EXECUTIVE SUMMARY

GROUP 19

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AMONG US CREWMATE

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EXECUTIVE SUMMARY

This document provides a detailed discussion of the process of building our final robot. It goes over the process's engineering aspects as well as design implementations, software and hardware specifications, customer needs, and additional information pertaining to the robot's functionality and creation.

Group 19 created an Among Us Crewmate robot using 3D printed parts designed in TinkerCAD as well as hardware components from the University of South Florida Foundations of Engineering Lab Kit. The robot is coded to follow a moving object between a 5 and 30 cm distance from itself. The target demographic is K-8 children, amongst whom the game Among Us has attained popularity in the past couple of years. We also hope to ignite an interest in robotics in our young users through the robot's easy-to-use and interactive functions.

Our team-based learning project design was highly effective in bringing our final robot together. The variety of skill sets and personal attributes that five engineering freshmen brought to the table led us to create a functional prototype made from several different engineering technologies while considering various other factors such as finances, consumer needs, scheduling, etc. This experience reinforced the findings cited in our literature reviews, which are strong proponents of team-based learning projects in engineering programs.

After brainstorming several animated character ideas and narrowing the choices down to two, the team agreed on the Among Us Crewmate bot design. Our robot comes with a custom mini Crewmate insert and doubles as an action figure. As seen in Figure 2, the Among Us design is notable for its red color and reference to those who used the mobile app Among Us during the Coronavirus Pandemic. Implementing a pop culture reference for students in the classroom evoke excitement for a robotics-based toy and and features like the miniature Crewmate accessory and detachable action-figure diversify usage. Ensuring the product is affordable, durable, safe to use, and easy to assemble keeps parents, teachers, students, and administrators satisfied.

The robot's code is designed to make it follow objects within a distance of 30 cm, come to a stop when the distance reaches 5 cm, and turn in the right and left directions when there is no object within 30 cm to find an object to follow. The turns are non-repetitive to maximize the chances of locating an object close enough to follow. The bot makes use of an ultrasonic sensor to detect objects and follow them. The robot is durable and safe for children with all wiring and motors kept inside a closed box. The feature which allows the robot to come to a stop if an object is within a 5 cm distance adds to its safety and durability. The robot's enclosure is only opened during assembly and disassembly making the risk of electrocution or injury by hardware components minimal. The robot is of high quality due to its 3D-printed parts and ease of assembly, which prevent any unnecessary stress on the components.

I. INTRODUCTION

The Among Us Crewmate aims to provide a fun and interactive way for K-8 students to get involved in robotics. The aim is to keep the design and functionality simple as the target demographic includes kindergarteners. The motivation for creating the robot is to see an impact in homes as well as the classroom as kids develop and explore an interest in robotics and STEM. The bot combines pop culture and robotics to create an easy-to-assemble, attractive, and affordable programming toy for students K-8.

In 2003, an article was written for the Australasian Journal of Engineering Education, comparing and contrasting project-based hands-on learning with lecture-based problem learning [1]. The article also dove into the faults and potential drawbacks of current engineering programs at the time. They found that there is an absence of communication skills and the ability to work in a team among engineering graduates. They also found that current engineering programs do not provide students with sufficient project experience. The research paper "Project-based Learning in Engineering Higher Education: Two Decades of Teaching Competencies in Real Environments" describes the strong positive effects of incorporating project-based learning in undergraduate and graduate programs observed at the Technical University of Madrid over the span of 20 years. It concludes that this methodology is the most adequate educational methodology for the development of competencies, linking teaching with the professional sphere [2]. This is described as a result of the learning method demanding active engagement in the course material as well as behavioral factors allowing for personal growth. In the article, Measuring the Value Added from Service Learning in Project-Based Engineering Education, it was concluded that service learning projects in engineering education seem to be most effective in promoting higher levels of cognitive development in certain skills, as well as fostering positive attitudes and shaping students' sense of identity [3]. The article goes as far as to vouch for the importance of having a broad categories to evaluate students and even faculty.

The robot makes effective use of technology for two significant aspects of the project, software development and hardware. In building the robot, our team also utilized Google Docs, Snapchat, and Microsoft Teams for organization and communication within the team. For software development, we relied on the Arduino language and IDE as well as help from the internet and YouTube. For designing the robot, we used TinkerCAD. Since we decided to 3D print the robot, we used the FlashForge Finder in the USF DFX Lab. To send our designs to the lab, we used the DFX lab's mobile application.

