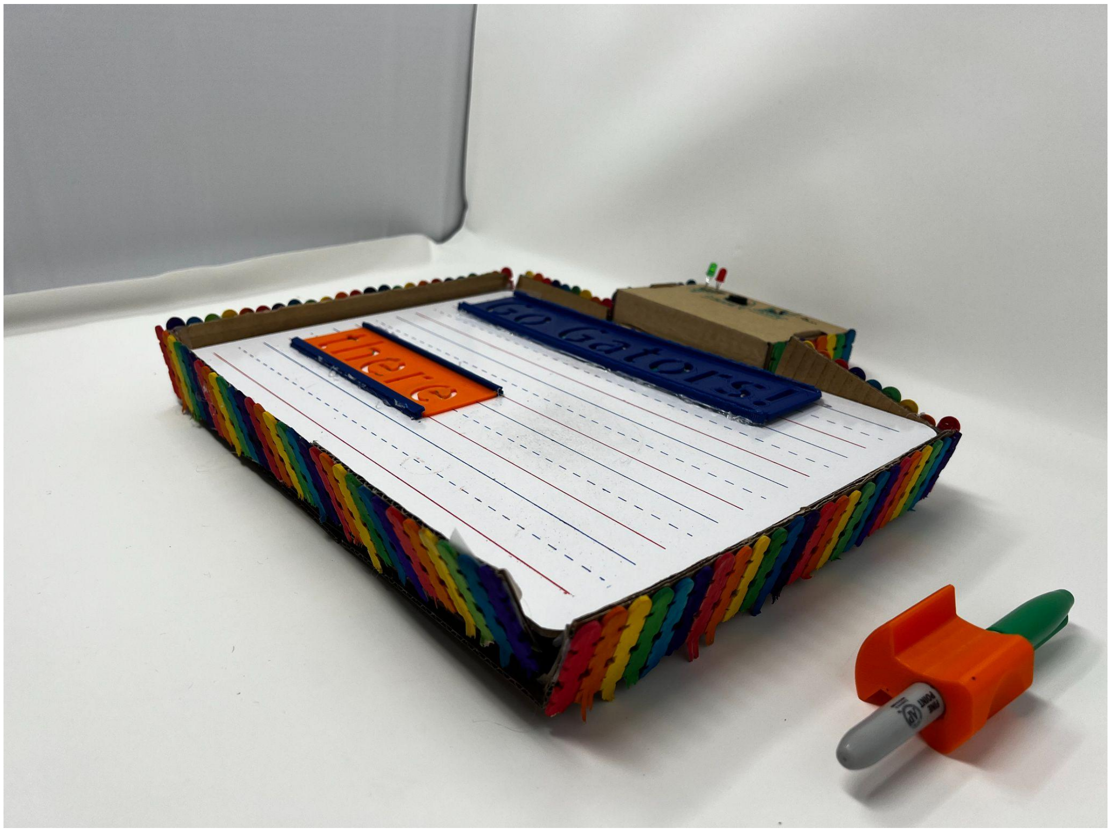
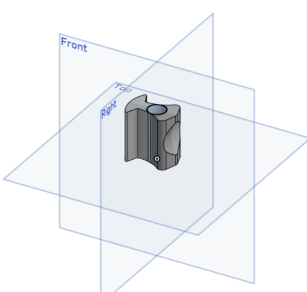
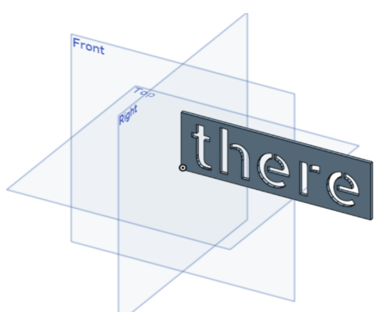
The “Handwriting Helper”







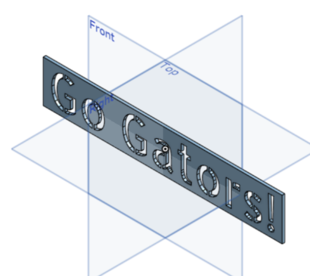


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Table of Contents

Human-Centered User Needs

Our human centered-users for this design were young kids who needed help learning to write or with improving their handwriting, most likely between the ages of 5 to 7. Many young children struggle with handwriting, and if not taught well, they can struggle to properly write for a lifetime. As a result, this can lead to confidence issues in the classroom. Children may feel sad seeing their peers move on while they are still stuck on their writing skills, for example. Furthermore, this could affect their grades as teachers may start taking points off for illegible handwriting.

There are many ways to improve a child's handwriting, which will be included in the Handwriting Helper. First, it will come with a special pencil and grip/holder that will ensure kids have the best grip on their pencil. The pencil grip design is to help children hold their pencil with the lateral pencil quadrupod grip. This specific grip scored the highest in total words and total legibility in a study about children's handwriting (Koziatek and Powell, 2003). The helper will also have templates for kids to practice letters and words. There will be stencils of words that they can trace over. Different stencil packs will have words catering to the child's interests, such as sports or animal packs. Finally, a big problem that children have when learning to write is pressing down too hard on the paper. An interview with Gretchen Moore, an elementary school teacher, revealed that she often finds her students struggling with this skill (G. Moore, personal communication, March 15, 2023). This can sometimes even tear the paper and make them more frustrated and discouraged. The Handwriting Helper will have sensors that will trigger a light and a buzzer when children push down too hard when writing. This will help them get a better feel for how hard to press.

