free, and vast internet resources of the Arduino microcontroller platform used in the activities.

The main components of the undergraduate thesis were to design a unit based around the 5E lesson plan model (Engage, Explore, Explain, Elaborate, and Evaluate), design and develop a robot from scratch, plan activities for the new robotics unit, and draw up conclusions based on a test run of the unit in a middle school classroom. The two big conclusions from the undergraduate thesis were: 1) with enough training, a teacher can troubleshoot problems by themself, and 2) robot motors and battery packs used were not sufficient for the designed activities.

Literature Review

Nine main sources emerged during the background research process for this graduate thesis. These sources provided guidance as to how to plan, execute, and document the PDP and how to collect meaningful, usable data.

The first main paper focuses on expanding available PDPs from just math and science teachers to engineering teachers (Reimers, Farmer, & Klein-Gardner, 2015). In order to expand to engineering teachers, the authors developed a matrix that featured five design standards that can be used when creating PDPs. These five design standards were kept in mind during the design of this PDP. The design standards include focusing on the fundamental nature, content, and practices of engineering to promote engineering content knowledge; pedagogical content knowledge; how engineering design can facilitate other subject learning such as science, math, language arts, reading, and other subjects; and aligning the PDP around current educational research and student learning standards. This graduate thesis, for example, could use the standard which focuses on promoting engineering fundamental knowledge by explaining what the engineering design process is along with how it is the foundation for much of what is done in engineering (Reimers, Farmer, & Klein-Gardner, 2015). Standards that are not initially incorporated in the first PDP can be employed in additional PDPs.

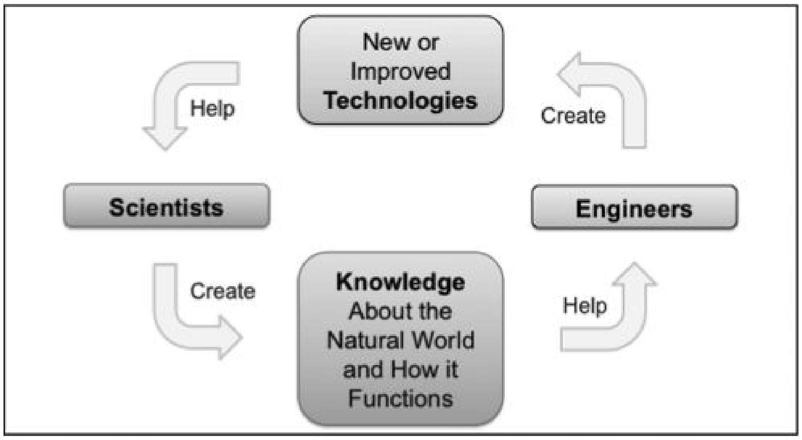


Figure 1: Relationship Between Scientists and Engineers

The second main paper provides insights regarding the inclusion of activities in a PDP (Donna, 2012). This paper focuses on the need for design-based activities to be incorporated into PDPs. These activities allow for teachers to experience the design process which can lead to a better understanding of engineering and STEM and ultimately turn into a culture stift at the teachers' respective schools. The paper includes a couple of flow charts, as seen in Figure 1 and Figure 2, that describe the relationships between science, engineering, and technology and an example of the design process, respectively . Both of these flowcharts provide additional conceptual context for the beginning portion of a PDP. Providing this engineering context in this graduate thesis would help to lay the engineering design process and conceptual foundation for the PDP and, ultimately, the content being presented.

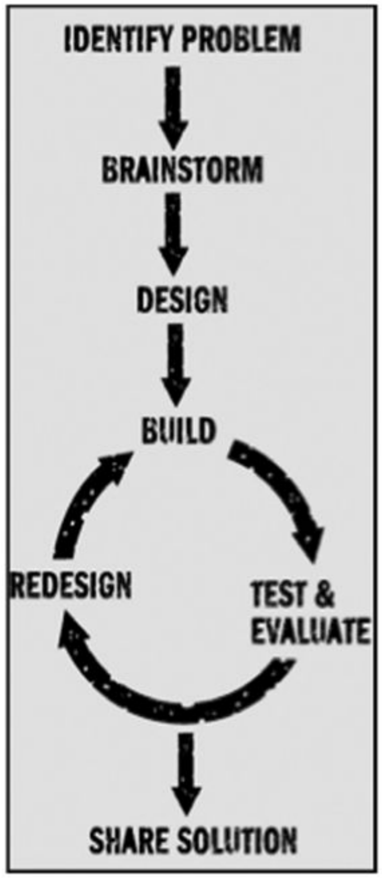


Figure 2: Engineering Design Process

The third source examines Project Lead the Way (PLTW) as a vehicle to examine how teachers learn and experience an engineering-based PDP (Nathan, Atwood, Prevost, Phelps, & Tran, 2011). PLTW is a transformative engineering learning experience for Pre-K-12 students and teaches across the U.S. The research asked a series of questions using a five or seven point scale. The research used two groups: control and experimental. The main difference between these groups was that the experimental group attended a summer institute to learn how to teach PLTW engineering courses and the control population did not attend. The source was able to get a total of 174 participants and collected data on the number of years teaching, highest earned degree, gender, and race/ethnicity of the participants. The main way this graduate thesis can improve on what was done is by expanding participants from just high school STEM teachers to both middle school and high school STEM teachers. Expanding the scope provides an opportunity for more teachers to get involved, which should result in a larger sample size.

The fourth source discusses how the field of engineering is rapidly changing with the introduction of new technology (Adams & Felder, 2008). The line between engineer and technician is being skewed by the introduction of new technology that can perform the same repetitive task over and over again. In conjunction with increasing technology, engineering education in higher education needs to adapt to the changing workplace. While this source does shed some light on the changing roles of technicians and engineers, there is not much emphasis on how to improve education through PDPs . This graduate thesis can take this changing workplace to help the next generation of engineers and technicians by running a PDP for teachers in middle and high schools to educate and inspire students to become engineers, technicians, problem solvers, and scientists. Teaching teachers will also increase the spread of the knowledge and content presented in the PDP.

The fifth source qualitatively studied elements of PDPs for secondary school engineering education (Daugherty, 2009). These PDPs included Engineering the Future: Science, Technology, and the Design Process (EtF), PLTW, Mathematics Across the Middle School MST Curriculum Project (MSTP), The Infinity Project, and INSPIRES. Each of the PDPs focus on certain aspects of engineering. For example, The Infinity

Project focuses on how to use LabVIEW, a block-based programming language, to improve programming literacy. This graduate thesis utilized a multiple case study model by examining what has already been done in the field of engineering education and how it relates to PDPs. In addition to a multiple case study approach, the thesis will develop a new PDP based on a previously developed robotics unit (Lerner, Carberry, & Walters, n.d.).

The sixth paper discusses teaching elementary school teachers through the means of a PDP and how it affected the students in those teachers' classrooms (Zakharov & Diefes-Dux, 2020). These students were in Grades 2-4 and were given multiple-choice pre-post knowledge tests to see how much they knew before the lessons and what they learned after them. The main conclusion from this study is that when the teacher taught an engineering unit, engineering and mathematical understanding went up, as measured by the pre-post knowledge test. This study assisted with the design of this graduate thesis by directing assessment toward a pre-post knowledge test for the teachers and a pre-post knowledge test for the teachers to give to their students. In contrast to this study, this graduate thesis will shift the focus from elementary school teachers to middle and high school teachers. The shift will allow the unit to be more in-depth physically and mathematically, provide more design insight, and present challenging engineering tasks to both the teachers and their students.

The seventh paper used units from the Engineering is Elementary (EiE) training to teach elementary school teachers about engineering and engineering practices (Porter, West, Kajfez, Malone, & Irving, 2019). Training teachers through a PDP allows them to transfer the engineering concepts and practices from the PDP to their classrooms. The results from the study demonstrated that teachers benefited greatly from these trainings in the subject area of engineering concepts and practices. The study also pointed out some potential hurdles for teachers when it comes to teaching engineering in their classrooms, which include time, money, and lack of knowledge or understanding of a specific concept. This graduate thesis used this information by allowing the participants to keep the robot platform that they work on during the PDP to help alleviate any potential knowledge and related time hurdles.

The eighth source focuses on the impact of a PDP on how high school STEM teachers enacted design-based pedagogical practices (Singer, Ross, & Jackson-Lee, 2016). The researchers used a pre-selected engineering design curriculum as the foundation of the PDP. The researchers determined that the scores were statistically significant using a reformed teaching observation protocol. This means that the impact of the PDP improved the pedagogical practices of the teachers. Using an existing curriculum allows for the ability to make a PDP centered around the pedagogical practices for that specific curriculum. The use of a pre-existing curriculum or unit directly applies to this graduate thesis since it is the conversion of a prior robotics unit into a PDP. In contrast to the evaluation method of this research study, this graduate thesis will use a pre-post knowledge test structure to facilitate knowledge comparisons in a data analysis step.

The final paper analyzed what worked and didn't work for middle school teachers who participated in a PDP aimed to prepare teachers to teach LEGO robotics units in-class and after school (Hynes & dos Santos, 2007). The study used teachers from thirteen Massachusetts public middle schools. These teachers participated in a two-week training during the summer and the data collected came in the form of confidence surveys, researcher observations, and teacher interviews. The methods used in this study apply to this graduate thesis by having teachers from multiple schools participate in a PDP with the method of data collection being a survey of general robotics knowledge. Differing from the above study, this graduate thesis will be reducing the amount of data sources to provide more concise data about what the teachers are learning.

There are many conclusions that can be drawn from the above literature review. One of these conclusions is that running a PDP in general is beneficial to the teachers that participate in them (Adams & Felder, 2008), especially when engineering design, connections to science, and the five design standards are referenced (Donna, 2012; Reimers, Farmer, & Klein-Gardner, 2015). Expanding the scope of a robotics PDP to middle school and high school teachers allows for more in-depth physical and mathematical units, increased design insight, and engineering challenges with increased difficulty (Nathan, Atwood, Prevost, Phelps, & Tran, 2011; Zakharov & Diefes-Dux, 2020). Using the pre-existing robotics unit previously developed is a good starting platform for designing a PDP since it encompasses the five design standards for a PDP (Daugherty, 2009; Lerner, Carberry, & Walters, n.d.). Another conclusion is that allowing the teachers to take the robots used in the PDP reduces the potential hardships the teachers typically encounter (Porter, West, Kajfez, Malone, & Irving, 2019). The PDP created as part of this graduate thesis will involve only a pre-post knowledge test structure (Hynes & dos Santos, 2007; Singer, Ross, & Jackson-Lee, 2016). This literature review proved to be very useful in identifying what has already been done and provided a foundational framework to use when developing a PDP.

METHODS

The PDP was divided into four main stages. The first stage was the setup which includes identifying the research question, developing a timeline, applying for funding, and getting IRB approval. The second stage was before the PDP ran which primarily included content development, robot development, and PDP organization. The third step was testing the PDP. The final stage was done after the PDP was tested and includes an analysis of all of the data collected from the pre-post knowledge survey.

Setup

The setup section focuses on the fundamental requirements of the research project which include creating a research question, developing a timeline, getting IRB approval, and acquiring funding.

Research question

Using the foundational knowledge from the aforementioned undergraduate thesis, literature review, and goals for this graduate thesis, the next step was to develop and test a PDP. In order to test the effectiveness of the PDP, the overall knowledge of the teachers was measured before and after the PDP. The research for this graduate thesis revolves around the main research question: “How much robotics related information do middle school and high school teachers know and learn while participating in a low-budget, variable-length, Arduino-based robotics PDP?"

Timeline

The timeline of the graduate thesis is broken up into several main phases as seen in Table 1. The first phase was fully filling out the thesis committee. Prior to this graduate thesis, there was an undergraduate thesis that provided the foundational robotics unit for the PDP. Dr. Adam Carberry and Dr. Molina Walters were part of the undergraduate thesis and agreed to join this graduate thesis. The third Master's thesis committee member became Dr. Shawn Jordan. The second phase of the graduate thesis involved researching how to plan, execute, and debrief a PDP. The main components to this phase were a literature review and talking with the thesis Committee to work on creating the PDP. The third phase consisted of developing the PDP. The main components in this phase included getting IRB approval, securing funding, researching robot improvements, compiling literature review conclusions, and synthesizing all of the prior robotics unit materials into PDP usable formats. The remaining phases are focused on the recruitment of teachers for the PDP, the implementation of the PDP, data analysis, and the final thesis defense and submission. All of the deadlines were soft deadlines with the single exception being the defense and submission of the thesis. The final deadline for scheduling a defense was early April to allow the defense to take place in mid-April with time for revisions to be submitted in early May.

Table 1: Timeline

Category	**Deadline**
Full Thesis Committee	Late September
Research for PDP	Late October
Recruitment of Teachers for PDP	ASAP after Research for PDP
Development of PDP	Late January
Implementation of PDP	Late February
Data Analysis	Late March
Defense/Submit Thesis	Early/Mid April

IRB approval

In order for the research data to be disseminated beyond the research team, the research process needed to be approved by the Human Subjects Institutional Review Board through the Arizona State University's (ASU) Office of Research Integrity and Assurance (see Appendix A). The main research method that required approval was the use of the pre-post knowledge survey. The exact survey can be seen in Appendix B. A consent form was created as part of the IRB approval process. The main components of this consent form included notification of how long the PDP would take, a volunteer clause, notification about data security, and researcher contact sections.

The aforementioned survey consisted of four main sections. The first section collected information that could link surveys together but also kept the data unidentifiable. The second, third, and fourth steps were the mechanical, electrical and programming knowledge surveys. They consisted of each component and what it was called. The programming section also included a code practice question. The sections were all developed to test the exact knowledge of the mechanical and electrical components along with a few coding concepts. The questions that were developed for each section were made by the lead researcher and were based off of the purchased robot kit. The mechanical and electrical sections of the survey all were 'name that part' style, which included a picture of a part and a drop down menu with all of the options (see Appendix A for exact details). The programming section was formatted differently with some of the questions having a correct answer and others presented as open-ended. The data collected from these surveys helped to answer the research question by providing information on how effective the PDP was at training the teachers on how to use the robotics kit and robotics unit.

Funding

The final fundamental requirement to complete the graduate thesis was securing funding. This project was funded through a $2000 Graduate Research Support Program Research Grant provided by the Graduate and Professional Student Association (GPSA). The proposal was submitted in December 2019 and received approval for funding in mid-February 2020 for the 2020 spring and fall semesters.