II. PROJECT PLAN

Our first step in our project plan was to pick the design of our robot. After deciding to create an Among Us Crewmate robot, the next step in the schedule was to write and finalize the code for the robot. Next step was to work on creating the computer aided designs for parts that would need to be 3D printed and then printing them. After that, we started perfecting the 3D printed parts for our robot by getting them printed and finalizing dimensions depending on trial and error. When the dimensions were finalized and the final design was printed, the final step was to set up the hardware and begin testing the design, software, and hardware.

The price constraint for the project was under $30. We were able to stay within this limit after careful consideration.

Table 1: Cost of Materials

Material	Cost
Arduino	$4.27
Breadboard	$1.43
2 pack of Wheels	$3.32
Universal Wheel	$1.00
Sensor	$3.40
Battery	$2.00
Servo Motor	$3.00
Female-to-Male Wires	$1.00
Resistor Kit	$1.30
Nylon Filament	$0.28
Total	$21.00

The team has come to find many ways in which we work well together as well as many ways in which there could be an improvement. A major strength of the team is that everyone was able to fill in when needed in areas that may not have been under their lead title. This helped the project progress as everyone was able to help out when needed in all areas. It allowed all members to feel comfortable asking other members for help. However, a big weakness would be communicating and showing up to class/ team meetings when expected. This caused some people to fall behind on their tasks and no one else knew they were behind. We overcame these weaknesses through communication and the establishment of deadlines and were running operations smoothly by the end of the semester.

III. PROTOTYPE DESIGN

The engineering specifications required for the robot are regarding feasibility, compactness, easy assembly, and reliability. The robot should cost under $30, requires 4-7 minutes to put together depending on the knowledge of the user, fit into a 6” x 6” x 6” cube enclosure when taken apart, and be coded to act as a follower, making left and right turns and changing speed by its sensor. The engineering specifications (Table 1) ensure the product is affordable, durable, and easy to assemble, keeping parents, teachers, students, and administrators interested.

Table 2: Engineering Specifications

Engineering Specification Metric	Target Value
Affordable	Under $30
Compact	6” x 6” x 6”
Easy Assembly	4-7 Minute Assembly
Following	70% Accuracy

Of our Snorlax (Figure 1) and Among Us Crewmate (Figures 2-4) candidate designs, we picked the Among Us Crewmate robot. The Among Us Crewmate features the Arduino board in the crewmate pack, a customizable headpiece, and the ability to follow a person. The design comes in multiple colors; however, the prototype features a multicolored Among Us Crewmate. The structure consists of 3-4 pieces that complete the Among Us Crewmate. A custom mini Crewmate insert included with the prototype makes the design customizable for students (Figure 5).

Compared to the Snorlax robot, the Among Us Crewmate drastically exceeds feasibility, educational quality, compactness, and easy assembly (Table 2). The feasibility and academic quality, the Among Us Crewmate scores three points higher than the Snorlax. In the compact and easy assembly categories, the Among Us Crewmate scores 5+ points more than its adversary. Overall, the Among Us Crewmate scored a 92%, while the Snorlax is 62%.