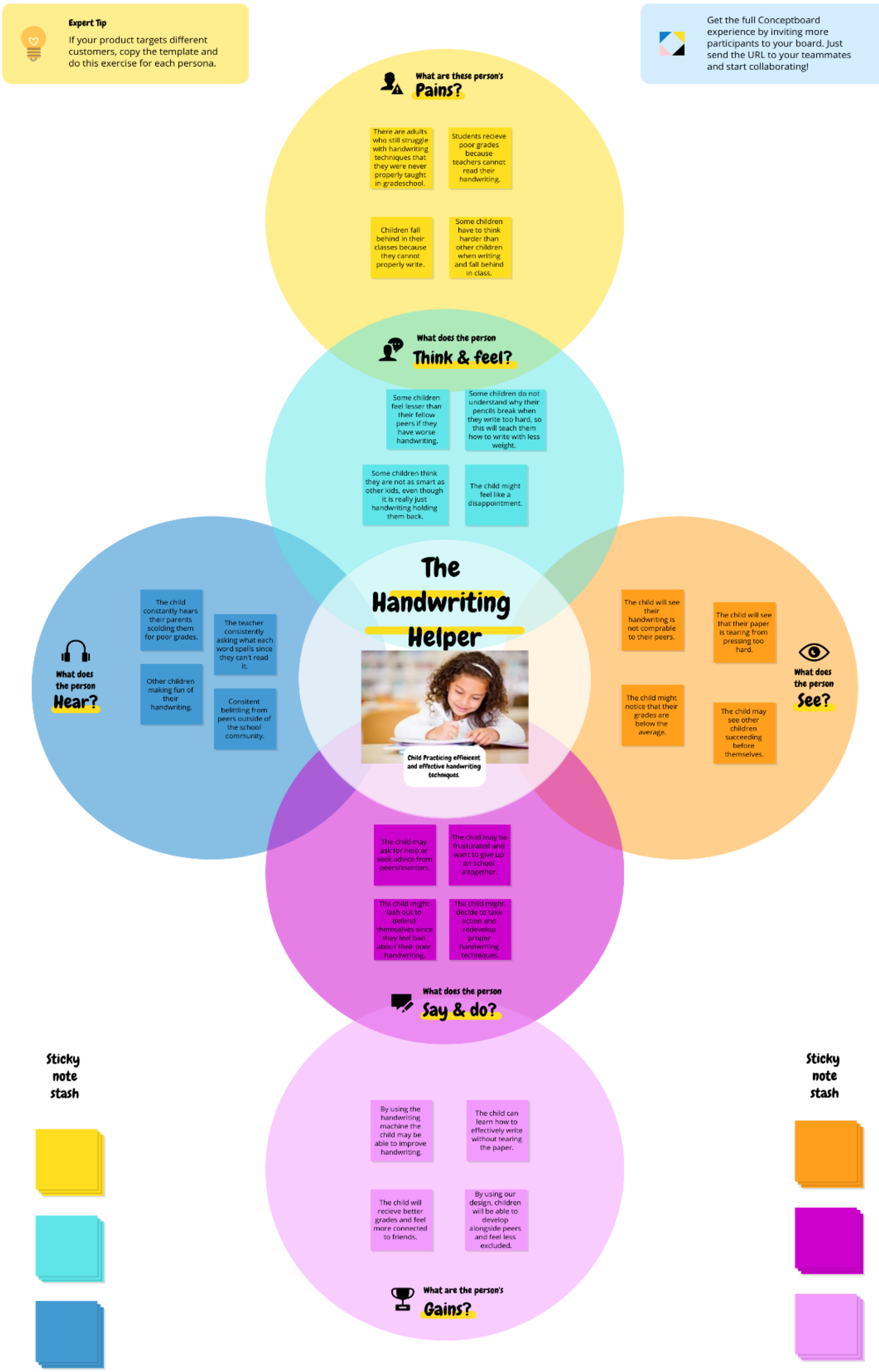

Figure 1: *User Empathy Map*

Design Justifications

The final design ideas were the “Handwriting Helper” and the “Smart Cup Stacker.” The Handwriting Helper is a whiteboard-based tool designed to help children develop their handwriting skills. It includes a marker grip to help children practice proper pencil grips and buttons underneath the whiteboard to let children know when they are exerting too much pressure while writing. The Smart Cup Stacker is a tool that helps children practice their fine motor skills like gripping objects and placing them with precision. The cups would be 3D-printed with divots that show children where to place the cups and allow the cup stack to be more stable.

Attributes	Attribute Weights	“Handwriting Helper” (out of 10)	Weighted Score	“Smart Cup Stacker” (out of 10)	Weighted Score
Safety	0.1	6	0.6	8	0.8
Effectiveness	0.4	10	4.0	9	3.6
Low-Cost	0.1	9	0.9	8	0.8
Durability	0.2	8	1.6	9	1.8
Ease of Use	0.2	10	2.0	8	1.6
Total	1.00		9.1		8.6

Figure 2: *Design Decision Matrix*

Ultimately, the Handwriting Helper was the best design decision, as shown in *Figure 2*, the decision matrix. This design has the most potential and is the most unique, since this tool doesn’t already exist. Additionally, teaching handwriting is an actual problem that many teachers struggle with in early grade school. An interview with Gretchen Moore, a first grade teacher, responded that handwriting was the number one issue for her students (G. Moore, personal communication, March 15, 2023). The implementation of a special hand grip will encourage a proper handwriting position (hold) and the whiteboard signals will encourage lighter writing. Most younger children think they need to press down on their pencils with a lot of pressure in order to write; however, this board will teach them to write with less weight and encourage lighter writings. The visual and aural queues are very child friendly. This idea could be implemented in the classroom as a learning station to teach fine motor skills and encourage proper handwriting. The effectiveness of the design was weighed the highest in the decision matrix because it was important that the design is useful for all children and helps solve a common problem in the classroom.

Ethical & Environmental Considerations

Our design has a fairly limited impact on the environment, and the process ensures that no unethical manners are practiced. To illustrate this point, the box that holds the Arduino components and whiteboard is made out of cardboard that can be recycled or repurposed once the product is no longer in use. The whiteboard stencils and pencil grips have a very long durability and can be used in schools for decades to come, instead of being thrown away after a couple of years. As for the individual components for the whiteboard, they can be easily replaced: the springs, buttons, arduino board, and the writing whiteboard itself can be removed and replaced once the box is opened up. This is excellent for sustainability and durability since the electronic parts can most likely be replaced completely and the old ones can be recycled. The whiteboard itself may be worn down quickly, and unfortunately this part is not recyclable. On the other hand, the whiteboard is also very easily replaceable, alongside the whiteboard markers and erasers.

Additionally, the manufacturing process for all of the parts are ethical. The electronic components are produced by well-known companies, such as Arduino. The wood and cardboard are sourced from local stores/suppliers. Although cardboard has a negative environmental impact of using more trees, the recyclability and durability balances this out. The only component that could be unethical is the whiteboards, which are manufactured in China. The conditions at this specific company's manufacturing centers are unknown, and it is hard to come to a clear conclusion.