Pre-Professional Development Program

Robot Development

The robot needed to teach the robotics unit introduced during the PDP is based on required improvements from the undergraduate thesis to be more robust, more teacher friendly, and more student friendly. The two largest updates came from the need to find more robust motors and battery boxes. In addition to these updates, the goal of having a stand alone purchasable kit that was inexpensive became paramount to the success (and potential longevity) of the PDP. With these updates and new goals in mind, the OSOYOO 2WD Robot Car Starter Kit met all of the requirements, most importantly, by costing only $29.99 at the time of writing (Kuklovskai¯a˘, n.d.). This kit comes with pre-soldered wire leads on the motors that have connectors specifically for the motor controller, a robust battery box, many sensors, and an online website with starter guides for four different projects. All of these modifications can be seen in Figure 3 and 4. The only downside to the above kit is that it uses special 18650 rechargeable batteries. Buying these batteries in bulk and a charger for them can get relatively expensive. Each of these robots cost about $50 each. The kit that the robot comes in is only $29.99, therefore 40% of the cost comes from purchasing LEDs, resistors, batteries, and chargers with most of that 40% being batteries and chargers. There were no grants that were researched to help teachers potentially offset these costs, however there are ways to get tax breaks from the IRS.

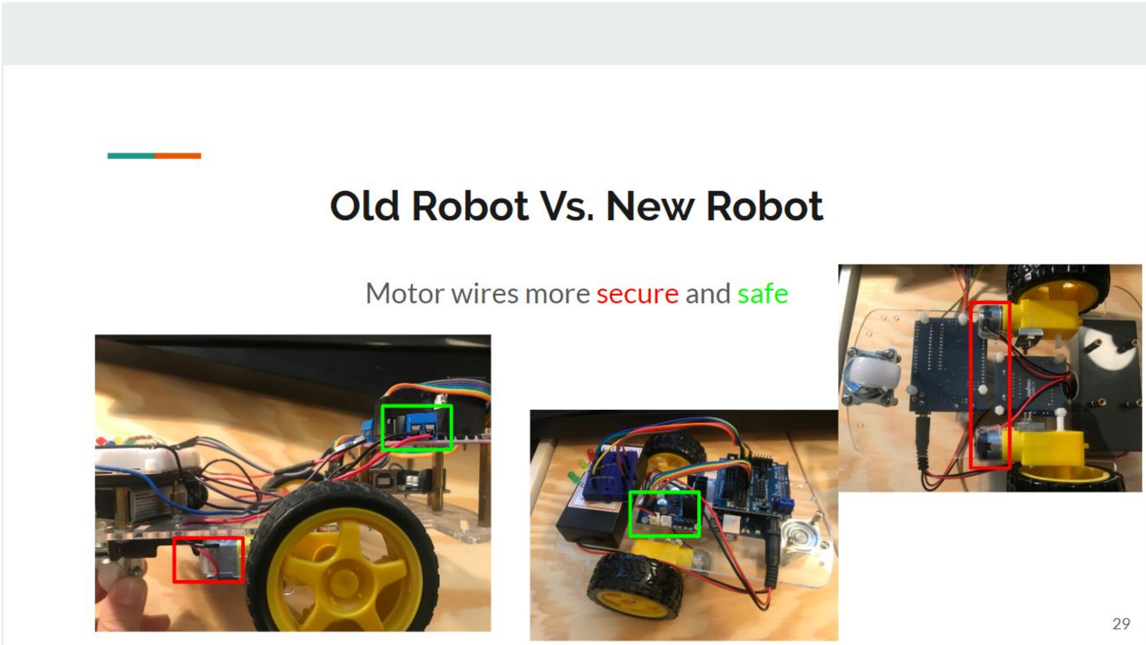


Figure 3: Old Robot v. New Robot - Motor Wires Secure and Safe

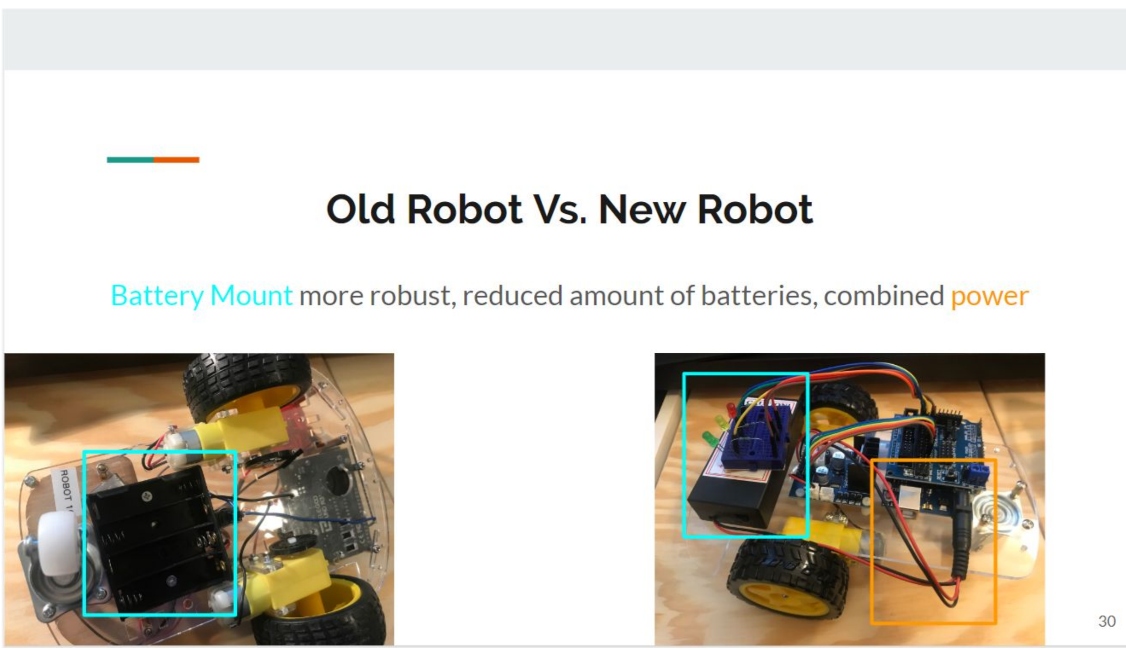


Figure 4: Old Robot v. New Robot - Battery Mount and Power System

Content Development

The content for the PDP came primarily from the slides that were created in the prior undergraduate thesis. Some of the content did change in composition since the original unit was developed for 5th-7th grade students and the PDP targeted middle and high school teachers. The PDP had several overarching learning objectives that would be the ultimate framework for the PDP. The first and primary learning objective was that the teachers would learn how to build, wire, and program the robot. The second learning objective was that the teachers would learn building techniques to efficiently build a robot. The third learning objective was to learn wiring techniques to accurately wire a robot. The fourth and fifth objectives were centered around understanding the underlying electrical and programming concepts to then make the robot blink an LED and spin a motor.

There were many hands-on components to the PDP that assisted in one or more of the aforementioned learning objectives. Thesis activities will be described following the rough agenda used in the PDP shown in Table 2. The PDP was broken up into three main subsections: mechanical, electrical, and programming. The mechanical section primarily consisted of building the robot. This construction of the robot involved assembling the motor mount subsystem, attaching the three wheels, and securing the electrical components in place on the chassis.

The electrical section consisted of a brief electrical concepts basics review, an electrical components introduction, and a hands-on activity of wiring the robot. The concepts of voltage and current were discussed in the review basics. The components explained in the component introduction are LEDs, resistors, motors, and motor controllers. In addition to the components, their respective interactions with the fundamental electrical concepts are also explained.

The programming section has four main stages. Depending on time and programming abilities, the last two stages may be removed from the PDP. The first stage was programming the LEDs. This stage makes sure that each LED is wired correctly and that the programming basics are explained. The hands-on activity included programming three LEDs to blink. The second stage was programming the motors. This stage involves setting the direction and speed for the motor along with applying the electrical concepts learned in the previous electrical section. The hands-on activity included programming the motor via the motor controller to make the robot drive forward and backward and to turn left and right. The third stage was introducing an advanced programming concept of functions. This concept allows for code to be more efficient. The hands-on activity was to optimize the previously made LED and motor code by using a few functions. The last stage was a culminating challenge where one teacher makes up a challenge, tries it themselves, and then gives that challenge to someone else. The hands-on activity here included completing a fellow teacher's challenge. All of the materials used within the PDP are in Appendix C. Upon the conclusion of the PDP, the teachers took home their robots. They were also told about the online resource that comes with the robot. The PDP did not use these different projects since they are well documented already online.

Table 2: Correlation Between Agenda Item, Hands-on Activities, and Learning Objectives

Agenda Item	**Hands-on Activity**	**Learning Objectives**
Build Robot	Building chassis of the Robot	● Build, wire, and program the robot ● Building techniques to efficiently build a robot
Wire Robot	Wiring chassis of the Robot	● Build, wire, and program the robot ● Wiring techniques to accurately wire a robot ● Underlying electrical and programming concepts and skills to aid in the wiring and programming of the robot
Program Robot (LEDs)	Human Programming Activity Programming the LEDs on the Robot	● Build, wire, and program the robot ● Underlying electrical and programming concepts and skills to aid in the wiring and programming of the robot ● Programming syntax and skills to be able to program a robot to have lights blink and drive forward
Program Robot (Motors)	Programming the Motors on the Robot	● Build, wire, and program the robot ● Underlying electrical and programming concepts and skills to aid in the wiring and programming of the robot ● Programming syntax and skills to be able to program a robot to have lights blink and drive forward
Program Robot (Functions)	Programming the robot with advanced techniques	● Build, wire, and program the robot
Program Robot (Self-Challenge)	Challenge each other to do something with the robot	● Build, wire, and program the robot

PDP Location and Participating Teachers

PDPs were initially set to be tested at various ASU campuses. Unfortunately due to funding, time constraints, and the COVID-19 pandemic, the ASU West campus was the first and only location to hold a PDP. The campus provided most of the organization, teachers, and space needed for the PDP. The recruitment of teachers was led by the staff at the ASU West campus. The staff sent out emails and brochures to recruit middle school and high school teachers to attend the PDP. There were no limits on who could attend and it was clear in the advertising that no prior experience was necessary. Ultimately, seven teachers were recruited and participated in two PDPs. Two were high school teachers and the remaining five were middle school teachers. All of the teachers taught STEM related classes and were looking to increase their knowledge of robotics, electronics, and coding.

During the Professional Development Program

Data Collection

After consent was given, there was a pre-post knowledge survey that was administered. The first survey was before the PDP and the second was at the end of the PDP. The main purpose of these surveys was to identify what the base knowledge was and what was learned throughout the program. The survey questions were developed specifically for this study to measure exact component and programming knowledge and recognition. A complete set of survey questions can be found in Appendix A.

General comments from the Professional Development Program

The PDPs each ran for one day. Each PDP was tailored for either middle or high school teachers. The first PDP had five teachers in attendance and the second PDP had two teachers. The level of depth and the speed at which the PDP progressed varied based on knowledge levels and learning speed.

One observation that affected the flow of the PDP was the operating system on the laptops brought by teachers. Some teachers brought school laptops that were unable to download the required software or the computer's operating system was unable to support the required software. The required software for the PDP is any form of the Arduino IDE. If a computer runs the Chrome OS, then there are additional complicated steps that need to be taken to get the software onto the computer. There are fewer issues if the computer runs Windows. If a school prevents anyone from downloading extensions, plugins, software packages, etc., then the teacher will have an issue in the PDP.

Robot Development

Throughout the two PDPs, one construction technique was learned that saves time and specific mistakes from happening. This technique involves attaching the plastic standoffs (Figure 5) immediately after removing the protective sheets from the plexi panel. By attaching the standoffs on the correct side, it prevents having to disassemble the motors once they are mounted. Also it provides a guide for where the motor controller and Arduino sit on the robot.

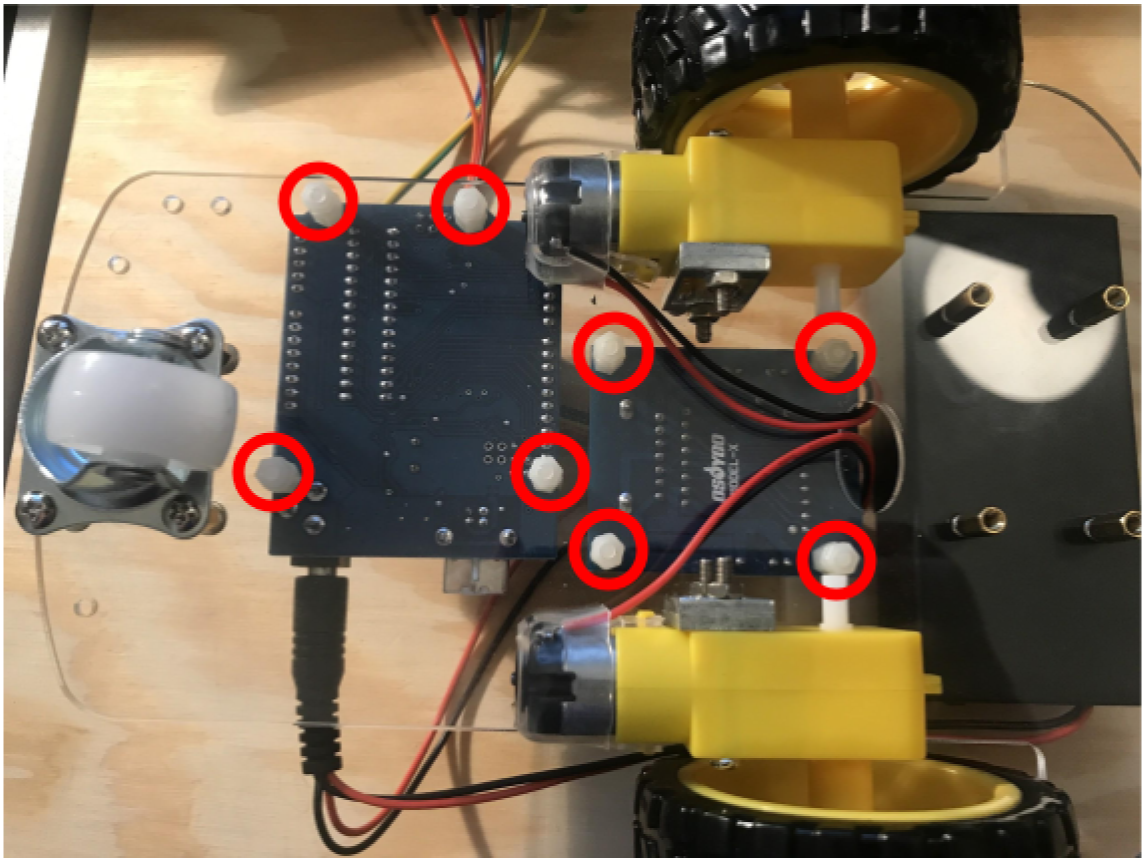


Figure 5: New robot showing where new standoffs (circled in red) are placed at the very beginning of construction

Post-Professional Development Program

Data Analysis

The pre-post knowledge tests administered during the PDP were identical allowing for an easy comparison between each attempt and each participant. These sets of data were analyzed together as one cohort (n = 7) and separately between middle school (n = 5) and high school (n = 2) teachers. Each of the sections of the survey had a different amount of questions. The mechanical section had 11 questions, the electrical section had 14 questions, and the programming section had 13 questions for a grand total of 38 questions. Each question was scored as either wrong (zero points) or right (one point).