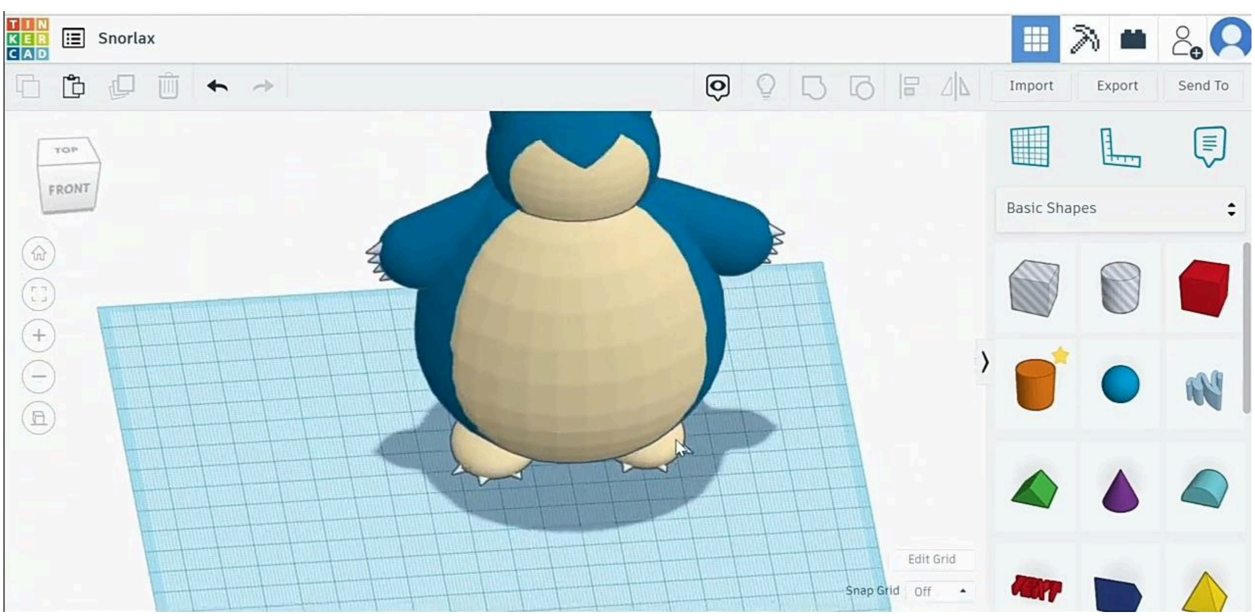

Figure 1: Preliminary Snorlax Robot Design.

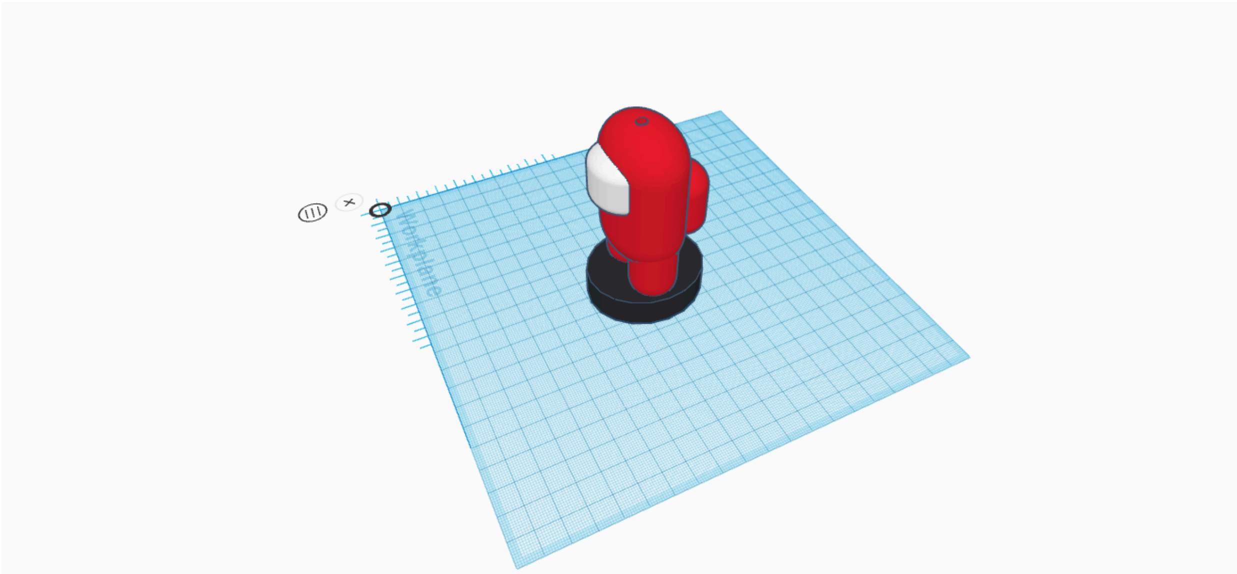

Figure 2: Among Us Crewmate Robot Action Figure.