In recapitulation, the product takes ethical and environmental concerns into account. All of the parts are fairly durable and easily replaceable. The box that comprises our design is made of wood and cardboard, and the electronic components can be recycled. The only thing that will go to landfills will be the whiteboard itself. The manufacturing process is ethical and does not exploit manual labor.

Light Booth Pictures

Figure 3: *Light Booth picture front angle*

Figure 4: *Light Booth picture top angle*

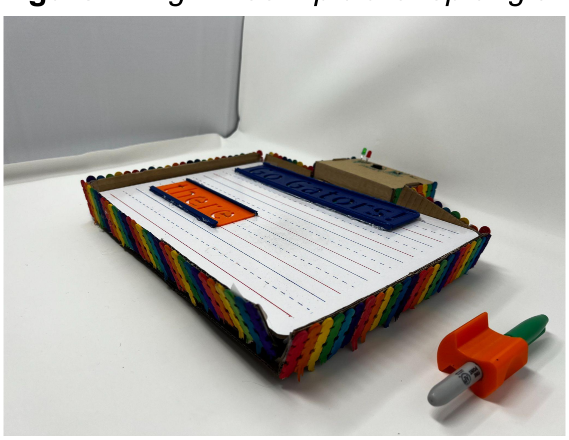

Figure 5: *Light Booth picture side angle*

Tinkercad Electronics User Manual

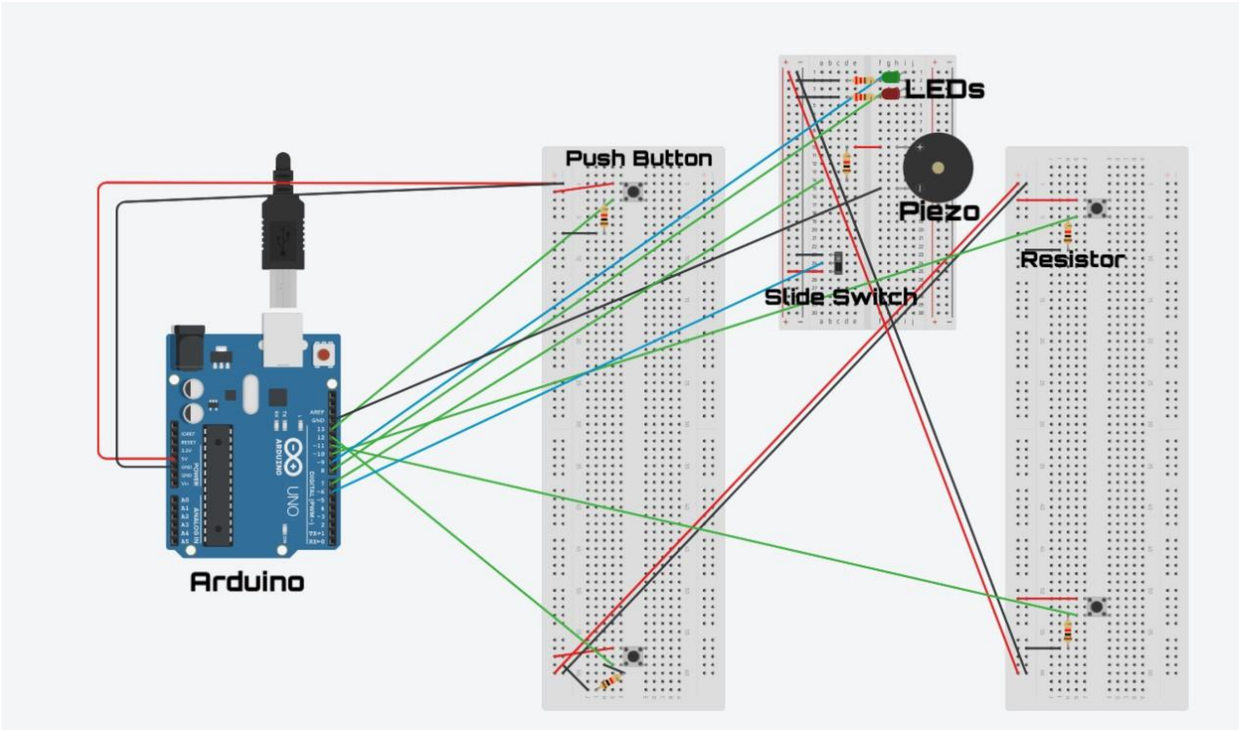

Figure 6: *Arduino circuit design made in Tinkercad*

1 Arduino Uno	1 Piezo Sensor	1 Red LED	4 1kΩ Resistors	Jumper Wires
4 Push Buttons	1 Slide Switch	1 Green LED	2 220Ω Resistors	3 Breadboards

Figure 7: *Arduino parts list*

Instructions:

Start with the Arduino board and three breadboards, as oriented in the image above. First, connect the 5V and GND from the board to the first breadboard, then connect the following two breadboards accordingly. Next, the process for connecting each button will be repeated four times, at four different locations. First, connect the push button in the middle of the breadboard, positioning each one at a corner. Now, connect the positive to the top of the button. On the lower part, connect the button to its corresponding pin on the Arduino board (the four buttons should go to pins 10-13). Next to that, have a 1 kilo ohm resistor, leading to a wire that connects it back to ground. As stated, repeat this process four times. After this, place the two LEDs in the final breadboard, positioning them at the far left. Connect the positive end to the Arduino board, with the green LED to pin 9 and red LED to pin 8. On the negative end, connect a 220 ohm resistor, then wire back to ground. Next, place the piezo in the middle of the breadboard. Connect one end to pin 7 of the board, and connect the other to ground. Ignore the extra resistor in the image. Now, place the slide switch on the right side of the breadboard. Connect the right side to positive, left side to ground, and the middle to pin 6. Ensure that all of the wires are connected to the right pin and that the components are fully pushed in.

For maintenance, whenever the electronics stop working, make sure that no wires or components have lifted out of their place. If a push button or LED stops working, simply replace it with a new component (no wiring should be moved, just replace it directly). In addition, the circuit can be powered by a battery, once the Arduino code has been uploaded. Therefore, once the battery runs out, just replace the battery. Overall, it is easy to maintain.