The consolidated data can be found in Table 3. The data presented is the average change in each of the survey's sections. All of the average changes increased in all of the categories. The high school teachers did not increase as much as the middle school teachers on all three sections. This observation suggests the participating high school teachers' came into the PDP with higher incoming knowledge of the given subjects observed on the pre-survey. A higher score during the pre-survey means a lower ability to improve later on. On the flip side, the middle school teachers improved significantly in each category with the largest being the programming category. Interestingly enough, the largest and smallest change came in the programming category. This dichotomy demonstrates the difficulty of programming along with the ability to learn and retain programming.

Table 3: Survey Data - Average Change

Average Change between surveys by category and population			
	Mechanical	Electrical	Programming
Total Population	2.9	4.9	4.0
High School Teacher Population	1.5	5.0	0.5
Middle School Teacher Population	3.4	4.4	5.4

LIMITATIONS

Throughout the development and execution of the PDP, there were many limitations that affected the outcome of the program and graduate thesis as a whole. One of these limits comes with the budget for the project. Despite being approved for GPSA funding, the kits that were purchased for the first PDP were not reimbursed and the costs were ultimately deemed not fundable by the grant. Not having the funding from GPSA limited the PDP development by not being able to have more PDPs. The reduction in available PDPs caused a small sample size of just seven for the data analysis portion.

The PDPs that did occur for this robotics unit were intended to be a pilot. There were many lessons learned and ways to improve the program for the future (see Discussion section). Lastly, this graduate thesis is being completed in the ‘+1’ year of a 4+1 program, which means that there is half the typical amount of time to develop, research, plan, and execute a thesis. More time would have allowed for discussions between GPSA and the thesis committee for more appropriate funding. Adequate time and appropriate funding would have meant the possibility of more PDPs that could have been run with a larger sample of participating teachers. A greater number of participating teachers would increase the sample size for this study allowing for more generalizable claims regarding the effectiveness of the PDP at training the teachers.

DISCUSSION

Throughout the PDP there were many lessons learned. The main lessons learned fall into one of three categories: 1) survey improvements, 2) available resources, and 3) testing system requirements for computers.

The focus of the surveys was on knowledge of parts and what they are called. This focus ended up not aligning well with the focus of the PDP. There could be some additional questions that the teachers are asked relating to how confident they are in teaching certain topics. Depending on their answer, they would then receive a follow-up question asking what resources they would need to become more confident in teaching the material. Also asking the teachers for feedback on the PDP would allow for the program to gradually improve over time.

During the PDP there were no additional resources the teachers could use outside of the PDP materials. Having a resource bank ready for the teachers before the PDP runs would help support the teachers learning outside of the training. These resources should be informed by requests made by teachers during pilot testing of the PDP.

Additionally, having a set of computer system requirements would allow for programming of the robot to be smoother for the teachers. One such solution could be having the teachers pre-download the Arduino software onto their computers a couple days before the PDP starts. Another solution to this computer issue is to make sure the PDP is being conducted in a space where there are enough software-ready computers already available.

Finally, the overall effectiveness of the PDP is not able to be determined since the sample size was only seven teachers. As mentioned in the limitations section, if more time existed, the potential for increased funding and participants would also exist.

FUTURE WORK

This work has set the stage for a variety of future work in the area of improving the overall foundational knowledge in the PDP, following through on a resource development plan, and conducting a comparative study.

One way in which the graduate thesis can be improved, is by including a set of concrete and concise foundational engineering concepts at the beginning of the PDP. The best way to decide what information should be included in the foundational knowledge can be found by conducting an extensive literature review or asking pilot teachers what information they would like to have seen in the PDP.

The resource development plan that has been discussed consists of having one website that will serve as the hub for four different forms of information. The information could come as a YouTube video with supporting documents, troubleshooting guide, and teachers toolkit. This website and domain name have not been created or purchased.

The YouTube videos and the supporting documents would consist of three main categories: building the robot, wiring the robot, and programming the robot. Building the robot will consist of two videos and documents, one that provides a step-by-step construction of the robot and another that shows how to mount all of the sensors that come from the purchased kit. Wiring the robot will consist of five videos and documents; these include an introduction of basic electrical concepts, how to wire an LED, how to wire a motor, advanced electrical concepts, and how to wire the sensors. The basic electrical concepts video and document will be able to provide information for LEDs and motors, whereas the advanced electrical concepts will provide the background knowledge for how all of the sensors work. Programming the robot will consist of six videos and documents; these include a getting started portion, how to program an LED, how to program a motor, how to program a function and what they do, how to program an if-else statement, how to program for, while, and nested loops, and how to program each of the available sensors. The getting started portion will also include a system requirements component to ensure that the user is able to write, compile, and deploy the Arduino code to the robot.

The troubleshooting guide will be a living breathing page on the website that will only expand over time. One example of an issue that needs to be troubleshot is when the code is not compiling or when it compiles and gives out an error. The guide can review the use of semicolons. Another problem could be that the code is not deploying. This could be discussed in the guide by reviewing how to check whether the correct Arduino board was selected for code deployment.

Lastly, the teachers toolkit would be a section on the website that has all needed resources to run the unit. This section would include the written 5E lesson plans, the budget for the unit, a budget calculator that can adapt to that teacher's class/situation, presentation slides for each unit, activities/worksheets for various parts of the unit, links to the YouTube videos, and links to the video documents. As units become available they will be organized by difficulty and complexity. Additionally, as the lesson plans are developed, the educational standards that apply will also be researched and added to make it easier for the teacher to be able to run the unit in their classrooms.

The second potential future work would be to conduct a new study. The study would look into the availability of external resources and how teachers retain knowledge. The data collection method would be through a pre-post-post knowledge survey. This survey would involve three different data points: before the PDP, immediately after the PDP, and two-three weeks after the PDP. Having these three data points would allow researchers to discuss how much information is retained during the robotics PDP. There would be two different participant groups. One group would be given access to all external resources available in the time between the last two surveys. The other population would not have access to additional resources between the last two surveys, but after completing the final survey would then get access to the resources. The comparison would come from looking at the knowledge retention rate between the teachers that had access to the resources and the teachers who did not have access.

Additionally, recording how much a resource is used and exactly what resource is being used would help to determine the effectiveness of the resources. By looking into the described data, it might provide insights into how to better convey the information, what resource communication methods work, and which resource communication methods simply do not work.

REFERENCES

Adams, R. S. & Felder, R. M. (2008). Reframing Professional Development: A Systems Approach to Preparing Engineering Educators to Educate Tomorrows Engineers. *Journal of Engineering Education*, *97*(3), 239–240. doi: 10.1002/j.2168-9830.2008.tb00975.x

Daugherty, J. L. (2009). Engineering Professional Development Design for Secondary School Teachers: A Multiple Case Study. *Journal of Technology Education*, *21*(1). doi: 10.21061/jte.v21i1.a.1

Donna, J. (2012). A Model for Professional Development to Promote Engineering Design as an Integrative Pedagogy within STEM Education. *Journal of Pre-College Engineering Education Research*, *2*(2), 1–8. doi: 10.5703/1288284314866

Graduate Research Support Program. (n.d.). Retrieved from https://gpsa.asu.edu/funding/research/graduate-research-support-program/

Hynes, M. M. & dos Santos, A. (2007). Effective Teacher Professional Development: Middle School Engineering Content. *International Journal of Engineering Education`*, *23*(1).

Kuklovskai¯a¯, E. (n.d.). DP. Retrieved from https://www.amazon.com/dp/B0794PWD7J/?coliid=I1WP8UFRLRFZ2X&colid=3I45IXNLAHUO3&psc=1&ref_=lv_ov_lig_dp_it

Lerner, J. B., Carberry, A., & Walters, M. (n.d.). Low-Budget, Variable-Length, Arduino-Based Robotics Unit. Retrieved from https://repository.asu.edu/items/52380#embed

Nathan, M. J., Atwood, A. K., Prevost, A., Phelps, L. A., & Tran, N. A. (2011). How Professional Development in Project Lead the Way Changes High School STEM Teachers' Beliefs about Engineering Education. *Journal of Pre-College Engineering Education Research (J-PEER)*, *1*(1). doi: 10.7771/2157-9288.1027

Porter, T., West, M. E., Kajfez, R. L., Malone, K. L., & Irving, K. E. (2019). The Effect of Teacher Professional Development on Implementing Engineering in Elementary Schools. *Journal of Pre-College Engineering Education Research (J-PEER)*, *9*(2). doi: 10.7771/2157-9288.1246

Reimers, J. E., Farmer, C. L., & Klein-Gardner, S. S. (2015). An Introduction to the Standards for Preparation and Professional Development for Teachers of Engineering. *Journal of Pre-College Engineering Education Research (J-PEER)*, *5*(1). doi: 10.7771/2157-9288.1107

Singer, J. E., Ross, J. M., & Jackson-Lee, Y. (2016). Professional Development for the Integration of Engineering in High School STEM Classrooms. *Journal of Pre-College Engineering Education Research (J-PEER)*, *6*(1). doi: 10.7771/2157-9288.1130

Zakharov, W., Strobel, J., & Diefes-Dux, H.A. (2020). Teacher level factors and student achievement in a cyber-enabled engineering education professional development program. International Journal of Research in Education and Science (IJRES), 6(1), 48-60.

APPENDIX A

UNIVERSITY APPROVALS FOR HUMAN SUBJECT TESTING

EXEMPTION GRANTED

Adam Carberry
IAFSE-PS: Polytechnic Engineering Programs (EGR)
480/727-5122
Adam.Carberry@asu.edu

Dear Adam Carberry:

On 2/3/2020 the ASU IRB reviewed the following protocol:

Type of Review:	Initial Study
Title:	Low-Budget, Arduino-Based, Robotics-Unit Professional Development
Investigator:	Adam Carberry
IRB ID:	STUDY00011409
Funding:	None
Grant Title:	None
Grant ID:	None
Documents Reviewed:	• Consent Form, Category: Consent Form; • Dr. Debra Walters IRB Training Certificate, Category: Off-site authorizations (school permission, other IRB approvals, Tribal permission etc); • Low-Budget, Arduino-Based, Robotics-Unit Professional Development IRB, Category: IRB Protocol; • Robotics PD Survey, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions);

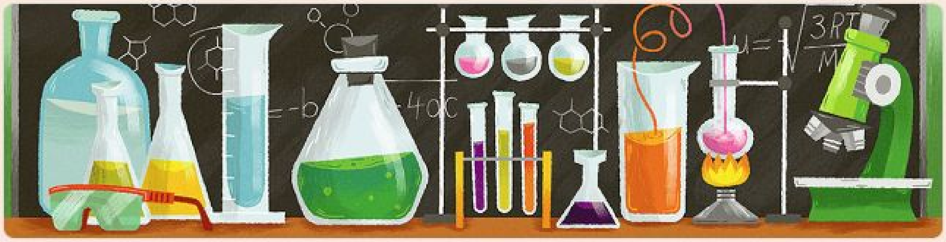
The IRB determined that the protocol is considered exempt pursuant to Federal Regulations 45CFR46 on 2/3/2020.

In conducting this protocol you are required to follow the requirements listed in the INVESTIGATOR MANUAL (HRP-103).

Sincerely,

APPENDIX B

SURVEY QUESTIONS USED TO ASSESS TEACHER CONTENT KNOWLEDGE BEFORE (PRE) AND AFTER (POST) THE PDP



Robotics Professional Development Check-In

The purpose of this form is to measure current amounts of knowledge at different points in time. If you do not know the answer to a question that is okay and select/type in "I don't know".

* Required

Enter your unique username *

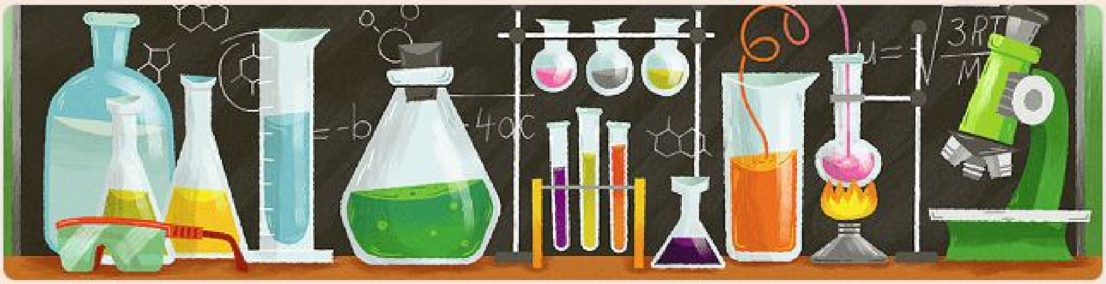
Your unique username will be the last two letters of your first name (UPPERCASE), the last two letters of your last name (lowercase), and the day of the month in your DOB. For example, if Albert Einstein (DOB is 3/14/1879) were to create a unique username it would be RTin14.

Your answer

When are you taking this check-in? *

- ◯ Before Professional Development
- ◯ After Professional Development
- ◯ Post-Professional Development

Next



Robotics Professional Development Check-In

* Required

Mechanical System

Component 1 *

Label the following component:

Choose

Component 2 *

Label the following component:

Choose

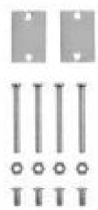
Component 3 *

Label the following component:

Choose

Component 4 *

Label the following component:



Choose

Component 5 *

Label the following component:

Choose

Component 6 *

Label the following component:

Choose

Component 7 *

Label the following component:

Choose

Component 8 *

Label the following component:

Choose

Component 9 *

Label the following component:

Choose

Component 10 *

Label the following component:

Choose

Component 11 *

Label the following component:

Choose

Back Next

Choose

- Wheels
- Flat head Screwdriver
- M3 Nut (metal)
- M3 Pillar (Plastic)
- I don't know
- Phillips Screwdriver
- M3 Pillar (Copper)
- M3 Screw (metal)
- M3 Screw (Plastic)
- Car Chassis
- Metal Motor Holders
- Universal Wheel

Robotics Professional Development Check-In

* Required

Electrical System

Component A *

Label the following component:

Choose ▾

Component B *

Label the following component:

Choose ▾

Component C *

Label the following component:

Choose

Component D *

Label the following component:

Choose

Component E *

Label the following component:

Choose

Component F *

Label the following component:

Choose

Component G *

Label the following component:

Choose

Component H *

Label the following component:

Choose

Component I *

Label the following component:

Choose

Component J *

Label the following component:

Choose

Component K *

Label the following component:

Choose

Component L *

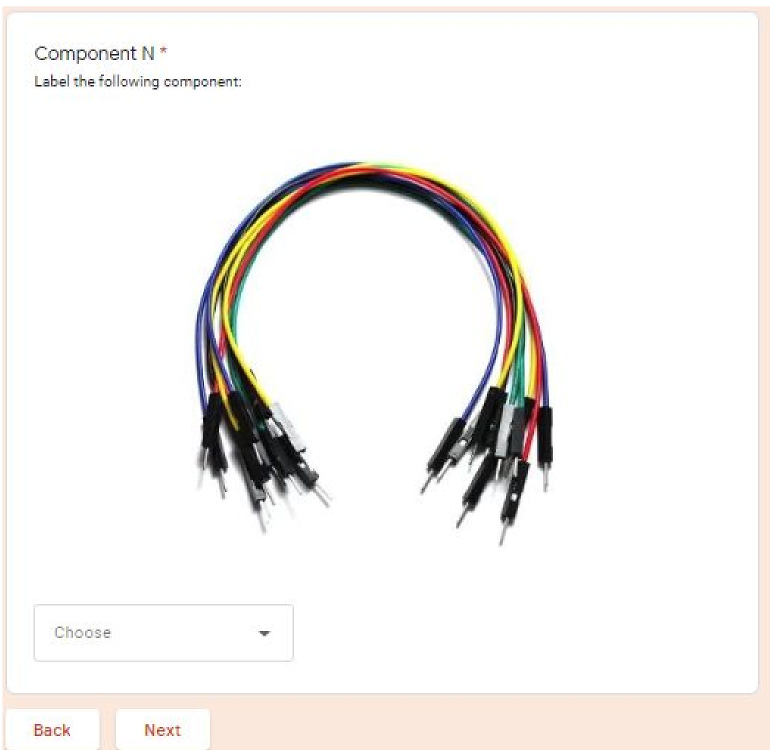
Label the following component:

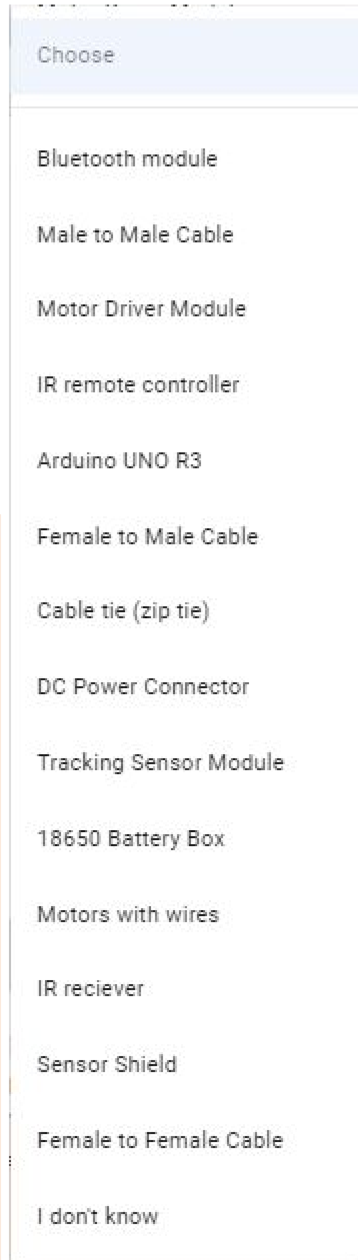
Choose

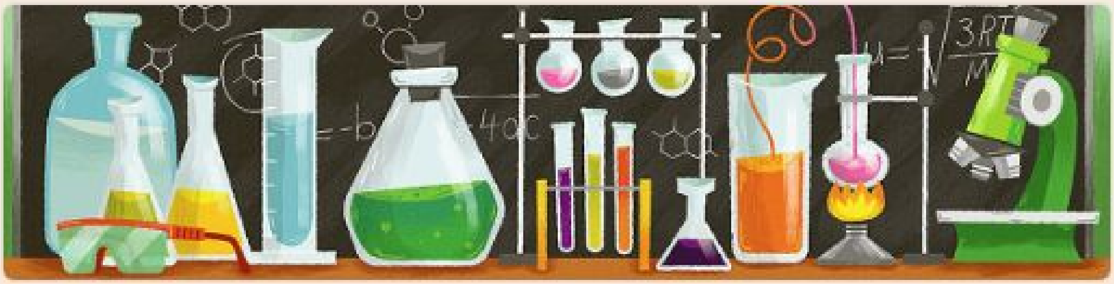
Component M *

Label the following component:

Choose


Component N *
Label the following component:
Choose
Back
Next


Choose
Bluetooth module
Male to Male Cable
Motor Driver Module
IR remote controller
Arduino UNO R3
Female to Male Cable
Cable tie (zip tie)
DC Power Connector
Tracking Sensor Module
18650 Battery Box
Motors with wires
IR reciever
Sensor Shield
Female to Female Cable
I don't know



Robotics Professional Development Check-In

* Required

Programming

Given a piece of code, answer the following questions about it.

Code Sample 1 (Use for the following 5 questions)

```
void setup() {
pinMode(7, OUTPUT);
pinMode(8, OUTPUT);
pinMode(9, OUTPUT);
digitalWrite(7, LOW);
digitalWrite(8, LOW);
digitalWrite(9, LOW);
}

void loop() {
digitalWrite(7, HIGH);
digitalWrite(8, HIGH);
digitalWrite(9, HIGH);
delay(1000);
digitalWrite(7, LOW);
digitalWrite(8, LOW);
digitalWrite(9, LOW);
delay(1000);
}
```

How many output pins are there? *

Your answer

How many times does the void setup() portion run? *

Your answer

What pins are being used in the code? *

Your answer

What does setting a pin high mean? *

Your answer

Assuming each pin is attached to an LED, describe what is happening in the above code? *

Your answer

Code Sample 2 (Use for the following 4 questions)

```
#define enA 9
#define in1 11
#define in2 12

void setup() {
  pinMode(enA, OUTPUT);
  pinMode(in1, OUTPUT);
  pinMode(in2, OUTPUT);
}

void loop() {
  digitalWrite(in1, HIGH);
  digitalWrite(in2, LOW);
  digitalWrite(enA, 170);
  delay(250);
  digitalWrite(in1, LOW);
  digitalWrite(in2, LOW);
  digitalWrite(enA, 0);
  delay(250);
}
```

What pin is enA attached to? *

Your answer

How many output pins are there? *

Your answer

What pins are being used by the code? *

Your answer

The above code is for a motor, describe what the behavior of the motor? (is it spinning, if so how fast?, be as specific as possible) *

Your answer

Code Sample 3 (Use for the following 5 questions)

```
void volume(int L, int W, int H){
  int V = L*W*H;
  return;
}

void setup() {
}

void loop() {
 int a = volume(2,5,10);
 int b = volume(1,9,8);
 int c = a-b;
}
```

What is the name of the function above? *

Your answer

What are the inputs to the above function? *

Your answer

What does the function do once receiving input values? *

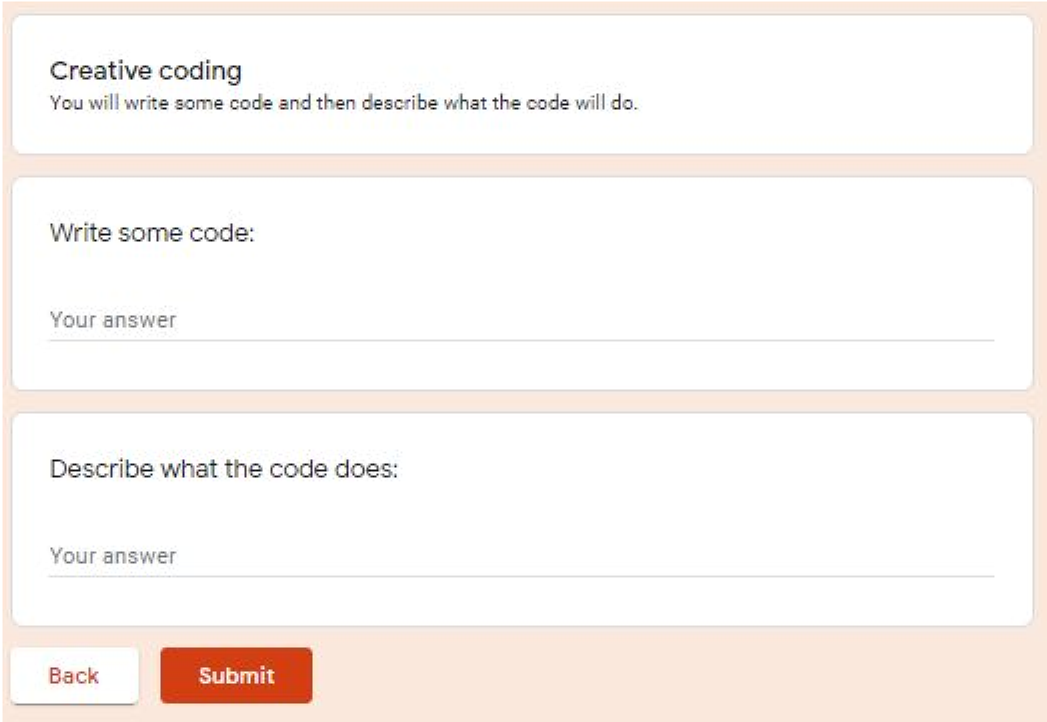
Your answer

What is the volume of 'int b'? *

Your answer

What is the value of 'int c'? *

Your answer



Creative coding

You will write some code and then describe what the code will do.

Write some code:

Your answer

Describe what the code does:

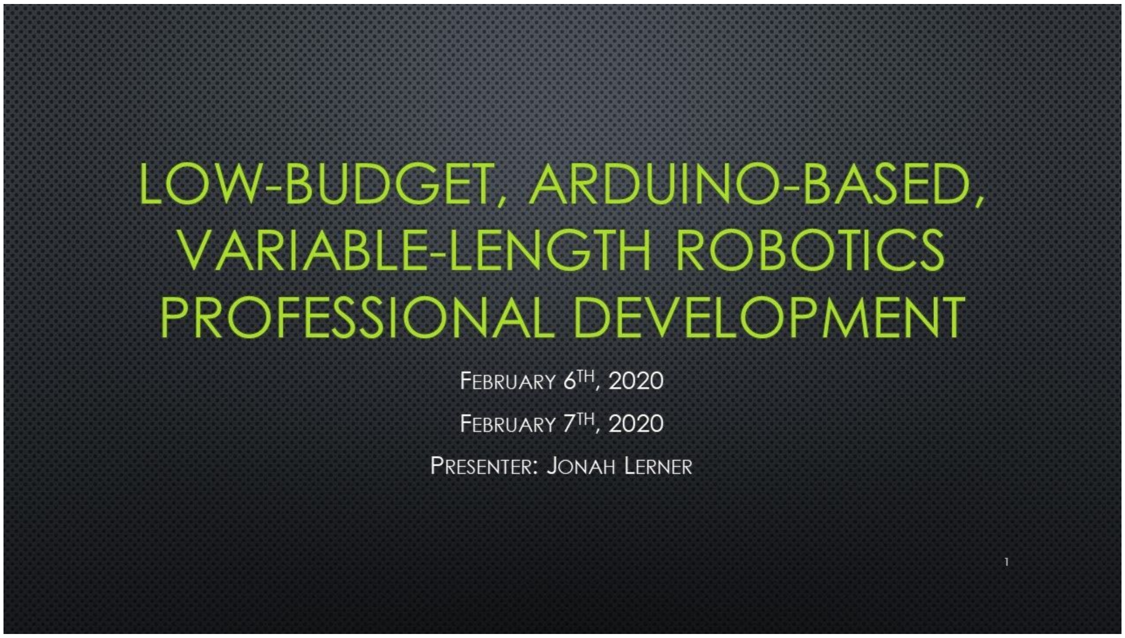
Your answer

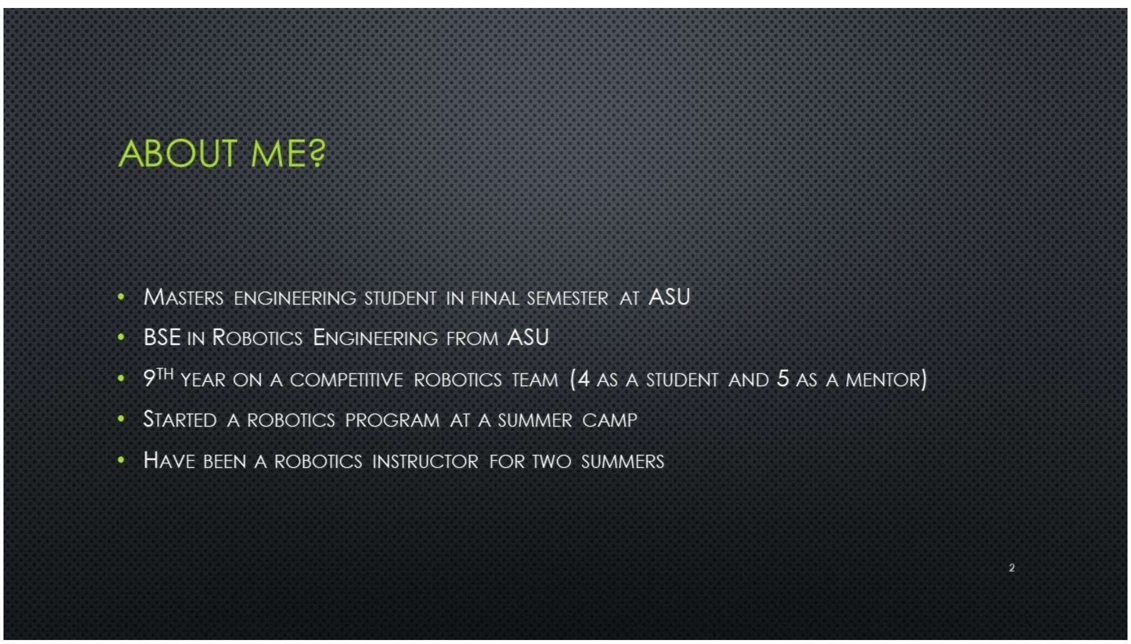
Back

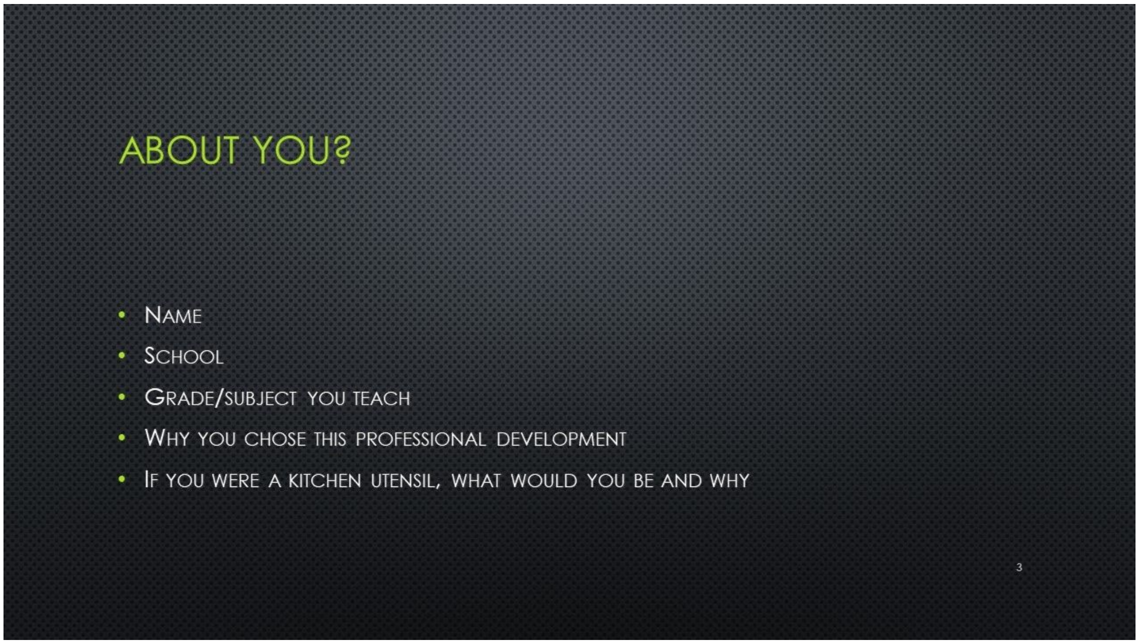
Submit

APPENDIX C

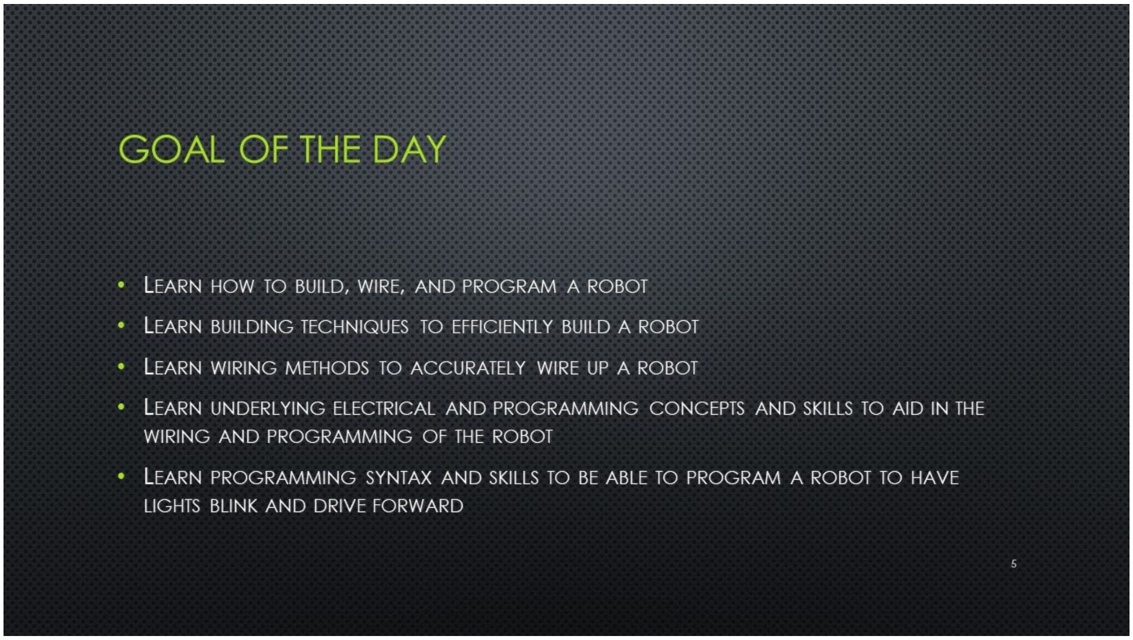
MATERIALS USED TO IMPLEMENT AND ORGANIZE THE PDP


LOW-BUDGET, ARDUINO-BASED, VARIABLE-LENGTH ROBOTICS PROFESSIONAL DEVELOPMENT
FEBRUARY 6TH, 2020
FEBRUARY 7TH, 2020
PRESENTER: JONAH LERNER
1

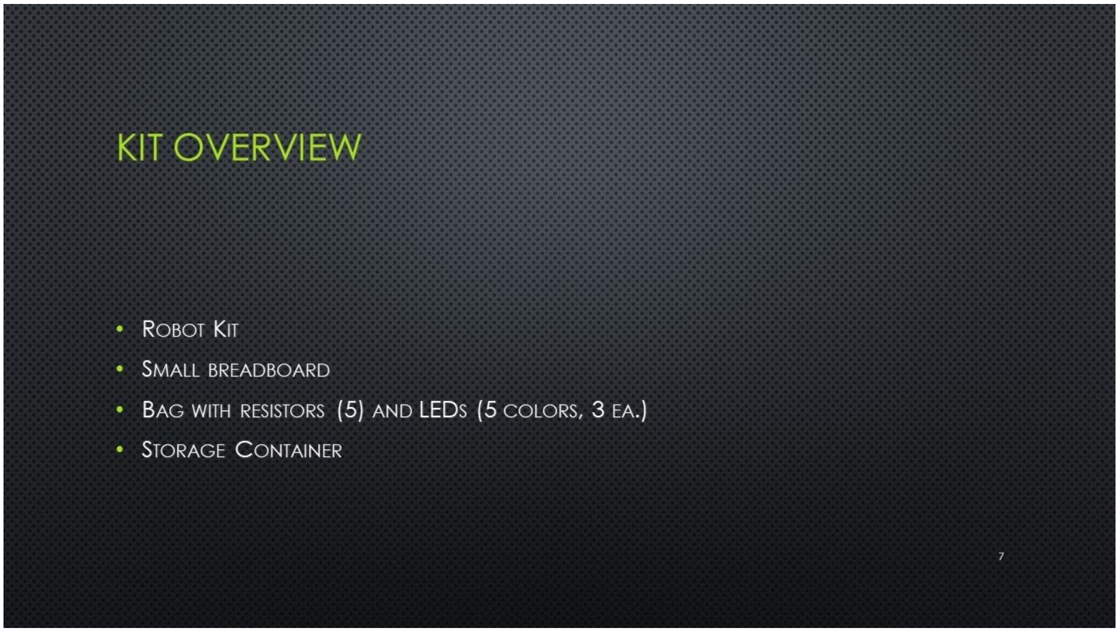

ABOUT ME?
• MASTERS ENGINEERING STUDENT IN FINAL SEMESTER AT ASU
• BSE IN ROBOTICS ENGINEERING FROM ASU
• 9TH YEAR ON A COMPETITIVE ROBOTICS TEAM (4 AS A STUDENT AND 5 AS A MENTOR)
• STARTED A ROBOTICS PROGRAM AT A SUMMER CAMP
• HAVE BEEN A ROBOTICS INSTRUCTOR FOR TWO SUMMERS
2

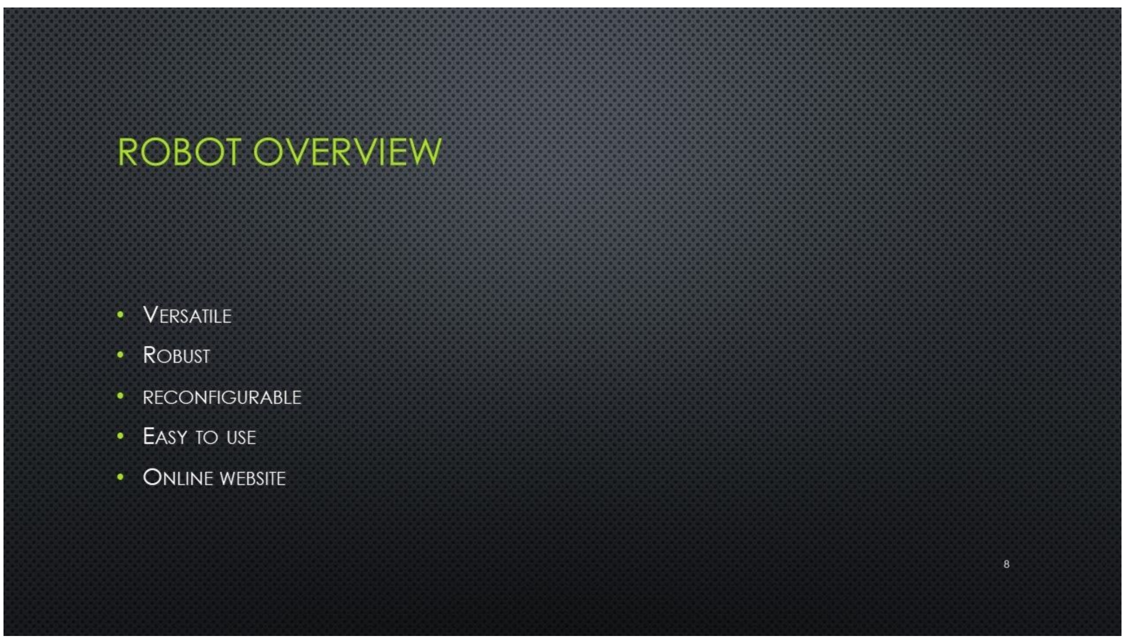

ABOUT YOU?
• NAME
• SCHOOL
• GRADE/SUBJECT YOU TEACH
• WHY YOU CHOSE THIS PROFESSIONAL DEVELOPMENT
• IF YOU WERE A KITCHEN UTENSIL, WHAT WOULD YOU BE AND WHY
3


SURVEY LINK 1
4


GOAL OF THE DAY
• LEARN HOW TO BUILD, WIRE, AND PROGRAM A ROBOT
• LEARN BUILDING TECHNIQUES TO EFFICIENTLY BUILD A ROBOT
• LEARN WIRING METHODS TO ACCURATELY WIRE UP A ROBOT
• LEARN UNDERLYING ELECTRICAL AND PROGRAMMING CONCEPTS AND SKILLS TO AID IN THE WIRING AND PROGRAMMING OF THE ROBOT
• LEARN PROGRAMMING SYNTAX AND SKILLS TO BE ABLE TO PROGRAM A ROBOT TO HAVE LIGHTS BLINK AND DRIVE FORWARD
5


PROFESSIONAL DEVELOPMENT AGENDA
• BUILD ROBOT (~9:30 - 10:30)
• BREAK (~10:30 - 10:40)
• WIRE ROBOT (~10:30 - 12:00)
• LUNCH (12:00 - 12:45)
• PROGRAM ROBOT
• LEDS (~1:00 - 2:00)
• MOTORS (~2:00 - 3:00)
• FUNCTIONS (~3:10 - 3:40)
• SELF-CHALLENGE (~3:40 - 4:30)
• WRAP-UP (~4:30-5:00)
6


KIT OVERVIEW
• Robot Kit
• Small breadboard
• Bag with resistors (5) and LEDs (5 colors, 3 ea.)
• Storage Container
7


ROBOT OVERVIEW
• Versatile
• Robust
• reconfigurable
• Easy to use
• Online website
8

RESOURCES

- GOOGLE DRIVE
- ROBOT KIT WEBSITE
- ROBOT KIT CD
- INTERNET
- YOUTUBE VIDEOS
- ETC.

9

ROBOT PARTS AND WHAT THEY ALL ARE

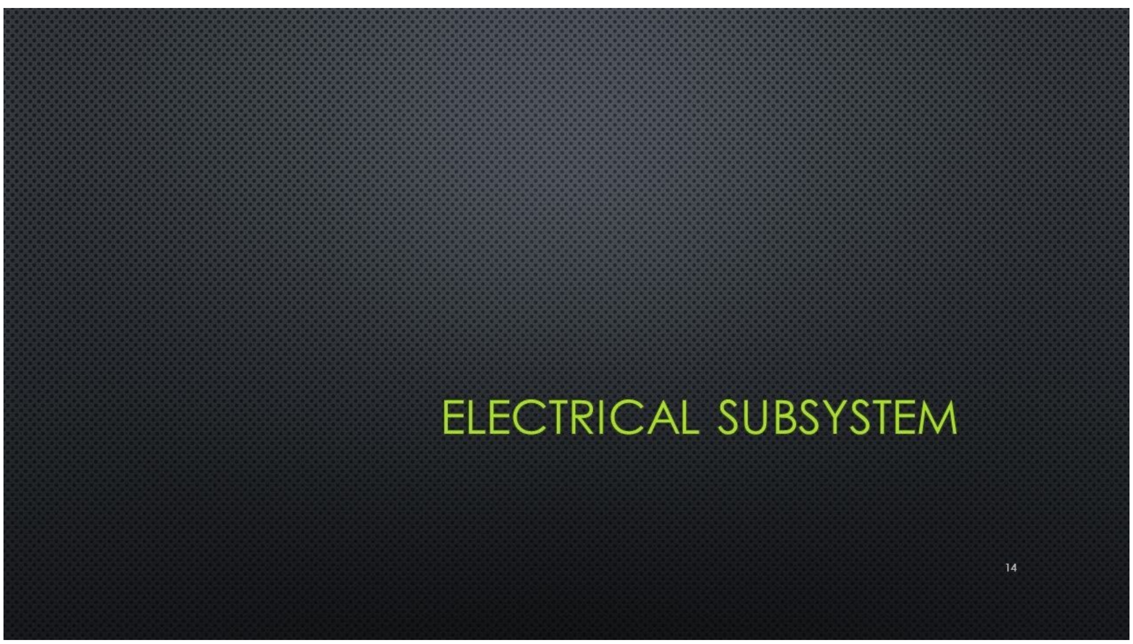
- HTTPS://OSOYOO.COM/2017/10/18/OSOYOO-2WD-ROBOT-CAR-STARTER-KIT-TUTORIAL-INTRODUCTION/