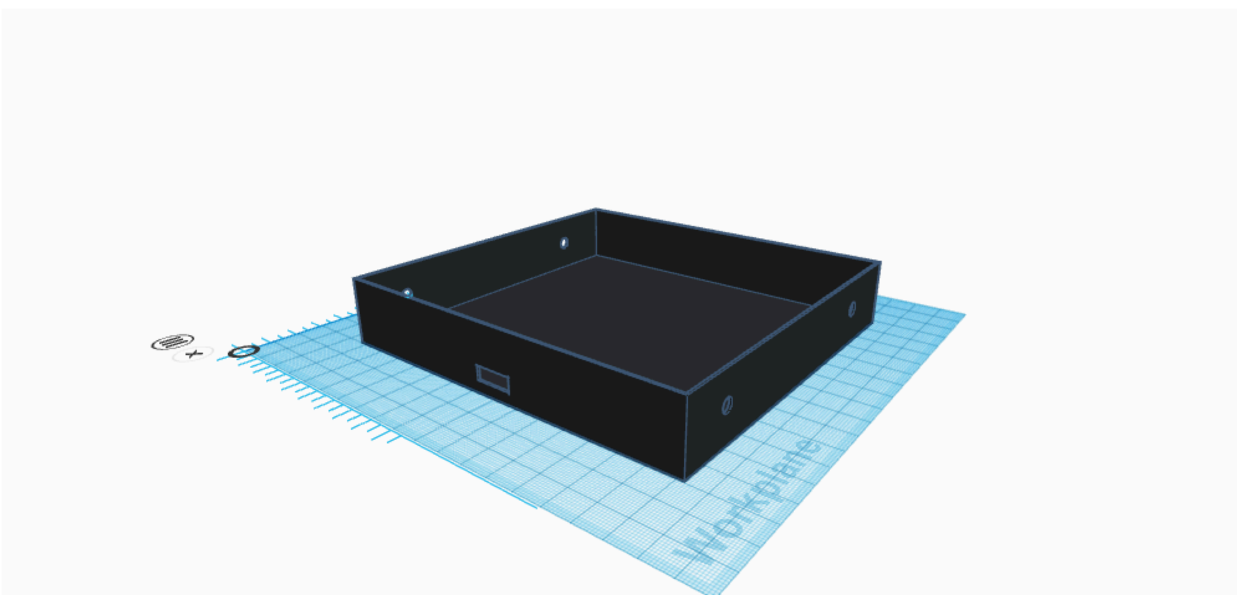

Figure 3: Among Us Crewmate Robot Base/Chassis for Hardware.

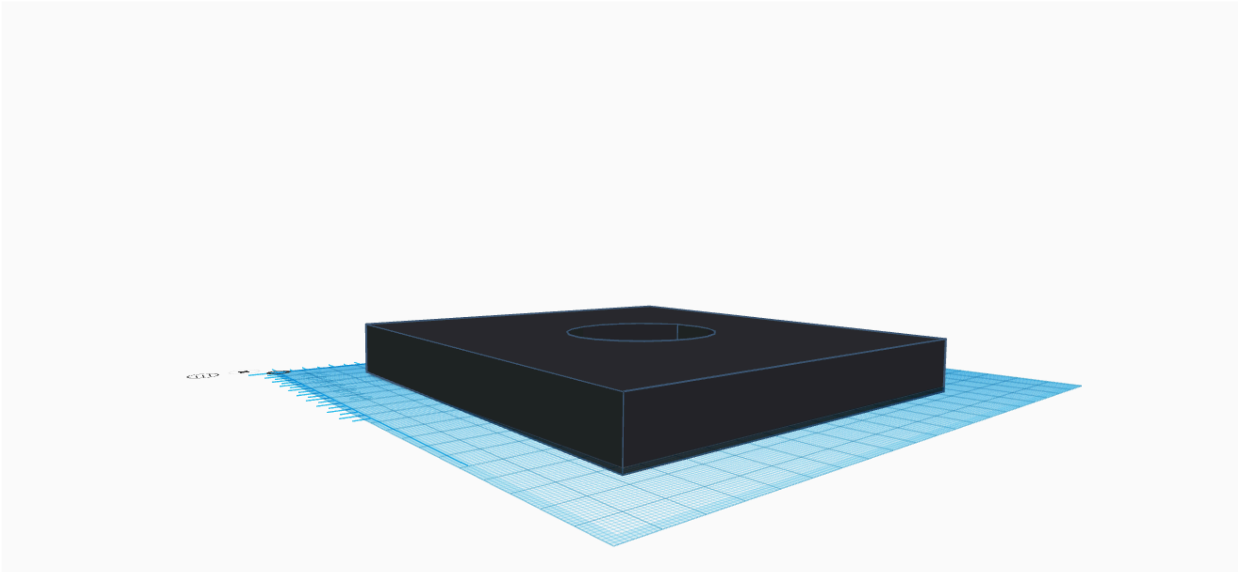

Figure 4: Among Us Crewmate Robot Lid for Hardware.