Engineering Drawings

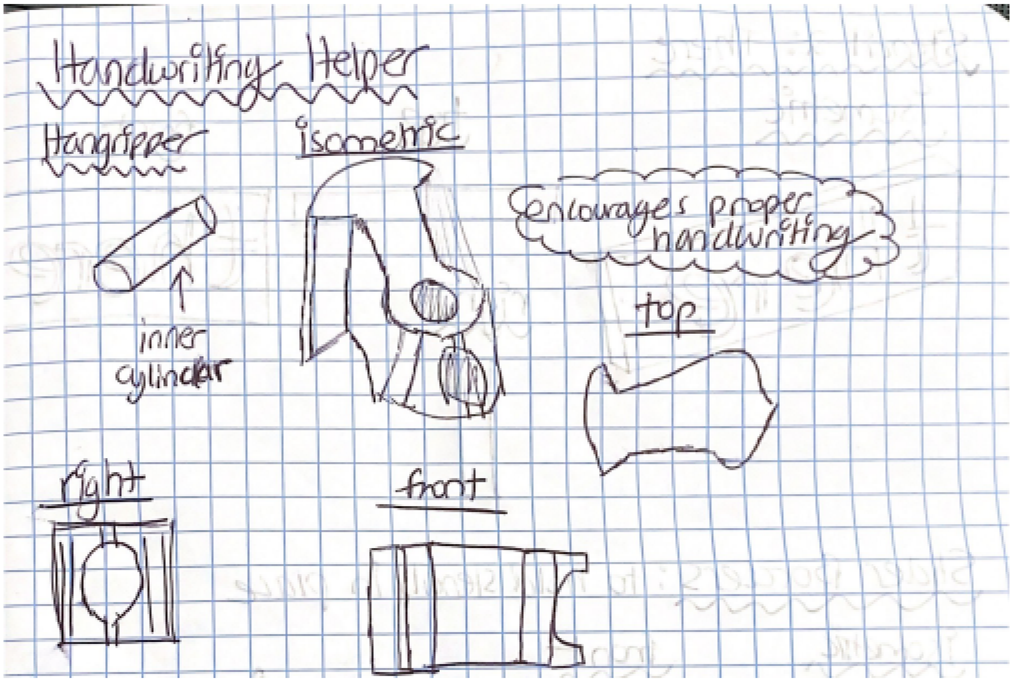

Figure 8: *Drawings of Handgripper design including isometric, right, front, and top views*

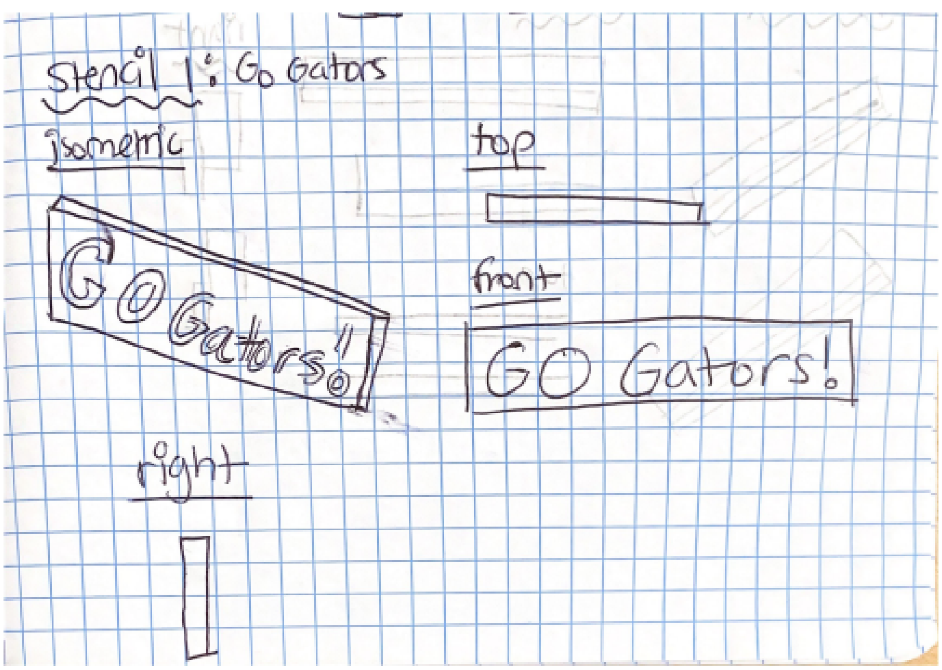

Figure 9: *Drawings of Stencil 1 "Go Gators!" design, including isometric, top, front, and right views*

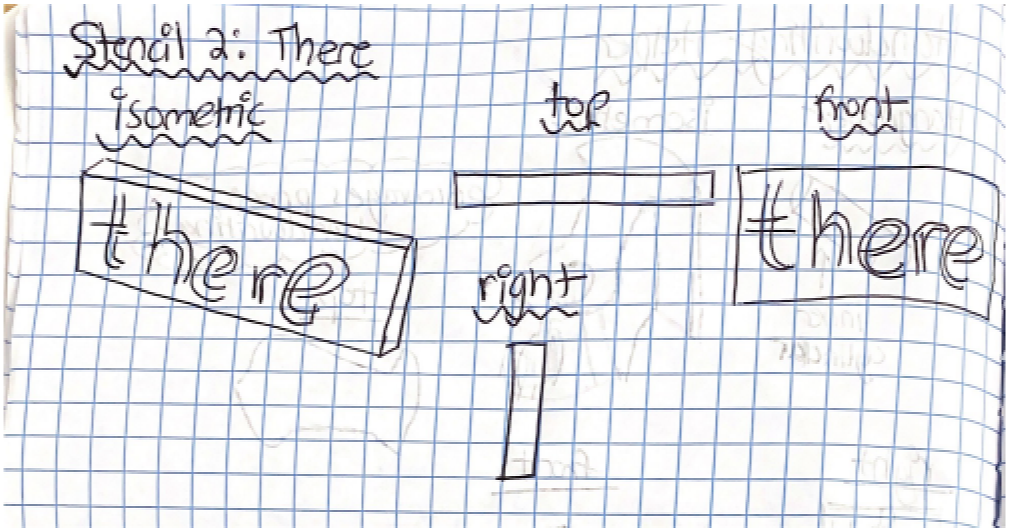

Figure 10: *Drawings of Stencil 2 “there” design, including isometric, top, front, and right views*