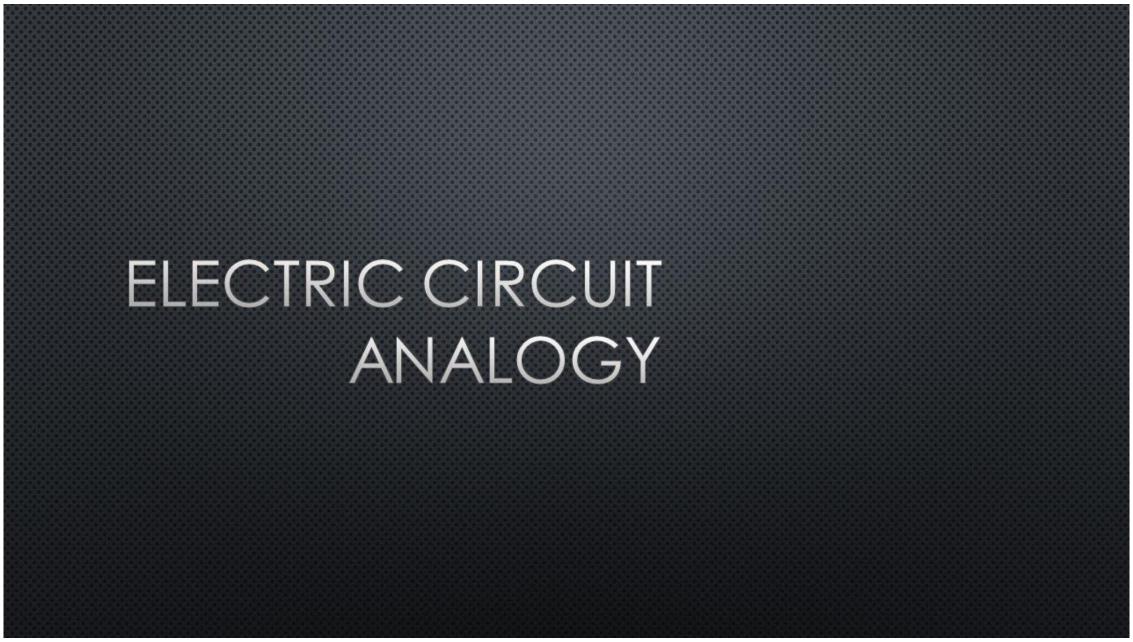
10


BUILDING THE ROBOT
PHYSICAL DEMONSTRATION
11


QUESTIONS?
12

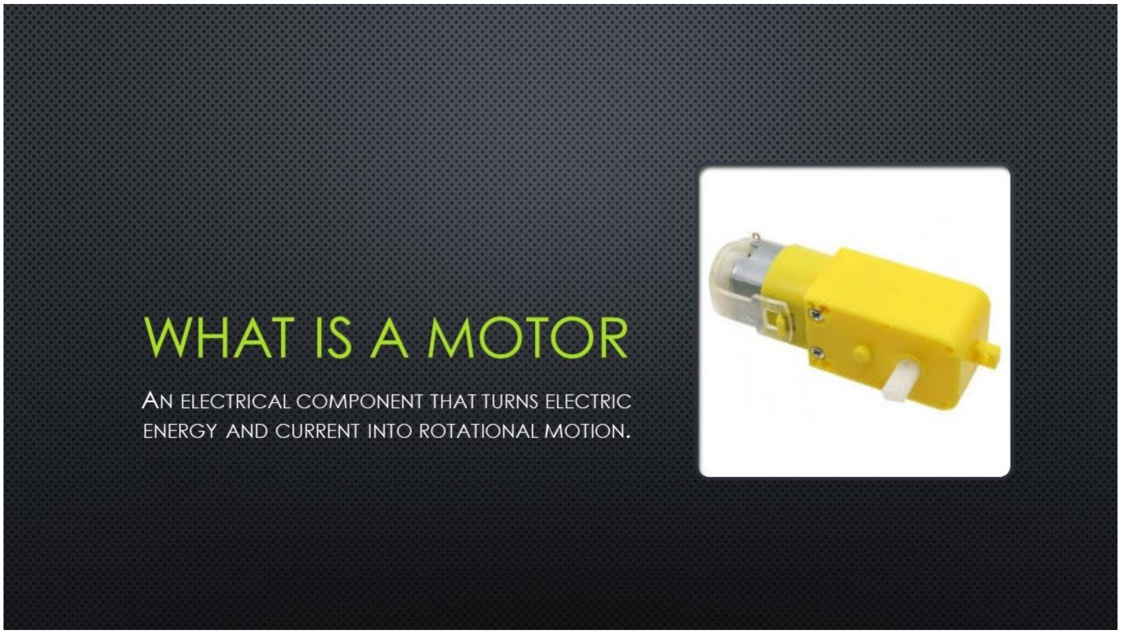

10 MINUTE BREAK
13

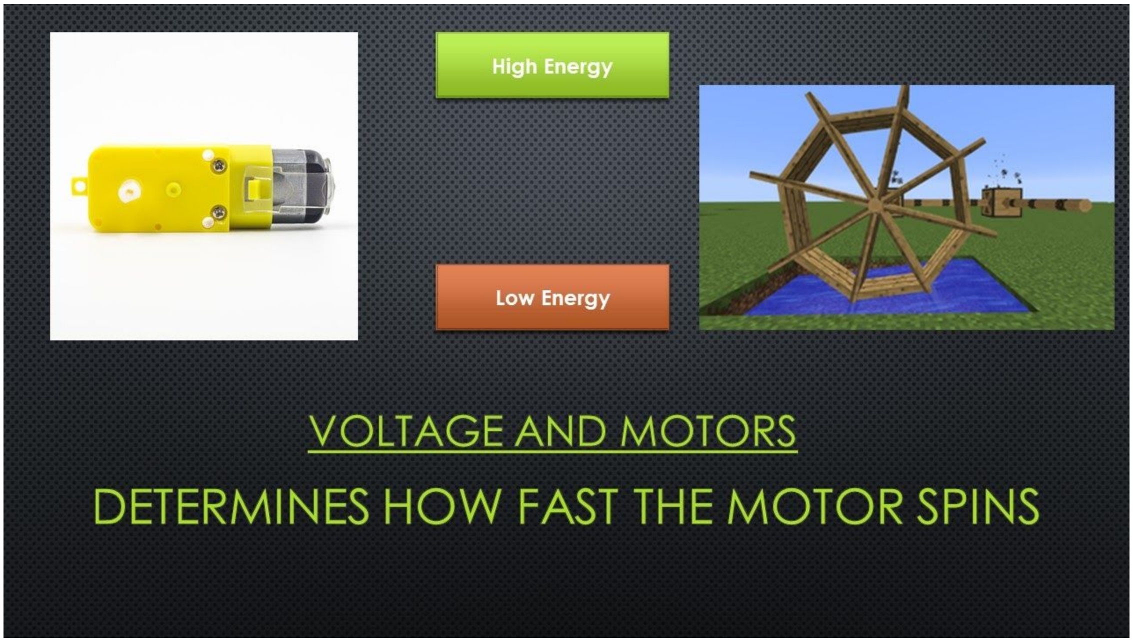

ELECTRICAL SUBSYSTEM
14

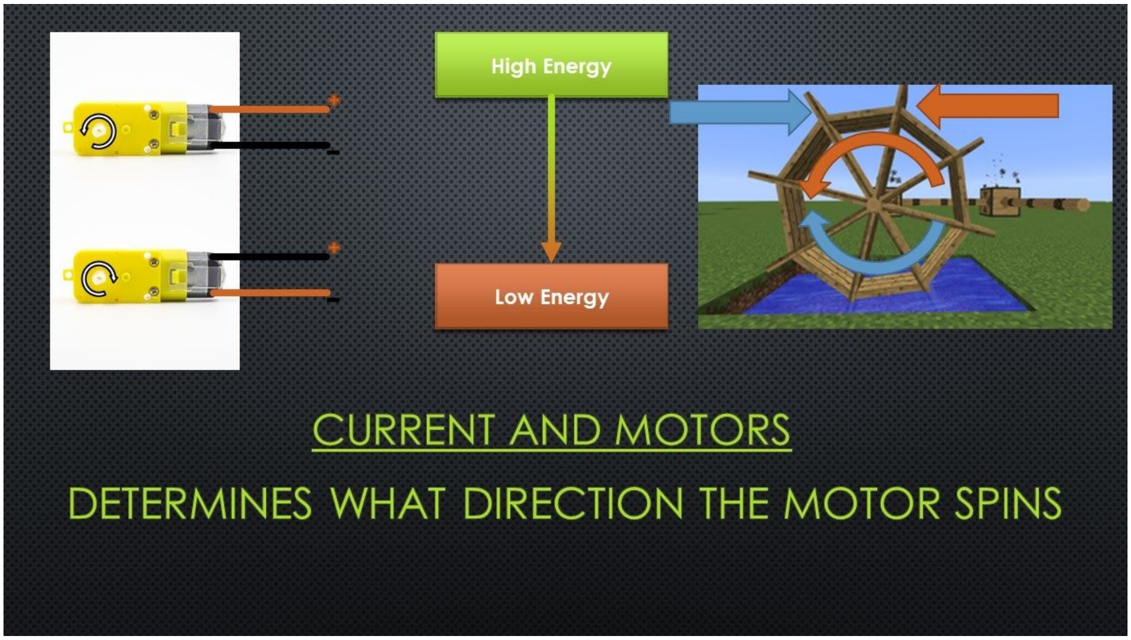

ELECTRIC CIRCUIT
ANALOGY


AA
DURACELL
ALKALINE BATTERY
High Energy
Low Energy
VOLTAGE
HOW MUCH ENERGY IS THERE?
CURRENT
HOW FAST IS THAT ENERGY TRAVELING?

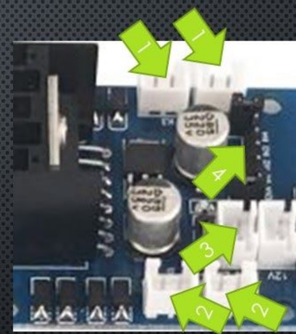

LEDS
• LIGHT EMITTING DIODES
• ONE DIRECTION
• REQUIRES SPECIFIC VOLTAGE
• REQUIRES SPECIFIC CURRENT
RESISTORS
• SLOWS DOWN CURRENT


WHAT IS A MOTOR
AN ELECTRICAL COMPONENT THAT TURNS ELECTRIC ENERGY AND CURRENT INTO ROTATIONAL MOTION.


High Energy
Low Energy
VOLTAGE AND MOTORS
DETERMINES HOW FAST THE MOTOR SPINS


+
-
+
-
High Energy
Low Energy
CURRENT AND MOTORS
DETERMINES WHAT DIRECTION THE MOTOR SPINS

MOTOR CONTROLLER



CAN SUPPORT UP TO FOUR MOTORS (1&2)

REQUIRES AN EXTERNAL BATTERY (3)

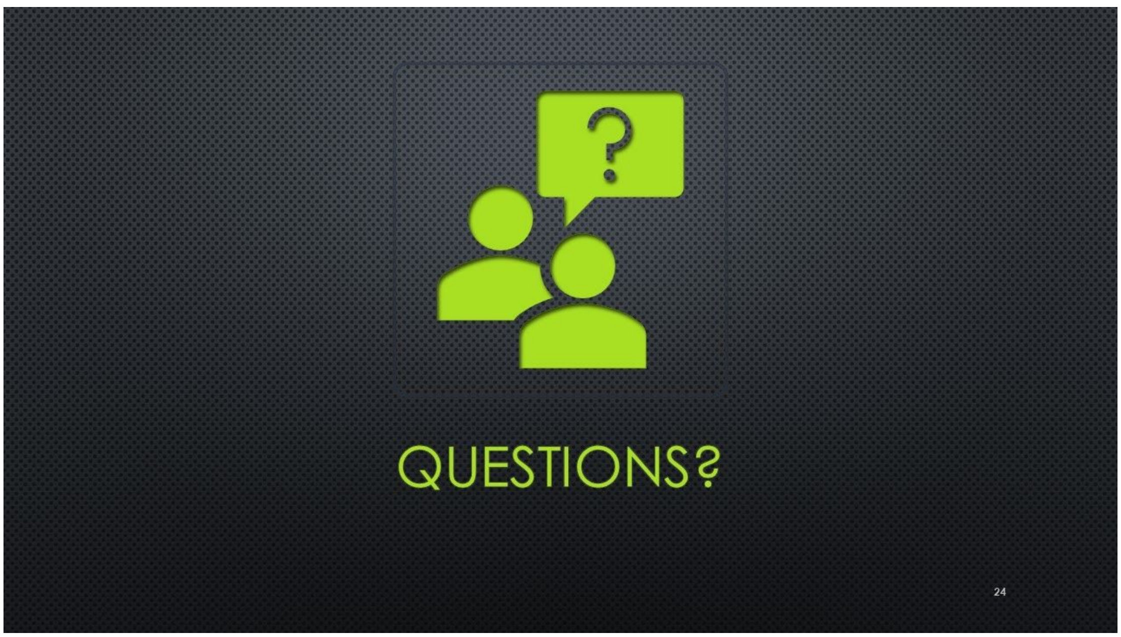
ALLOWS FOR CONTROL OF MOTORS WITH ARDUINO (4)

WIRE UP THE ROBOT

- ATTACH THE MOTORS TO THE MOTOR CONTROLLER
- WIRE THE MOTOR CONTROLLER WIRES TO THE ARDUINO
- STICK THE BREADBOARD ONTO THE REMOVABLE TOP OF THE BATTERY BOX
- WIRE UP THREE LEDS WITH RESISTORS ON THE BREADBOARD TO THREE PINS ON THE ARDUINO

22


ELECTRICAL REVIEW
What is voltage?
What is current?
What is a resistor?
What is an LED?
What is a motor?
What is a motor controller?
How can we control a motor?
23


QUESTIONS?
24


LUNCH BREAK
25


PROGRAM THE ROBOT
26


HUMAN PROGRAMMING ACTIVITY
GOAL
• Get presenter to perform a given task
HOW
• Taking turns, give presenter commands and they will follow them
NOTE
• Please remember the presenter is human and can be hurt


01
What is important to remember when programming?
02
Do details matter in programming? Why or why not?
03
What is something you learned from the Human Programming Activity?
DISCUSS THE ANSWER TO THESE QUESTIONS

ARDUINO IDE AND WEB EDITOR

- MAKE ACCOUNTS THROUGH THE ONLINE ARDUINO WEB EDITOR
- HTTPS://CREATE.ARDUINO.CC/
  - CLICK ON ARDUINO WEB EDITOR

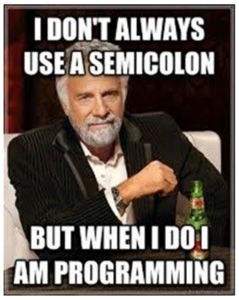
29

```
void setup() {
//  [insert what the robot is here]
// only runs once
}

void loop() {
//  [insert what you want the robot to do here]
// runs forever
}
```

```
/*
FUN FACTS:
// double backslash comments a line out, the code will not run this line
// for long comments do this: /*[insert your long comment]*/
//NOTE: there needs to be semi-colons after every line
*/
```