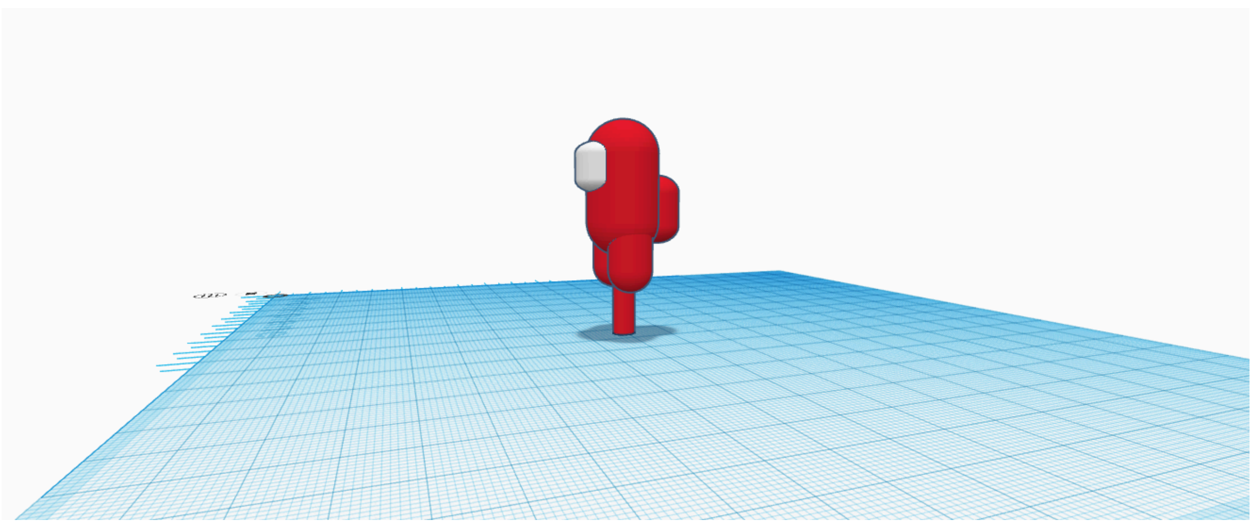

Figure 5: Miniature Among Us Crewmate for Robot.

Table 3: Weighted Benefit Analysis and Customer Needs

Criteria	Weight	Options			
		Among Us		Snorlax	
		Score	Total	Score	Total
Feasibility	20	8	160	5	100

Educational Quality	20	8	160	5	100
Reliability	10	10	100	10	100
Beauty	10	10	100	10	100
Compact	15	10	150	3	45
Easy Assembly	15	10	150	5	75
Durability	10	10	100	10	100
	Total:		920		620

For the Among Us Crewmate Robot, we encountered three major design challenges. The three challenges were the creation of a secondary vessel to hold the hardware, the printed base walls being too thin, and the base of the mini Among Us figure being too small. Each of these issues was resolved swiftly with additions and changes to the CAD designs.

IV. PRODUCT DEVELOPMENT

The Among Us Crewmate robot is composed of various hardware components from our Engineering kit as well as material from the 3D Printing Lab. The exterior component was designed using TinkerCAD and is 3D printed using the 3D printer from the university. First, the chassis was printed that serves as a base to keep all the electronic components such as the Arduino board, sensors, etc. Then, different body components and a headpiece of the robot were printed according to the customization needs of our project.

The fabrication method of our robot includes:

1. Assemble the electronic parts and correctly join the wires with each safely.
2. After the electronic components are put together in the chassis, the lid is closed.
3. The headpiece of the cremate robot is inserted into it.
4. Carefully attaching the body, the headpiece, and the chassis, the robot is set to operate.