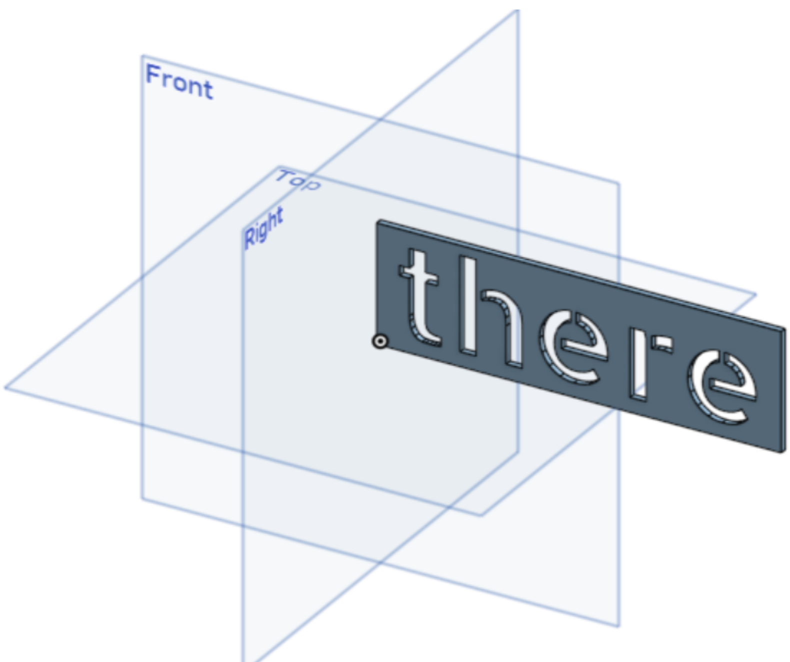

Figure 11: *Isometric Onshape Drawing of Stencil 2 “there” design (Onshape Link in Appendix)*