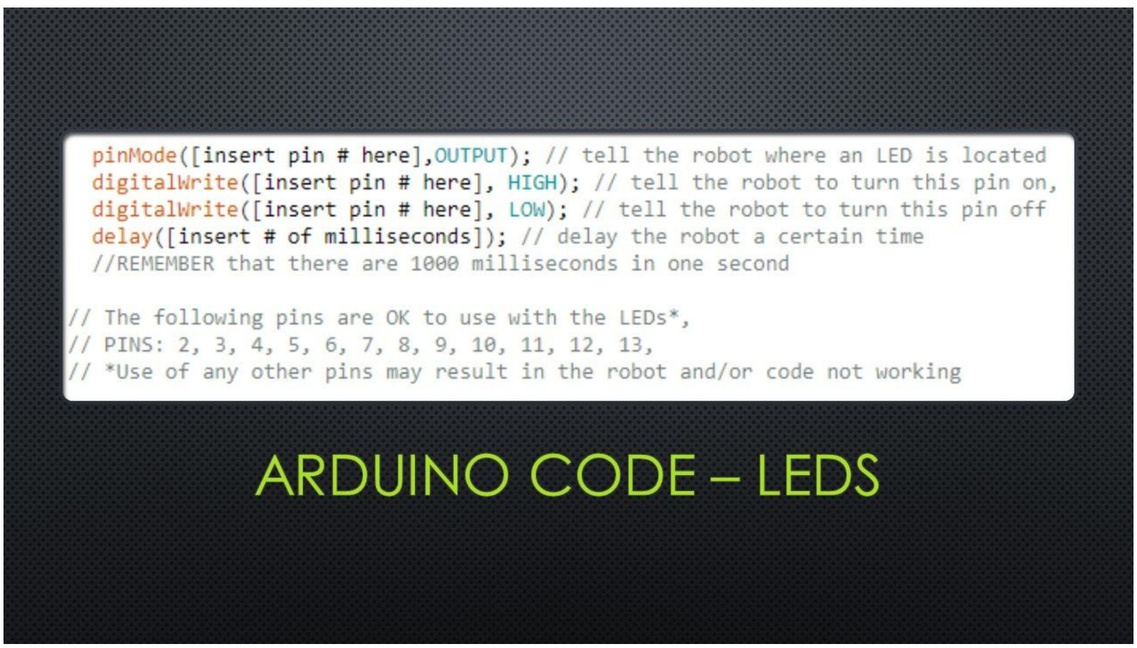
ARDUINO CODE - BASICS

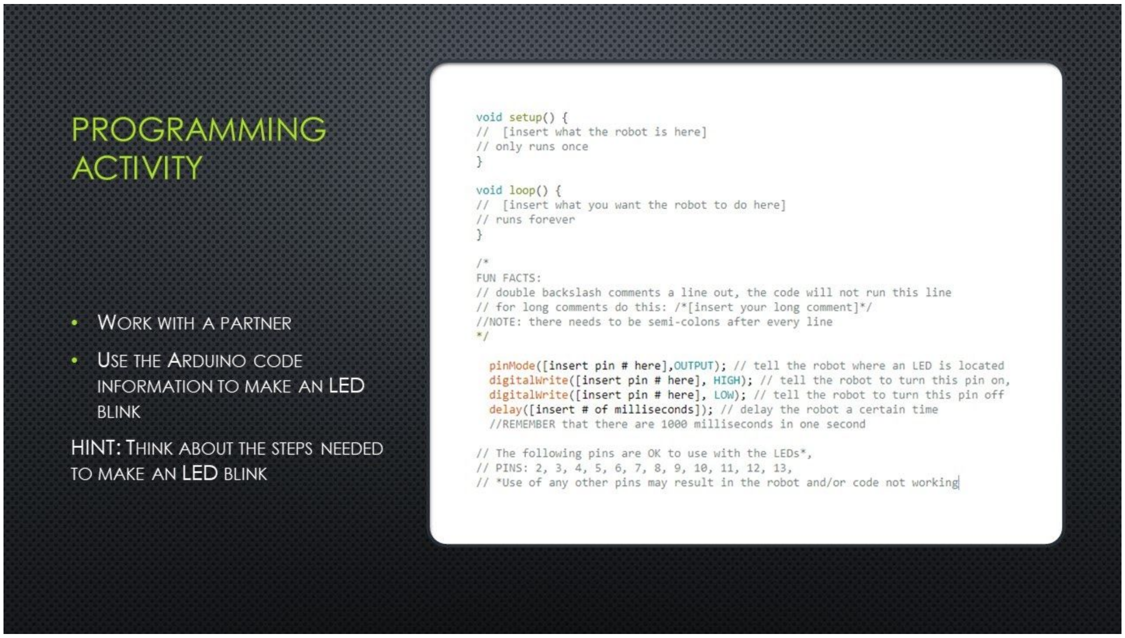

I DON'T ALWAYS USE A SEMICOLON
BUT WHEN I DO I AM PROGRAMMING

WHO WOULD WIN?
a bunch of code
one misplaced semicolon
;
Who would win?

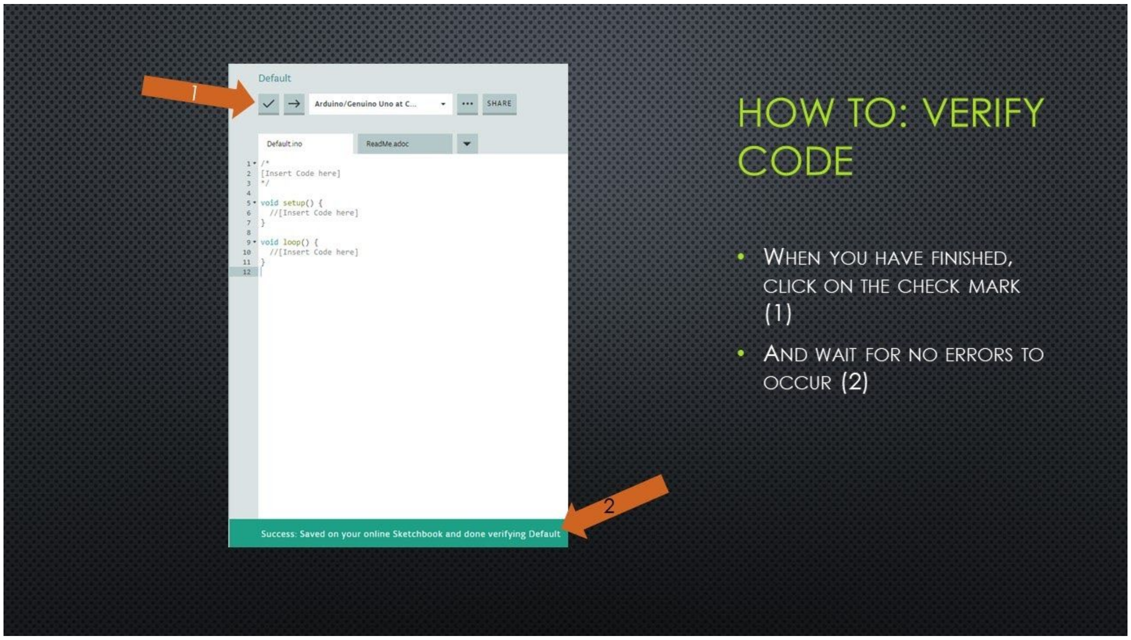
DIDN'T SLEEP FOR 2 DAYS
BECAUSE OF A SEMICOLON

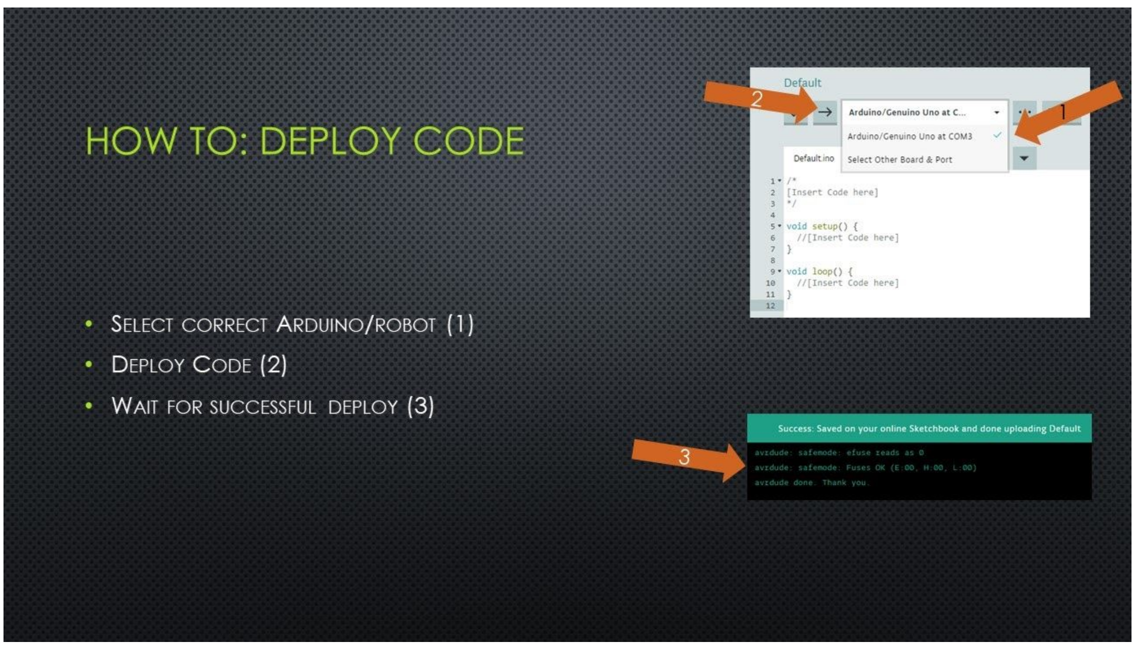
me: *sees I'm missing a semicolon*
my brain:
don't say it
don't say it
don't say it
don't say it
don't say it
don't say it
me: wHy wONt mY coDe cOmPiLE?

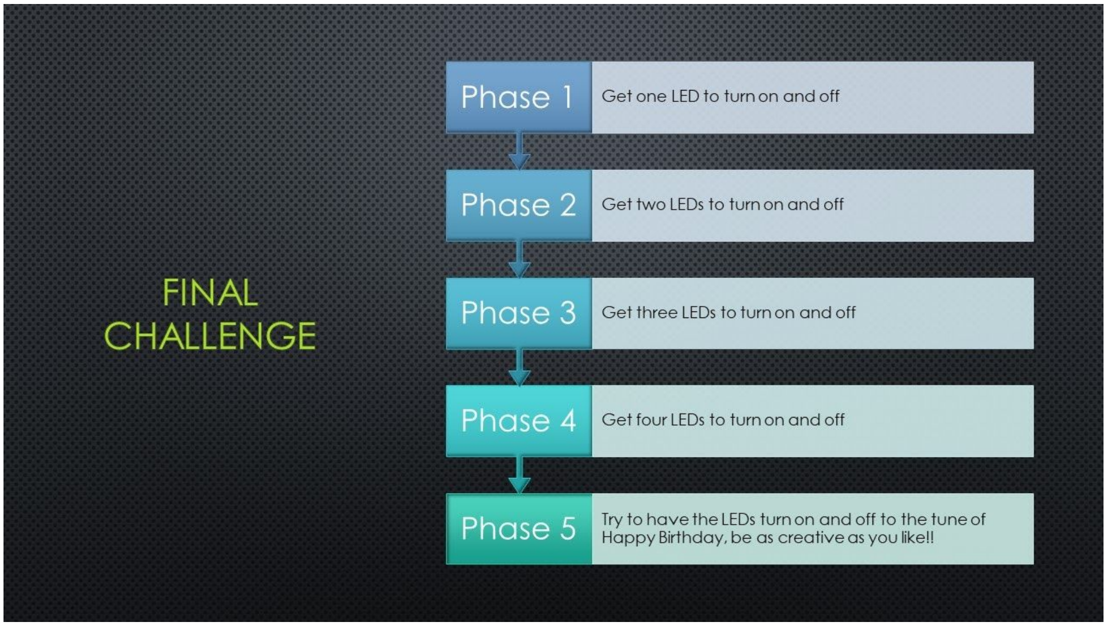
ARDUINO – SEMICOLONS
Moral of the story: Use a semicolon after every line

pinMode([insert pin # here],OUTPUT); // tell the robot where an LED is located
digitalWrite([insert pin # here], HIGH); // tell the robot to turn this pin on,
digitalWrite([insert pin # here], LOW); // tell the robot to turn this pin off
delay([insert # of milliseconds]); // delay the robot a certain time
//REMEMBER that there are 1000 milliseconds in one second
// The following pins are OK to use with the LEDs*,
// PINS: 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13,
// *Use of any other pins may result in the robot and/or code not working
ARDUINO CODE – LEDS


PROGRAMMING ACTIVITY
• WORK WITH A PARTNER
• USE THE ARDUINO CODE INFORMATION TO MAKE AN LED BLINK
HINT: THINK ABOUT THE STEPS NEEDED TO MAKE AN LED BLINK
void setup() {
// [insert what the robot is here]
// only runs once
}
void loop() {
// [insert what you want the robot to do here]
// runs forever
}
/*
FUN FACTS:
// double backslash comments a line out, the code will not run this line
// for long comments do this: /*[insert your long comment]*/
//NOTE: there needs to be semi-colons after every line
*/
pinMode([insert pin # here],OUTPUT); // tell the robot where an LED is located
digitalWrite([insert pin # here], HIGH); // tell the robot to turn this pin on,
digitalWrite([insert pin # here], LOW); // tell the robot to turn this pin off
delay([insert # of milliseconds]); // delay the robot a certain time
//REMEMBER that there are 1000 milliseconds in one second
// The following pins are OK to use with the LEDs*,
// PINS: 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13,
// *Use of any other pins may result in the robot and/or code not working


Default
Arduino/Genuino Uno at C...
SHARE
Default.ino
ReadMe.adoc
/*
[Insert Code here]
*/
void setup() {
//[Insert Code here]
}
void loop() {
//[Insert Code here]
}
HOW TO: TYPE IN CODE
• WHERE IT SAYS [INSERT CODE HERE], PUT YOUR CODE INSTEAD

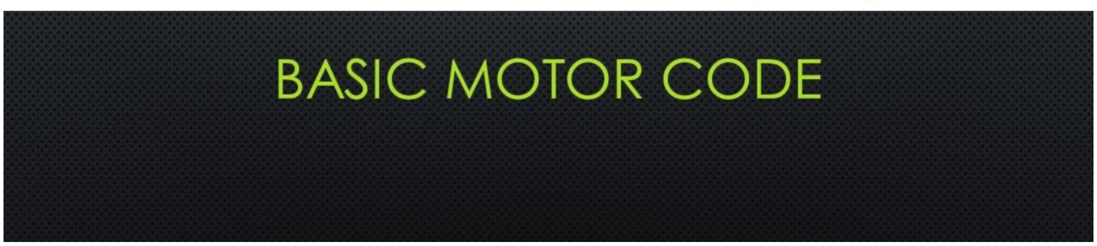

HOW TO: VERIFY CODE
When you have finished, click on the check mark (1)
And wait for no errors to occur (2)
Default
Arduino/Genuino Uno at C...
SHARE
Default.ino
ReadMe.adoc
/*
[Insert Code here]
*/
void setup() {
//[Insert Code here]
}
void loop() {
//[Insert Code here]
}
Success: Saved on your online Sketchbook and done verifying Default
1
2

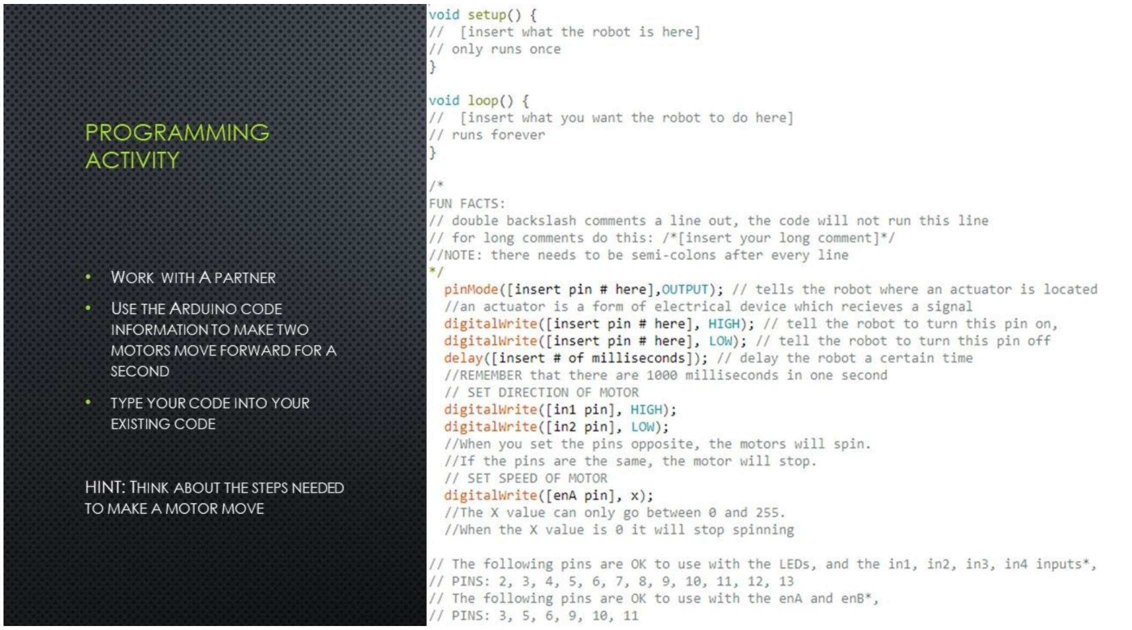

HOW TO: DEPLOY CODE
Select correct Arduino/robot (1)
Deploy Code (2)
Wait for successful deploy (3)
Default
Arduino/Genuino Uno at C...
Arduino/Genuino Uno at COM3
Select Other Board & Port
Default.ino
/*
[Insert Code here]
*/
void setup() {
//[Insert Code here]
}
void loop() {
//[Insert Code here]
}
Success: Saved on your online Sketchbook and done uploading Default
1
2
3

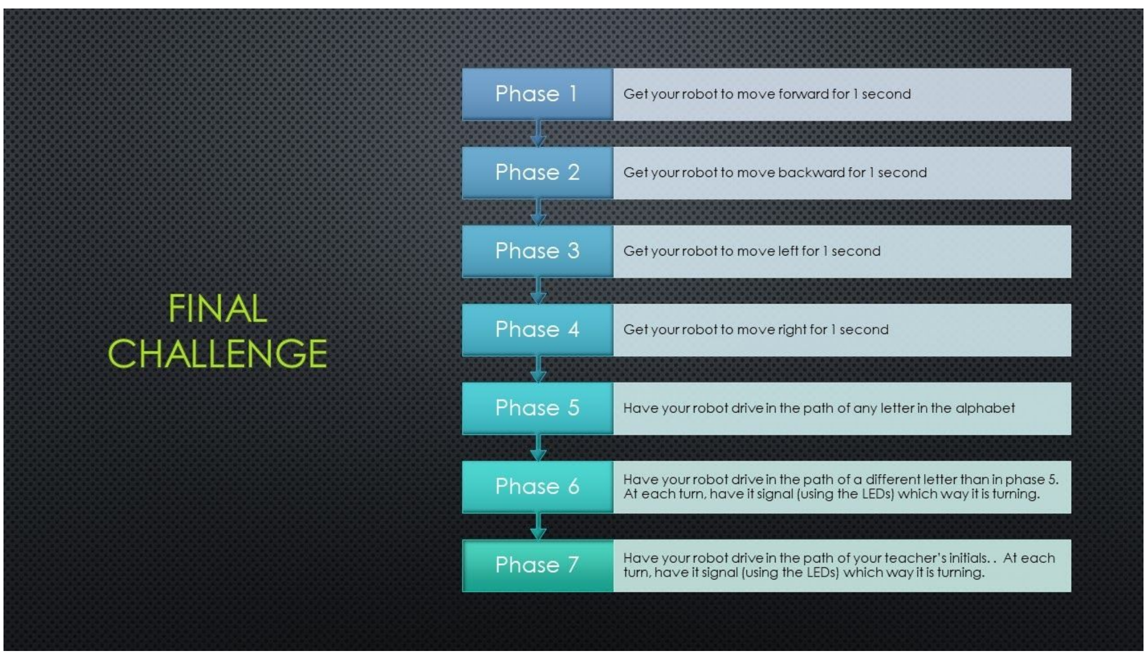

FINAL CHALLENGE
Phase 1
Get one LED to turn on and off
Phase 2
Get two LEDs to turn on and off
Phase 3
Get three LEDs to turn on and off
Phase 4
Get four LEDs to turn on and off
Phase 5
Try to have the LEDs turn on and off to the tune of Happy Birthday, be as creative as you like!!


5 MINUTE BREAK
38

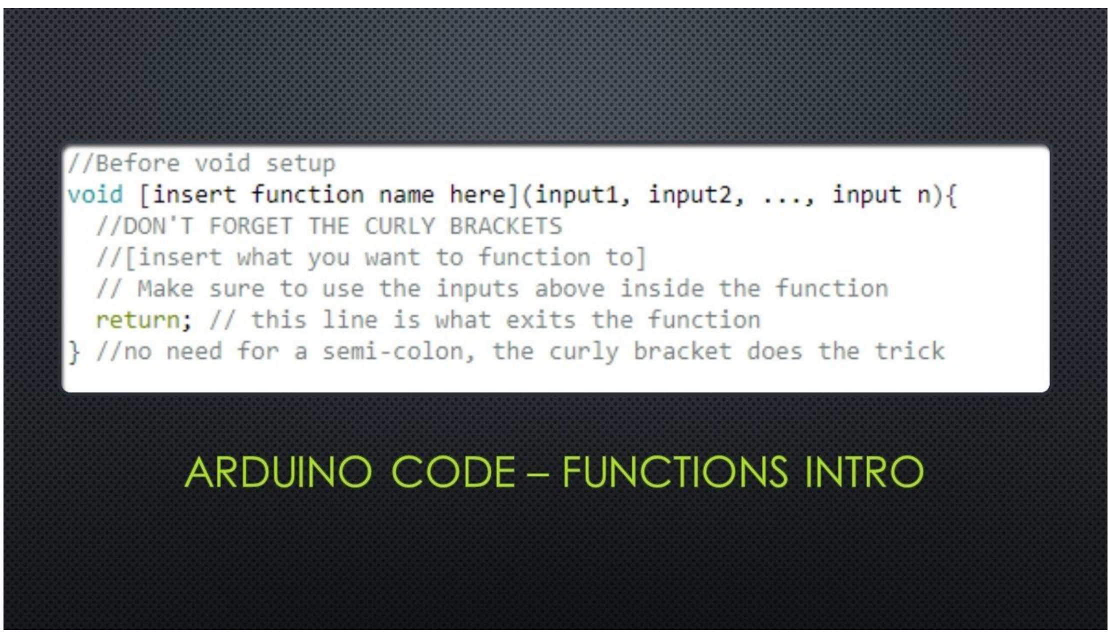

```
// SET DIRECTION OF MOTOR
digitalWrite([in1 pin], HIGH);
digitalWrite([in2 pin], LOW);
//When you set the pins opposite, the motors will spin.
//If the pins are the same, the motor will stop.
// SET SPEED OF MOTOR
digitalWrite([enA pin], x);
//The X value can only go between 0 and 255.
//When the X value is 0 it will stop spinning
```

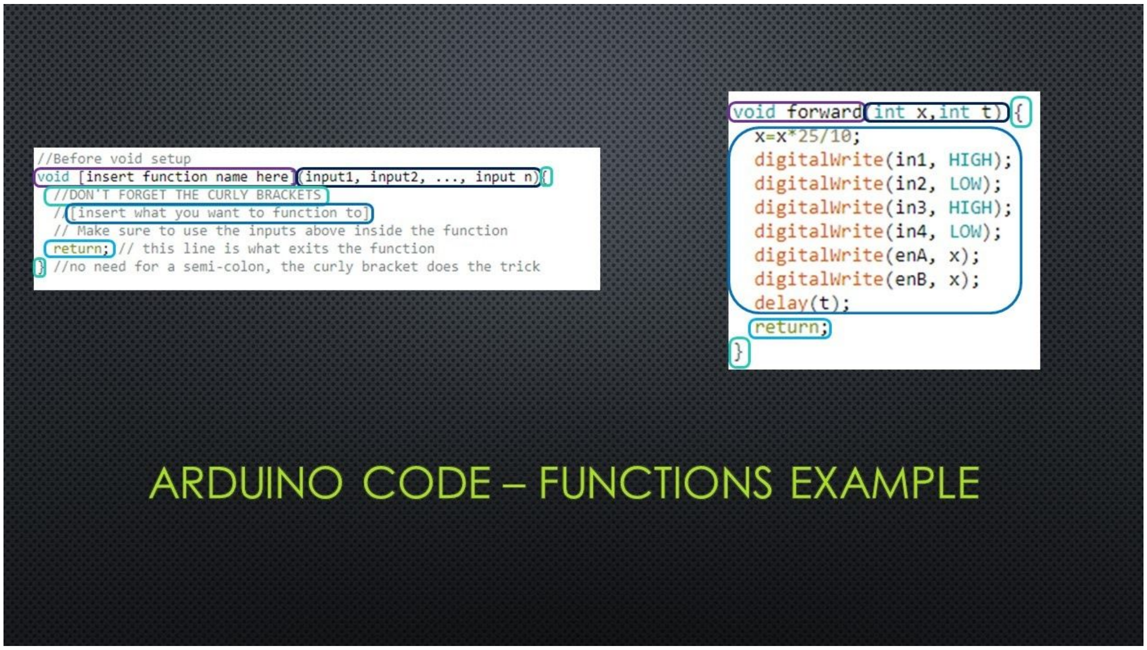



PROGRAMMING ACTIVITY
Work with a partner
Use the Arduino code information to make two motors move forward for a second
Type your code into your existing code
HINT: Think about the steps needed to make a motor move
void setup() {
// [insert what the robot is here]
// only runs once
}
void loop() {
// [insert what you want the robot to do here]
// runs forever
}
/*
FUN FACTS:
// double backslash comments a line out, the code will not run this line
// for long comments do this: /*[insert your long comment]*/
//NOTE: there needs to be semi-colons after every line
*/
pinMode([insert pin # here],OUTPUT); // tells the robot where an actuator is located
//an actuator is a form of electrical device which recieves a signal
digitalWrite([insert pin # here], HIGH); // tell the robot to turn this pin on,
digitalWrite([insert pin # here], LOW); // tell the robot to turn this pin off
delay([insert # of milliseconds]); // delay the robot a certain time
//REMEMBER that there are 1000 milliseconds in one second
// SET DIRECTION OF MOTOR
digitalWrite([in1 pin], HIGH);
digitalWrite([in2 pin], LOW);
//When you set the pins opposite, the motors will spin.
//If the pins are the same, the motor will stop.
// SET SPEED OF MOTOR
digitalWrite([enA pin], x);
//The X value can only go between 0 and 255.
//When the X value is 0 it will stop spinning
// The following pins are OK to use with the LEDs, and the in1, in2, in3, in4 inputs*,
// PINS: 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13
// The following pins are OK to use with the enA and enB*,
// PINS: 3, 5, 6, 9, 10, 11


FINAL CHALLENGE
Phase 1
Get your robot to move forward for 1 second
Phase 2
Get your robot to move backward for 1 second
Phase 3
Get your robot to move left for 1 second
Phase 4
Get your robot to move right for 1 second
Phase 5
Have your robot drive in the path of any letter in the alphabet
Phase 6
Have your robot drive in the path of a different letter than in phase 5. At each turn, have it signal (using the LEDs) which way it is turning.
Phase 7
Have your robot drive in the path of your teacher's initials. . At each turn, have it signal (using the LEDs) which way it is turning.

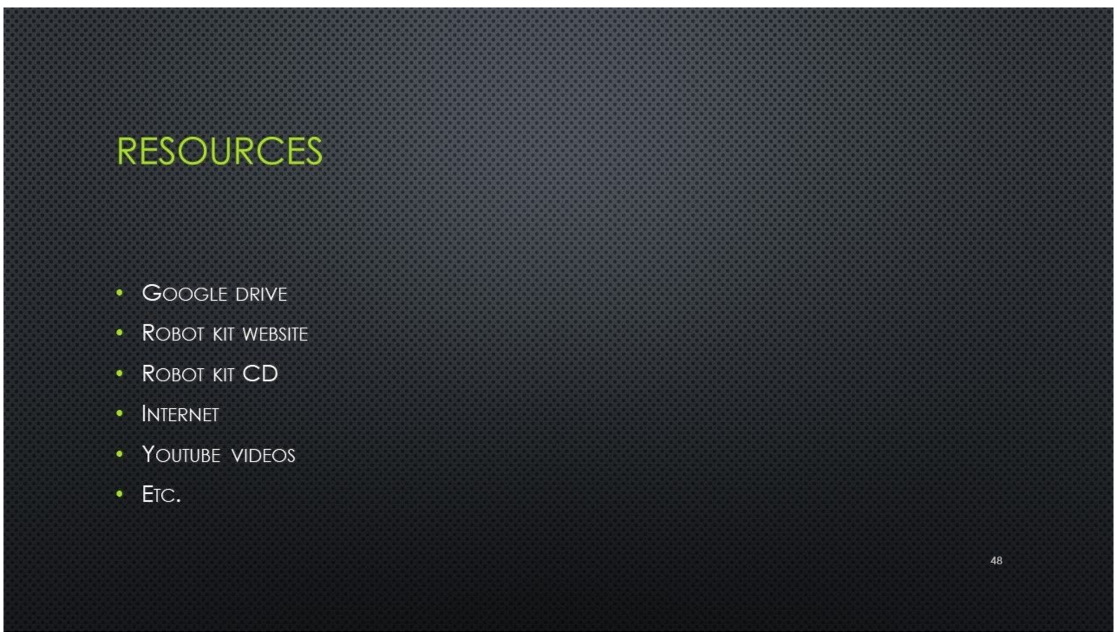

5 MINUTE BREAK
43


//Before void setup
void [insert function name here](input1, input2, ..., input n){
//DON'T FORGET THE CURLY BRACKETS
//[insert what you want to function to]
// Make sure to use the inputs above inside the function
return; // this line is what exits the function
} //no need for a semi-colon, the curly bracket does the trick
ARDUINO CODE – FUNCTIONS INTRO


//Before void setup
void [insert function name here](input1, input2, ..., input n){
//DON'T FORGET THE CURLY BRACKETS
//[insert what you want to function to]
// Make sure to use the inputs above inside the function
return;// this line is what exits the function
} //no need for a semi-colon, the curly bracket does the trick
void forward(int x,int t){
x=x*25/10;
digitalWrite(in1, HIGH);
digitalWrite(in2, LOW);
digitalWrite(in3, HIGH);
digitalWrite(in4, LOW);
digitalWrite(enA, x);
digitalWrite(enB, x);
delay(t);
return;
}
ARDUINO CODE – FUNCTIONS EXAMPLE


QUESTIONS?
46


IN CONCLUSION…
47


RESOURCES
• GOOGLE DRIVE
• ROBOT KIT WEBSITE
• ROBOT KIT CD
• INTERNET
• YOUTUBE VIDEOS
• ETC.
48


SURVEY LINK 2
49


THANK YOU! ENJOY THE ROBOTS!!
50