The 3D printing of the robot, at first, did not go as planned. We encountered a few hurdles during the manufacture of the chassis. The first problem was our inaccuracy to print the exact dimensions of our robot chassis. The first prototype was smaller than our anticipation hence, our electronic components did not fit well into it. Therefore, after alterations to our first dimension, we 3D printed another new chassis that now accurately fits all our components.

Pictures Leading Up to the Final Prototype:

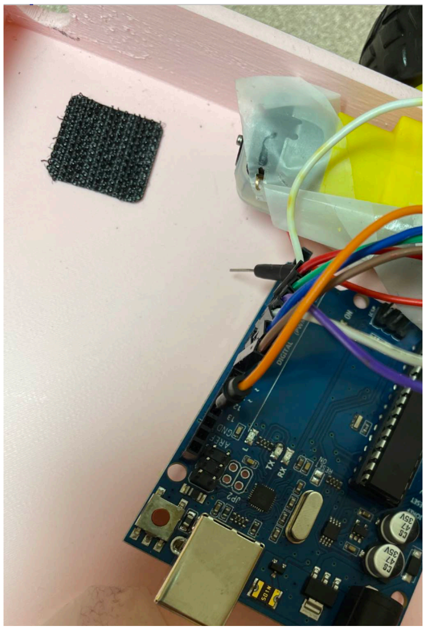

Figure 6: Arduino board on chassis

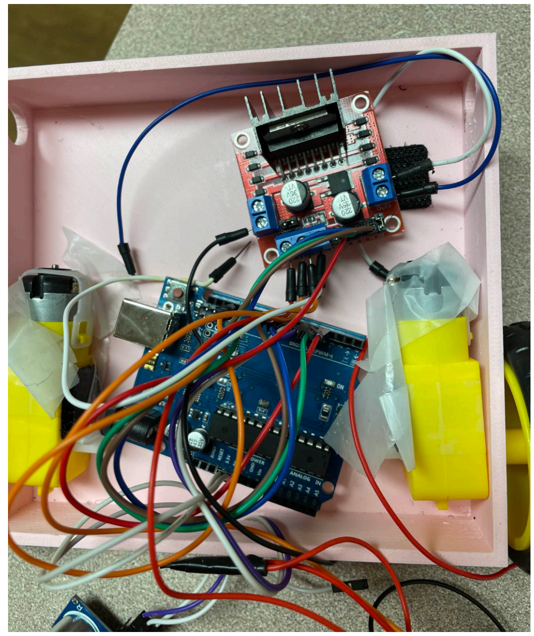

Figure7: Arduino connected to motor and sensors

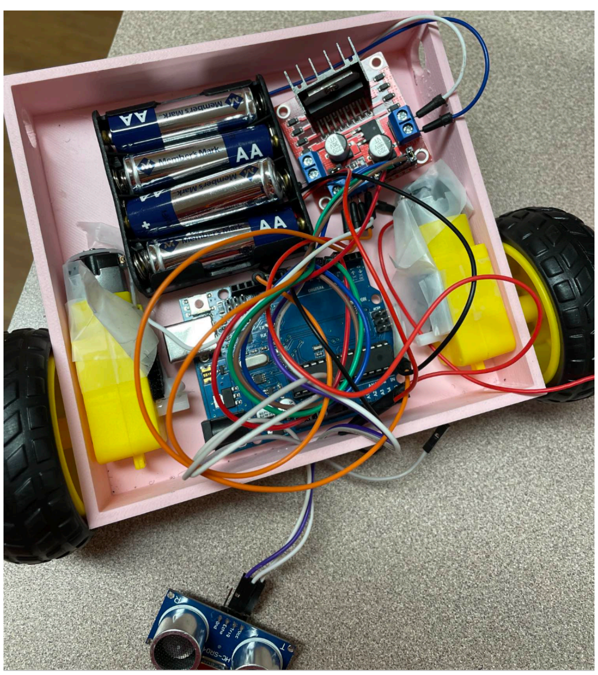

Figure 8: All the equipments connected

Figure 9: The Final Prototype

V. SOFTWARE DEVELOPMENT

Figure 10: Code Flow Chart.