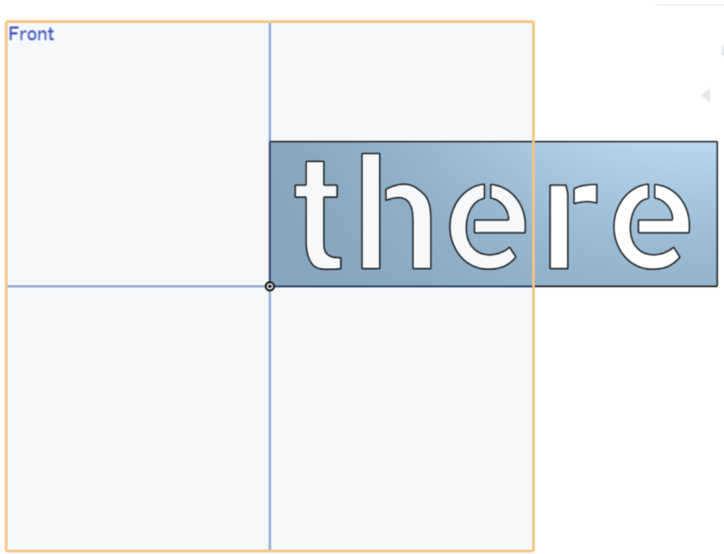

Figure 12: *Front Onshape Drawing of Stencil 2 “there” design*

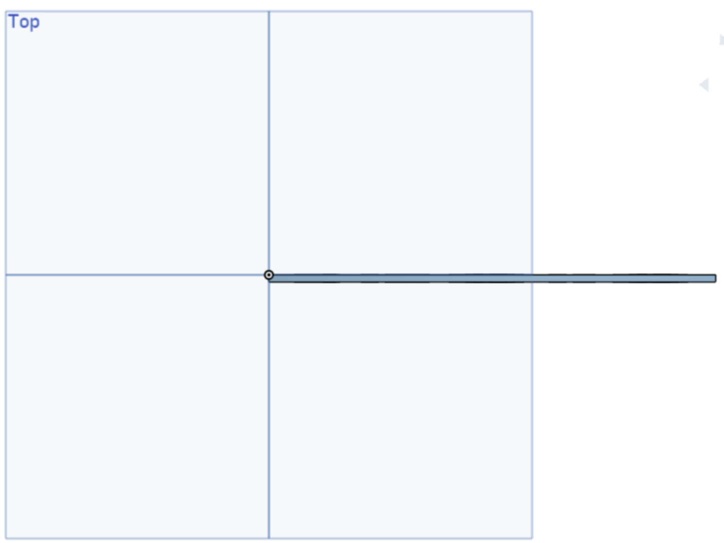

Figure 13: *Top Onshape Drawing of Stencil 2 “there” design*

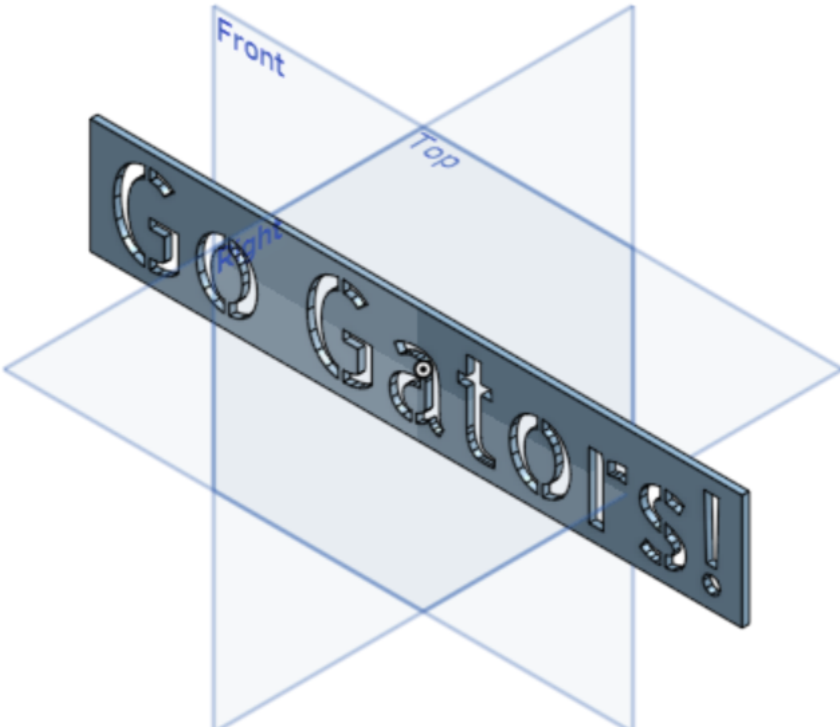

Figure 14: *Isometric Onshape Drawing of Stencil 1 "Go Gators!" design*

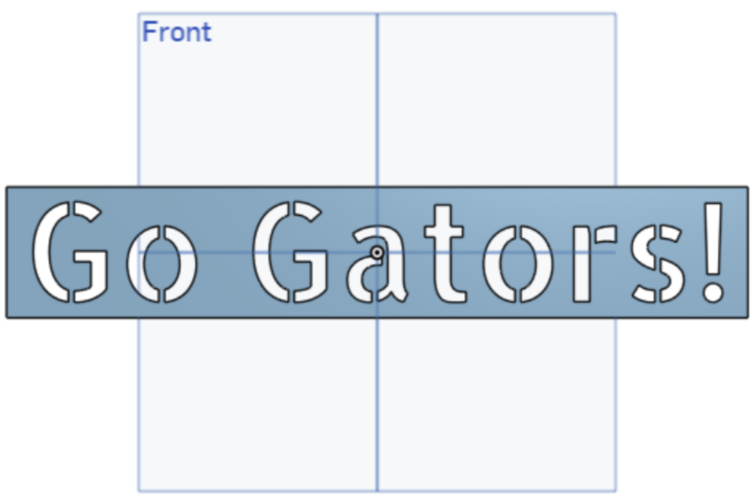

Figure 15: *Front Onshape Drawing of Stencil 1 "Go Gators!" design*

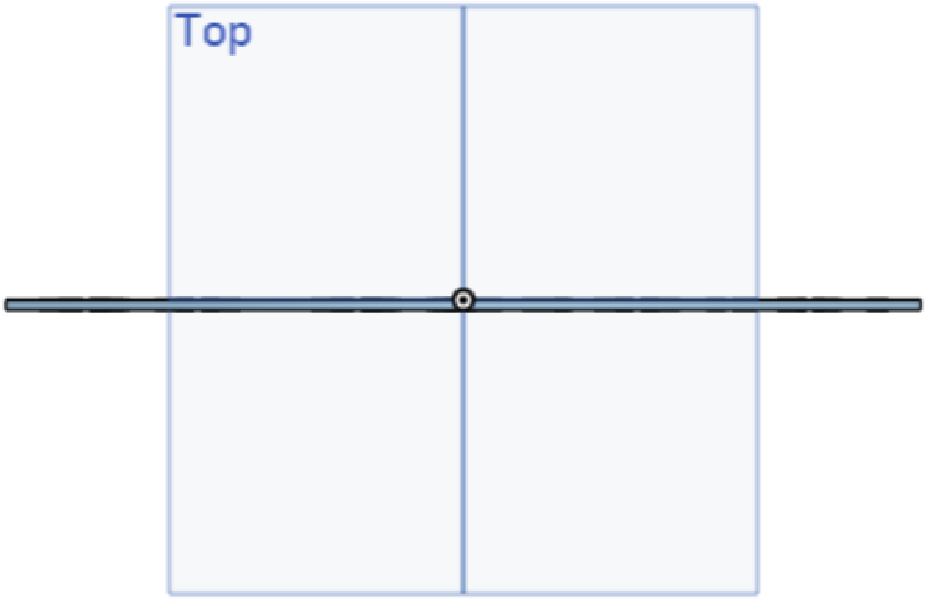

Figure 16: *Top Onshape Drawing of Stencil 1 “Go Gators!” design*

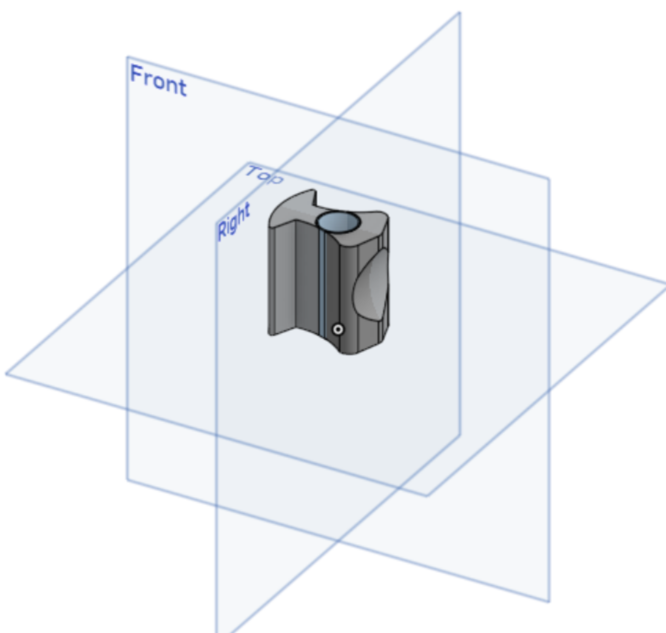

Figure 17: *Isometric Onshape Drawing of Hangripper design*

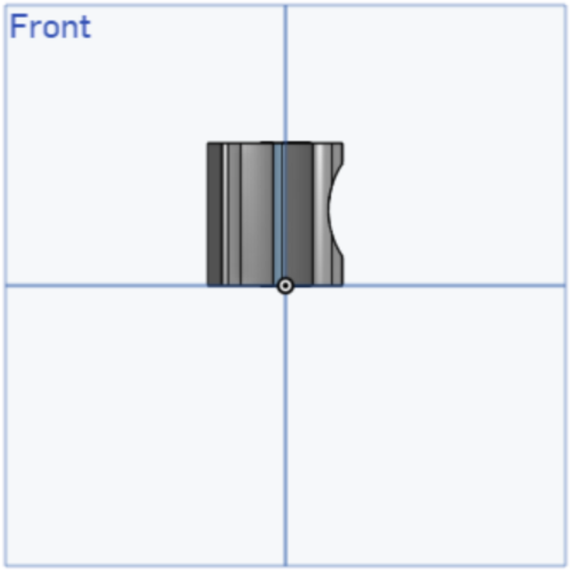

Figure 18: *Front Onshape Drawing of Hangripper design*

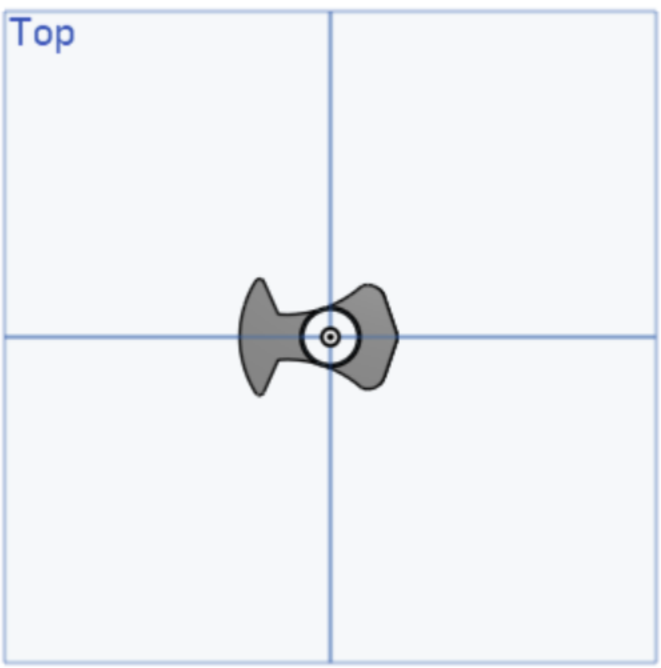

Figure 19: *Top Onshape Drawing of Hangripper design*

The Hangripper part can be fitted over a dry erase board marker, and helps children find the correct hand positioning to write with. The part is molded on the outside to fit a hand in the correct position, with a hole on the inside that is large enough to fit on a marker.

Stencil 1 is one stencil that children can use to practice their handwriting. It provides a reference for them to trace their letters, and can be placed onto the whiteboard. The words on the stencil are "*Go Gators!*"