The code is designed such that the robot stops when there is an object 5 cm away and moves towards the object if the distance is less than or equal to 30 cm. Otherwise, the robot should turn around to the right and left alternately and try to find an object within a 30 cm distance. If the previous turn was to the left, the next turn will be to the right.

```
int echoPin = 8;
int trigPin = 7;
int in1 = 2;
int in2 = 3;
int in3 = 4;
int in4 = 5;
int prevDirection = 1;

long duration;
int distance;
```

Figure 11: Arduino Code Part 1 (Initialization).

This part initializes all variables used in the code. The program first declares the trig and echo pins for the ultrasonic sensor (used to trigger the sensor to send and receive sound pulses), four inputs for the H-bridge to control the DC motors (two pins control one motor), the direction variable which keeps track of the last turn direction, and the distance and duration variables which will be calculated in the program. The duration and distance variables keep track of the duration of the echo and the distance the object is at from the robot. ‘int’ represents integer type variables and ‘long’ is used to make sure the variable capacity doesn’t overflow in case the recorded duration exceeds the lesser capacity of an ‘int’ type variable.

```
void setup() {

  pinMode (trigPin, OUTPUT) ;
  pinMode (echoPin, INPUT);

  pinMode (in1, OUTPUT);
  pinMode (in2, OUTPUT);
  pinMode (in3, OUTPUT);
  pinMode (in4, OUTPUT);

  Serial.begin (9600) ;
}
```

Figure 12: Arduino Code Part 2 (Setup).

In the setup function, we define pins in the hardware that will be used to collect data and send it to the robot’s hardware components. The trig pin is set as the output and the echo pin as the input because one sends a signal and the other receives it. The H-bridge pins are set to output because they provide output to direct the motors. The setup function will only run once when the code is activated.

```
void loop() {

  digitalWrite (trigPin, LOW);
  delayMicroseconds (2);
  digitalWrite (trigPin, HIGH);
  delayMicroseconds (10) ;
  digitalWrite (trigPin, LOW);
  duration = pulseIn (echoPin, HIGH);
  distance = duration * 0.034 / 2;

  if (distance <= 5) {

    digitalWrite(in1, LOW);
    digitalWrite(in2, LOW);
    digitalWrite(in3, LOW);
    digitalWrite(in4, LOW);

  } else if (distance <= 30) {

    digitalWrite(in2, LOW);
    digitalWrite(in1, HIGH);
    digitalWrite(in3, LOW);
    digitalWrite(in4, HIGH);

    if (prevDirection == 1) {
      prevDirection = 0;
    } else if (prevDirection == 0) {
      prevDirection = 1;
    }
```

Figure 13: Arduino Code Part 3 (Loop if the distance is within [0 cm,30 cm]).

The loop function, which will run iterations of our Arduino sketch, begins with sending a sound wave using the trig pin. The pulseIn function gives the duration of the echo using the echoPin, which triggers reception of the reflected sound wave. Using the speed of sound, the distance of the robot from the object is calculated and used in further navigation of the robot. The series of if-else statements is used to determine, using the distance variable, the movement the object should execute based on the object's calculated distance from it. Each block only executes if the condition in parentheses in the first line is met. The prevDirection variable keeps track of the direction the robot's moving in and keeps updating it for the next loop iteration. The robot moves to the right if its value is 0 and to the left if its value is 1. When the distance is <= 5, the values LOW values of the motor pins cause the robot to stop. When the distance is >5 and <= 30, both the motors are activated so the robot moves forward. When the distance is >30, depending on the value of prevDirection, only the right or left motor is activated to make the robot turn to find an object nearby. The last delay statement provides the arrangement time (10 milliseconds) to set the components/code in order for the next iteration. The delay statements throughout the code serve this function.

```
  } else if (distance > 30) {
    if (prevDirection == 1) {

      digitalWrite(in1, LOW);
      digitalWrite(in2, HIGH);
      digitalWrite(in3, LOW);
      digitalWrite(in4, HIGH);

    } else if (prevDirection == 0) {

      digitalWrite(in1, HIGH);
      digitalWrite(in2, LOW);
      digitalWrite(in3, HIGH);
      digitalWrite(in4, LOW);
    }

  }

  delay(10);

}
```

Figure 14: Arduino Code Part 4 (Loop if the Distance is > 30)

The fabrication videos we have recorded so far are the video developed for our Robotic Behaviour assignment (https://youtu.be/zR6ZxSNLC40) and the video presented in our Showcase Portfolio (https://youtu.be/OvDO8p8h2wQ).

The major software development challenge encountered by us was that our software lead had no prior knowledge of Arduino and the language wasn't as intuitive as the high-level programming languages she had programming experience with. The software development process involved a lot of debugging, getting help from teaching assistants, reading, and watching video tutorials to understand the workings of each command used in the code. We were able to get the code ready and tested ahead of time.

VI. PROTOTYPE TESTING

The prototype follows an object using an ultrasonic sensor. The design features an Among Us character placed on a platform with three wheels, allowing it to move around and follow the user. The robot also includes a custom insert which can be placed on top of the larger Among Us figure and engages children in the robot. Both the main Crewmate and the attached mini Crewmate are detachable, allowing children to play with them as action figures. The robot is designed to be very safe, with all wiring and motors kept inside a closed box that is only opened during assembly or disassembly. As a result, the risk of electrocution is minimal. The robot is of high quality and very durable due to its 3D-printed parts and the ease of assembly, which prevents any unnecessary stress on the components.

Table 4: engineering specifications

Weight	170g

Dimensions	5.6 x 5.4 x 5.7 inches
Maximum speed	5 cm/s
Assembly time	5-7 minutes
Power requirements	12v
sensors	Ultrasonic Sensor

The prototype meets the engineering specifications because it fits inside of a 6x6x6 box, it is fast to assemble, and it uses the ultrasonic sensor to follow a person or object.

While creating the robot, there were issues with printing the designs to fit all the parts together. The first time it was printed the Among Us and Mini Among Us, the part that connects them did not fit and broke, as shown in Figure 6. To solve this problem, the Mini Among Us was printed again with a slightly smaller part that fits properly, as shown in Figure 7. Additionally, difficulty was faced in finding a suitable method to connect the two back wheels as they weren't using any motors. Lastly, a search was made for a stick that was the right size and could fit in the wheels to secure them in the robot while still allowing it to move. After reprinting the parts that weren't fitting and finding a stick to connect the wheels, the robot became fully functional.

Figure 15

Figure 16

VII. RECOMMENDATIONS

Upon the completion of the Among Us Crewmate robot prototype to the public, Group 19 intends to collect further research and feedback to adhere to the requests of the public. In addition to redefining and understanding changes in customer needs, Group 19 will conduct a secondary survey of students, administrators, parents, and educators to further understand how the product can be increasingly beneficial. Of the many informational categories, Group 19 will focus on assembly time, customer satisfaction, feasibility, design mechanics, and additional customization. Group 19, based on the feedback, will develop a second prototype that meets the current needs of the consumers.

VIII. CONCLUSIONS

The Among Us Crewmate Robot will encourage K-8 students to pursue robotics and other STEM-related fields. By creating a personalized robot based on the character design from the video game, Among Us, Group 19 plans to create a lot of traction. They have also gotten children away from their screens while keeping them entertained. As Group 19 developed their prototype for the Among Us Crewmate Robot, a design optimization survey was required to understand the demands of their audience. With responses from educators, students, and parents, it was found that many enjoyed the idea of an Among Us Crewmate Robot that was highly customizable and compact. The Among Us Crewmate Robot uses 3D printing and hardware components. The primary program for the 3D parts was TinkerCad and each piece was printed using the University of South Florida’s Design for X Laboratory. While printing the components, there were inherent issues with the inaccuracy of printing due to dimensional errors. These issues taught Group 19 to allocate time aside for printing multiple versions of each component to ensure each piece works properly. In addition to hardware findings, there were a few software-related findings for the creation of the Among Us Crewmate Robot. In creating the code for the robot, Group 19’s software lead had no prior knowledge of Arduino. This difficulty of learning Arduino would be combated by obtaining knowledge of the programming language; leading Group 19 to find that when moving to mass production it requires individuals with knowledge of the Arduino coding language. Overall, the prototype creation of the Among Us Crewmate Robot achieved its promise of providing K-8 students with an interactive way to get involved in robotics. Despite the challenges faced, Group 19 has created an Among Us Crewmate Robot that combines pop culture and robotics to create an easy-to-assemble and affordable programming toy.

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