Stencil 2 is another stencil that children can use to practice their handwriting. This stencil features, "*there*," a word that children sometimes have trouble spelling and is a common word on early spelling tests.

Onshape Link:

https://cad.onshape.com/documents/9dbaae29dfd16838725d20e0/w/f5d6fe5647ac58085a9fc9d3/e/452324736e27d03105f76218?renderMode=0&uiState=643ea24acc1264305e471b46

Project Flowchart

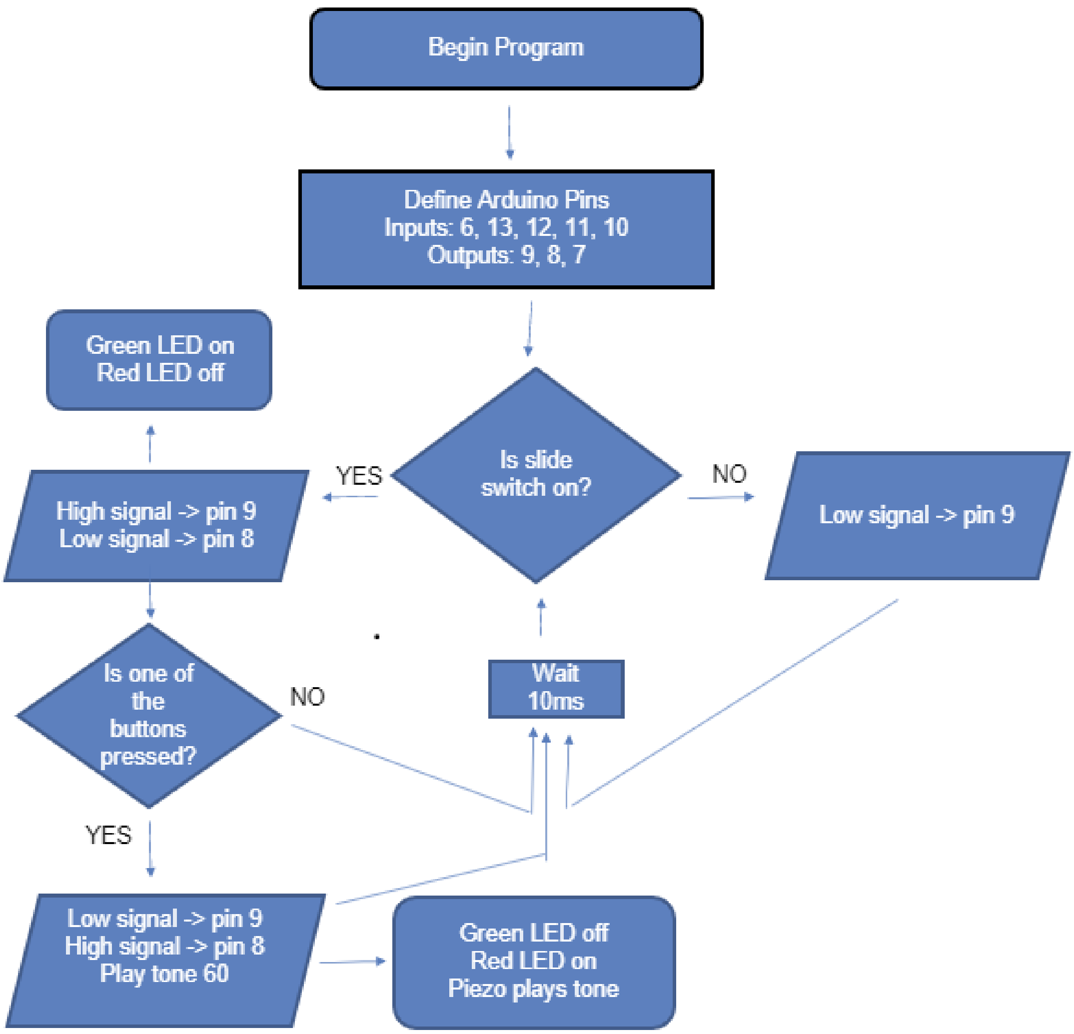

Figure 20: *C++ Code Flowchart made in PowerPoint*

The flowchart shown in *Figure 9* details the C++ code in the Commented Code section that controls the Arduino. First, the Arduino pins 6, 13, 12, 11, and 10 are assigned as inputs (for the buttons) and the pins 9, 8, and 7 are assigned as outputs (for the LEDs and piezo). Then, the program determines if the slide switch is on. If "yes", the green LED turns on. If no, the LEDs remain off, and the program waits 10ms then asks if the slide switch is pressed again. If the slide switch is pressed, the program then determines if one of the 4 buttons is pressed. If “no”, the program waits 10ms, then asks if the slide switch is on again. If yes, the green LED turns on, the red LED turns off, and the Piezo plays a tone to let the user know a button has been pressed. The program waits 10ms, then asks if the slide switch is on again.

Commented Code

```
// C++ code
// set ups the pins
void setup()
{
  pinMode(6, INPUT);
  pinMode(9, OUTPUT);
  pinMode(8, OUTPUT);
  pinMode(13, INPUT);
  pinMode(7, OUTPUT);
  pinMode(12, INPUT);
  pinMode(11, INPUT);
  pinMode(10, INPUT);
}

void loop()
{
  // the if statement that depends on the slide switch
  if (digitalRead(6) == HIGH) {
    digitalWrite(9, HIGH); // green light on
    digitalWrite(8, LOW); // red light off
    // four if statements, one for each button
    if (digitalRead(13) == HIGH) {
      digitalWrite(9, LOW); // green light off
      digitalWrite(8, HIGH); // red light on
      tone(7, 420, 200); // play tone 80 (C5 = 523 Hz)
```

```
    }
    if (digitalRead(12) == HIGH) {
      digitalWrite(9, LOW); // green light off
      digitalWrite(8, HIGH); // red light on
      tone(7, 420, 200); // play tone 60 (C5 = 523 Hz)
    }
    if (digitalRead(11) == HIGH) {
      digitalWrite(9, LOW); // green light off
      digitalWrite(8, HIGH); // red light on
      tone(7, 420, 200); // play tone 60 (C5 = 523 Hz)
    }
    if (digitalRead(10) == HIGH) {
      digitalWrite(9, LOW); // green light off
      digitalWrite(8, HIGH); // red light on
      tone(7, 420, 200); // play tone 60 (C5 = 523 Hz)
    }
  } else {
    digitalWrite(9, LOW); // green light off (red light also off)
  }
  delay(10); // Delay a little bit to improve simulation performance
}
```

Design Limitations

Overall, our final functional prototype design came together well. Before we built it, we tested how the buttons and the whiteboard would work together, and the buttons were able to support the whiteboard without being pushed down, so we knew this part of the design would work. We built the 3D printed parts and the Arduino parts separately from one another, so each process didn't interfere with the other. The first time the Handgripper was printed, the dimensions were larger than expected, so it was resized and reprinted. The functionality of the prototype is similar to that of a final product, since the design is portable. A battery pack was installed to power the Arduino parts, which means that they don't have to be connected to a computer to be powered. Once the code is downloaded on the Arduino, the prototype is fully functional and portable.

Our final prototype design has some design limitations, including its durability. The box that holds the Arduino parts is in a cardboard box, which is not very durable for a children's toy. Children may spill food or water on the cardboard, which may cause the toy to break, especially with the electronics inside. Additionally, the parts of the product are not attached in the strongest way possible. To prevent the product from breaking, a final design should feature waterproof parts and screws that hold the product together. This would better fit the human centered design of the product, since children can be destructive and a longer-lasting product would help them learn more and save their parents money.

Additionally, the product could include springs to change the pressure required for the buttons to be pressed. Additional research could be done to find the optimal pressure when handwriting, and fit springs in the product to mimic this pressure. The springs would make the whiteboard harder to push down, making the buttons more difficult to press. Finding the optimal pressure would improve the design of this product and make it more suited for the user’s needs.

References

Koziatek, S. M., & Powell, N. J. (2003). Pencil Grips, legibility, and speed of fourth-graders' writing in cursive. *The American Journal of Occupational Therapy*, *57*(3), 284–288. https://doi.org/10.5014/ajot.57.3.284

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Appendix

Tinkercad Link:

https://www.tinkercad.com/things/hgOsF4c4Khx?sharecode=q17n50yGigoTM2wJ49cDJVNw4_L6eTy7Ii9rz1IiYYY

Onshape Link:

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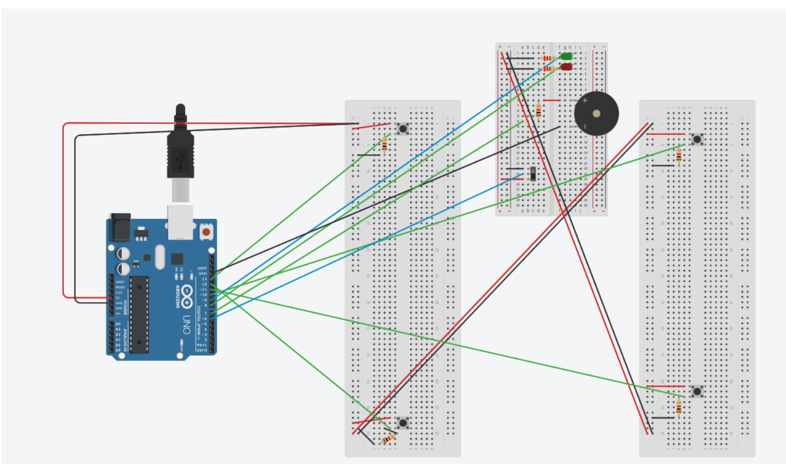
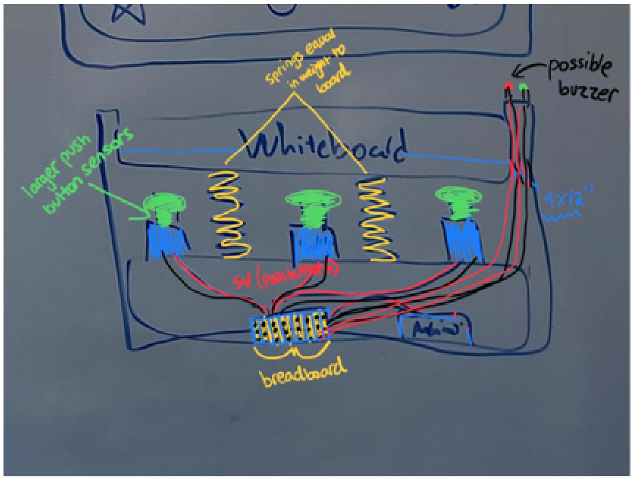


Initial Sketches:



Team Charter Link:

https://docs.google.com/document/d/15Aii5D2OnDnret2R5quAetgLnwonfgFZ3VHWpvcJN2E/edit?usp=sharing

Team 3 Picture: