# Project Deliverable E - Project Schedule and Cost

**GNG 1103 Group C03**
Benoit Tremblay (300236751)
Rebeca Poulin (300236741)
Jess Beardshaw (300227707)
Isabelle Barrette (300228564)
Sarah Alkadri (300245117)

**University of Ottawa**
**February 20th, 2022**

**Wrike Link:**
**https://www.wrike.com/workspace.htm?acc=4975842&wr=20#path=folder&id=824968763&c=list&vid=64521612&a=4975842&t=830081712&so=5&bso=10&sd=0&f=&st=nt-1**

# Introduction

As design day is approaching, it is critical to plan our prototypes accordingly. Our team is committed to designing the best product possible that satisfies the clients' needs. To do this, our team needs to plan each design stage concerning our individual schedules. As our team is preparing to begin the first prototyping stage, communication between team members is critical.

This deliverable discusses the importance of budgeting the cost of our materials and researching effective products according to our final conceptual design discussed in the previous deliverable. We have compared different products with respect to the cost, time constraints, and projected usability to determine how we should proceed. Other concerns discussed are technical and resourceful risks surrounding circumstances not under our control, such as team member changes and receiving fault products.

Discussing all the risks before beginning the next design process will prepare us for all unfortunate scenarios that could set us back, preventing us from producing the best design possible. Our team is committed to the quality of the final solution, displaying the commitment we have put into the project.

# 1. Design Drawing

## 1.1 Camera End Effector

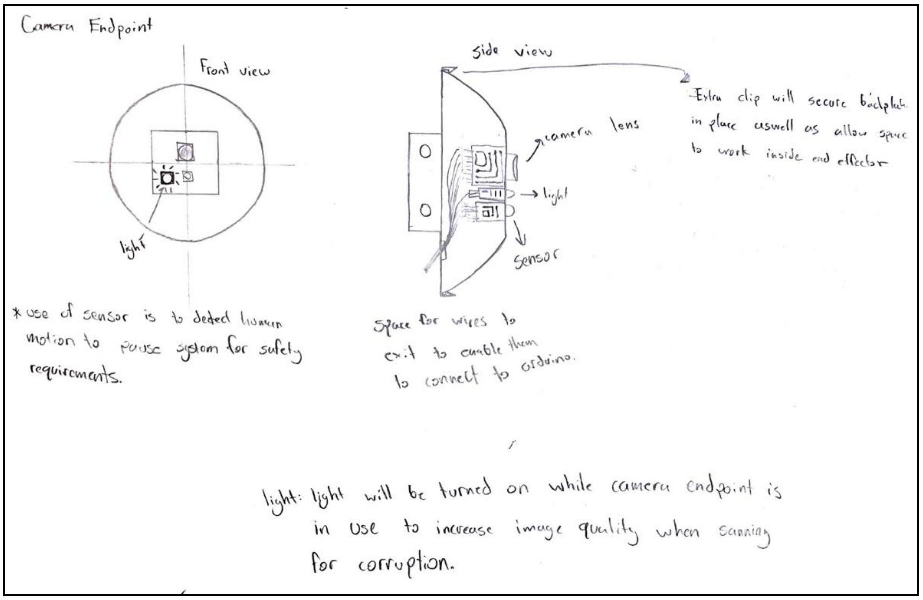


*Figure 1. Camera end effector front and side views*

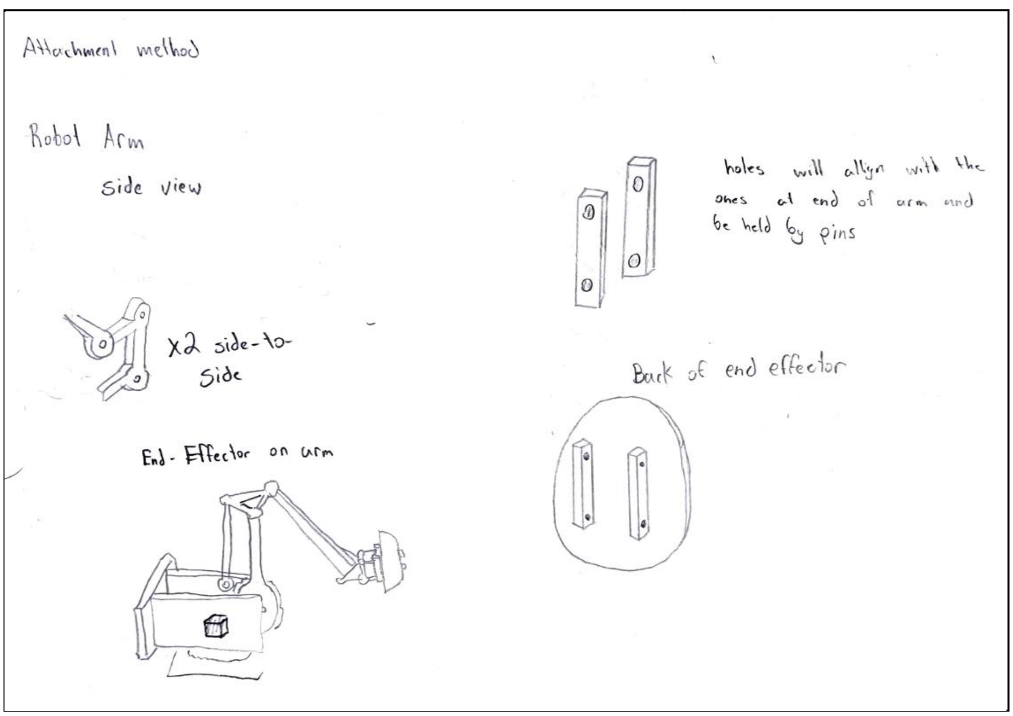


*Figure 2. Camera end effector attachment method to robot arm*

## 1.2 User Interface

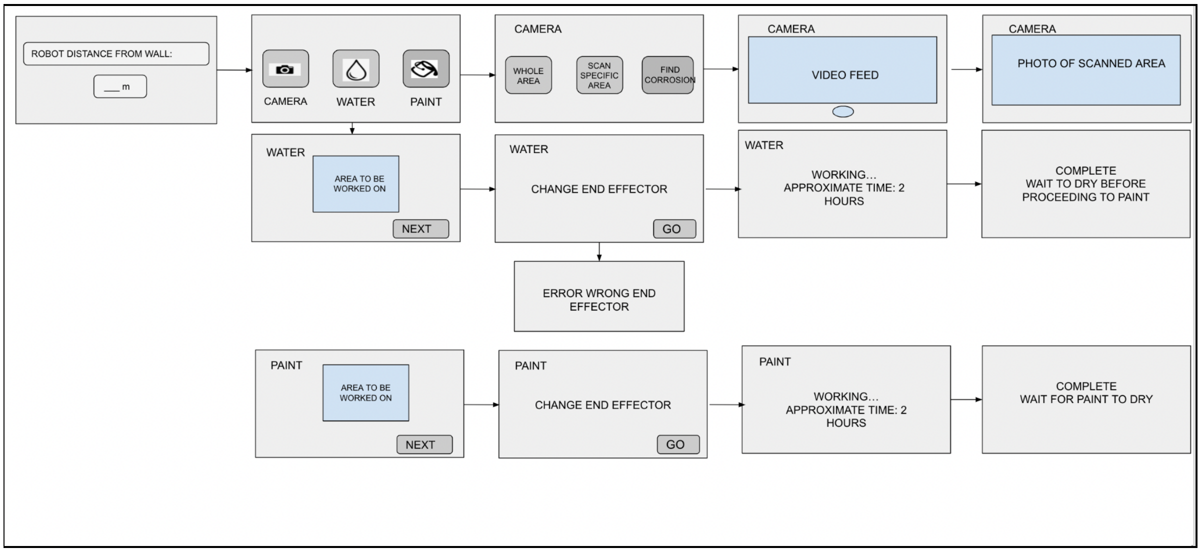


*Figure 3. Simple user interface screen*

## 1.3 Water Gun End Effector

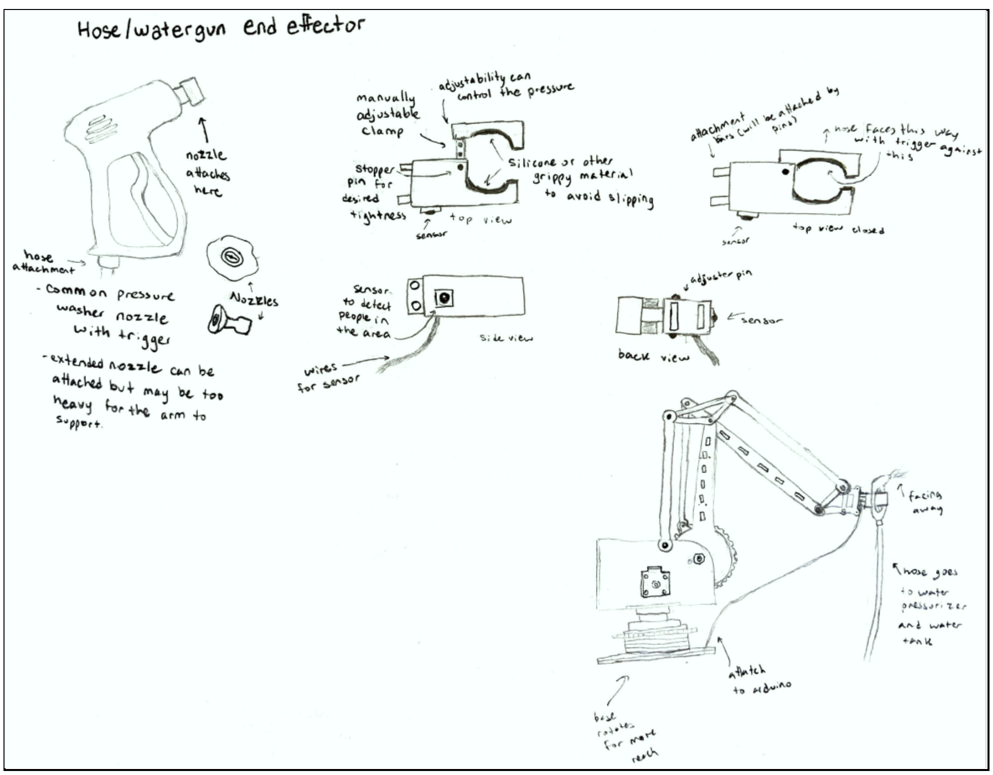


*Figure 4. Water gun end effector with adjustable clamp*

## 1.4 Paint End Effector

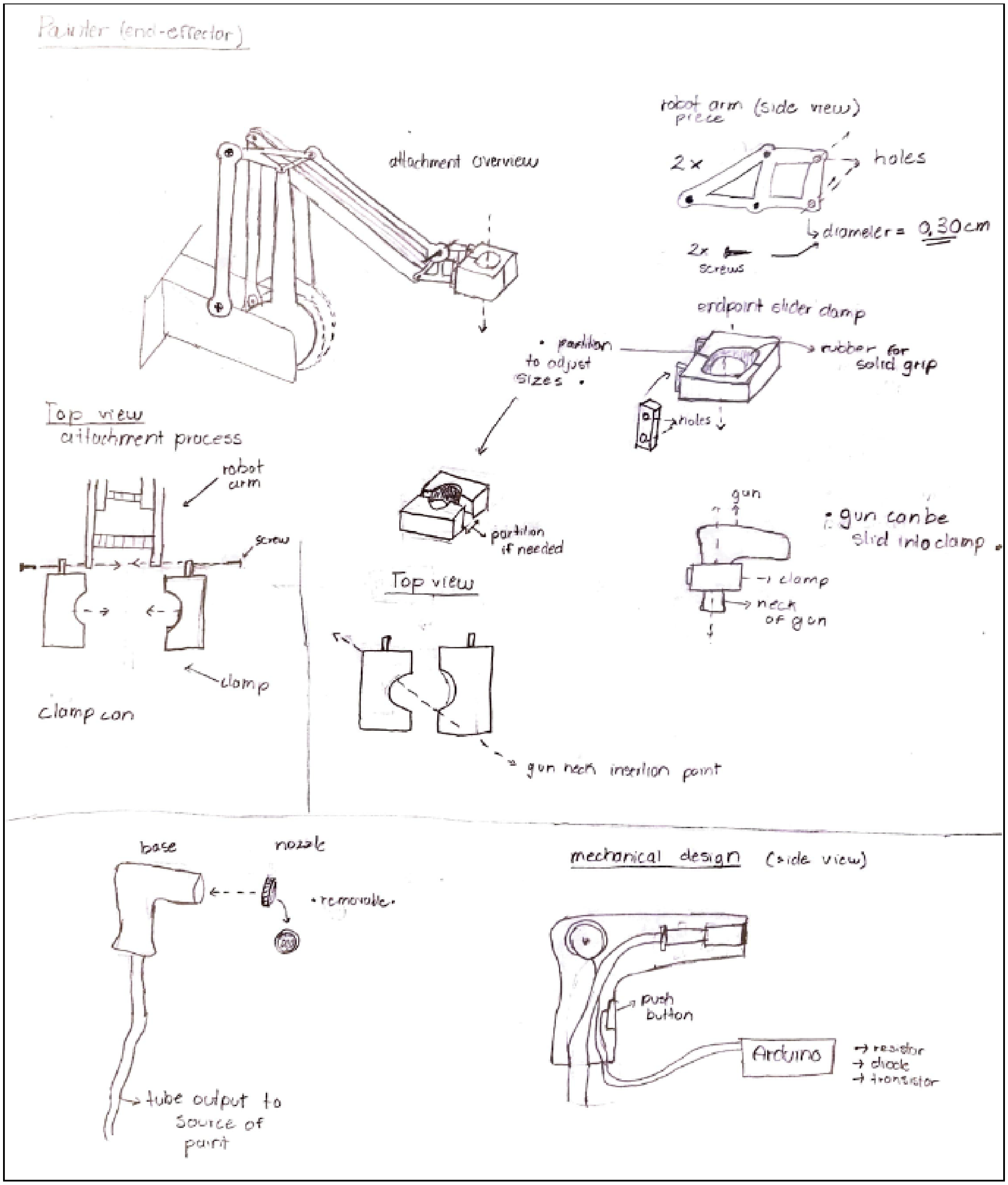


*Figure 4. Paint end effector with adjustable clamp and paint tank*

## 2. Bill of Materials

| Item Name and Link | Quantity | Cost ($) | Justification |
|---|---|---|---|
| Camera<br>Arducam with adapter board | 1 | 23.68 | The camera chosen needs to be compatible with Arduino software in order to access the data (live video feed) and send it to other devices. |
| PIR motion sensors<br>PIR motion sensors | 1 | 10.59 | These sensors will be added to different end-effectors to ensure safety while operation. (soldered) |
| Adjustable clamp<br>Stainless steel adjustable | 1 | 8.99 | This clamp is necessary to provide support to both the water gun and paint gun effectors. It can remain attached to the thor arm for both processes since it is compatible with different sizes. |
| 3D printing materials | | 0.00 | Since most of our end effector components will be 3D printed, we will be using the machines and materials provided in the Maker Lab. |
| Arduino kit and wires | 1 | 0.00 (Free at Maker Lab) | The Arduino will be useful for the spray guns in order to connect the sensors and triggers to a specific output in our software. This kit includes a breadboard and some resistors in order |
| Soldering kit | 1 | 0.00 (Free at Maker Lab) | Used to mend our wires together and solder them to our things like our camera and sensors to ensure that they will not be easy to break off or to fall apart simply by moving. |
| Total product cost (without taxes or shipping) | | 43.26 | |
| Total product cost(including taxes and shipping) | | 61.11 | |

*Table 1. Bill of materials with total product cost estimate*

## 3. List of Equipment (Prototype I)

This prototype will include a mix of analytical and physical components to present the general function that the end-effectors will have.

| Item Name | Description | Type | Prototype # | Source |
|---|---|---|---|---|
| CAD software (Onshape) | This will be used to create a computer-aided design of different end effectors. | Analytical (Software) | 1 | https://www.onshape.com/en/ |
| Arduino Studio (Tinkercad) | To test circuits. | Temporary software | 2 | https://www.tinkercad.com |
| 3D printer | To 3D print all end effectors and attachment pieces. | Equipment. | 3 | MarkerSpace |
| Coding Software(CLion, CodeBlocks) | To implement code. | Software | 4 | Personal device |

*Table 2. List of equipment for prototype development*

# 4. Project Risks

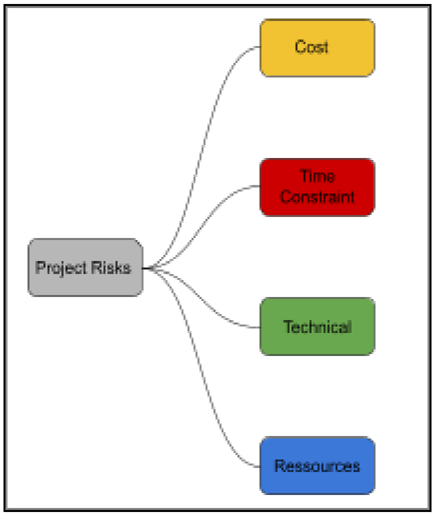


*Figure 5. Project risks diagram*

Four main categories of risks that can affect our project are the cost, time constraints, technical aspects, and resources.
With a low project budget comes a higher risk for the parts ordered. As a group, we must be cautious about spending our budget. Arduino parts are costly, so there are concerns surrounding the majority of our budget supplying these parts. To expand our budget for other project sections, we must conduct extensive research to purchase the best products at the most affordable cost. We mustn't need to repurchase parts from either inadequate functionality or shipment delays. Reading reviews and comparing extensive products will ensure that the parts we receive will work on the first trial and adequately complete the proposed task. For example – the camera module. Since Arduino parts are difficult to find, one of the only cameras modules available within a timely matter are expensive considering our budget. If the product is faulty, that could create a significant risk on our project timeline. To avoid this, we benchmark different camera modules, read reviews, and consider the risks with each product to determine which camera is the best choice.

The second risk category is time constraints. We need to plan and set dates to complete everything correctly within the time limit with less room for mistakes and unexpected events. We must pick our materials appropriately as certain websites and materials risk taking too long to arrive, which means we would not have a finished product before design day. As previously mentioned, to prevent this from happening, as previously mentioned, we will have to research many different products concerning the cost constraints.

Technical problems are most likely to be the most common problem we run into along the way. They can range from fixing small coding errors before design day to more drastic technical issues, such as the robot arm not working or data corruption. The robotic arm breaking is out of our control, but other technical aspects can be controlled to reduce risks. For example, simple preventative measures like saving the code and having a backup of the code can prevent unfortunate code corruption. As a team, we need to prepare for these risks to reduce their chances of occurring or reducing their impact.

The last risk category is resources. This consists of material resources to human resources. For example, we could receive faulty materials. We have no control over these scenarios, nor can we do anything to prevent them. It is essential to have backup plans in an unfortunate instance. Resource risks could be losing a teammate due to the increased workload of other classes. The workload has begun to grow as we are approaching the end of the semester. To continue to expedite our progression, we need to set specific game plans and distribute tasks appropriately. A plan will allow the other teammates to assist someone if they fall behind from heavy course loads.

In summary, these categories of risks largely revolve around the materials we need to get, so it is crucial to prepare correctly and get the proper material that will have the least risk possible on design day.

# 5. Prototyping Test Plan

## 5.1 Objectives

During prototype testing, we want to ensure we cover all the planned functional criteria during test simulations. We will plan appropriately before testing with the robot arm considering all possible outcomes and what we can do afterwards accordingly. After testing, we will get feedback to improve our design in the appropriate areas for the next prototype.

## 5.2 Test Plan

| Test # | Objective | Description and Test Method | Expected Result/Stopping Criteria | Test Duration and Date |
|---|---|---|---|---|
| **1** | Mathematical code concept | To have a logical and functional mathematical approach of the functionality and movement of the arm. | Applicable to our code concept further on. | 1 or 2 days Reading week |
| **2** | Analysis of materials | Lots of materials are used in this design, such as different 3D printable materials, cameras, sensors and Arduino components such as the wires and diodes. These will have to be tested for their effectiveness and researched extensively, | Be approved by the TA/PM and purchase materials ASAP. | 2 or 3 days Reading week |
| **3** | Engineering drawing of end-effectors | Detailed engineering drawing on paper of our design and the orthographic projections to show all sides and important components | Functional drawing with all technical components provided. | 2 days Reading week |
| **4** | Basic code for arm movement | Once the mathematical concept is achieved and the inverse kinematics equation is understood, the equations can be translated to code for future testing | Test on the robot model with school Arduino, capable of performing defined tasks | 2 or 3 days While the drawings are being made |
| **5** | 3D modelling on Onshape or Solidworks | 3D drawing or model on a 3D modelling site to determine our “final” design with more precision and to better our understanding of our design and ensure our understanding of it. | Is complete and able to be 3D printed successfully | 2 days As soon as engineering drawing is done |
| **6** | Camera and corrosion detection code | If all goes well, the corrosion code we have found may be accessible to us and may be able to be translated, and that translation to a language that we understand would be this step. | Granted permission of the detection code, successfully translated from Python to C. | 4 days While drawings and models are being |

| | | | | |
|---|---|---|---|---|
| | | | Functional with robot testing. | made |
| **7** | Create user interface and test with what we have | Attempt different user inputs and see how these are processed and outputted compared to the expected outcome. | The code successfully directs the user to each desired input screen | 1 day Before the first session with robot |
| **8** | Test materials with what we currently have | Materials have been analyzed, and the best ones are chosen and must be put to the test to see if they are good for our product. They will be tested in durability and compatibility with the arm and the code. | Test Arduino parts with arm and code. The camera can fit in our end effector piece. | 2 days First session with robot arm |
| **9** | Test arm movement code on arm | The algorithm and code for the inverse kinematics movement of the arm should be completed, and it will be tested on the arm as soon as the opportunity presents itself so that any issues are discovered and it can be modified accordingly quickly | The robot successfully performs the inputted function | 1 day First session with robot arm |
| **10** | Paper or cardboard quick prototype | Quickly make a 2D and/or 3D tangible model of end-effectors as a size comparison to the actual robot and objects that will be used with them to be sure of our dimensions | Production is successful | > 1 day First session with robot arm |
| **11** | Retouch engineering drawing and 3D modeling of end-effectors | Any miscalculations or wrong dimensions are discovered through the previous tests and now the drawings and models can be readjusted to accommodate our new discoveries | Successfully implement changes for second improved prototype designs. | 1 day After first session with robot |
| **12** | Second Paper or cardboard prototype | Another comparison with a quick and easy prototype and the arm with the new calculations and retouched dimensions to see if it is correct, if not repeat steps 5 and 6 until the prototype works | Successfully implement changes for second improved prototype designs. | 1 to 5 days For next session with robot arm |
| **13** | 3D printed model of what we have designed so far | The 3D model is adjusted and can now have the pieces printed and assembled for testing on the robot. If the previous analysis and prototyping were effective, this should be done once or twice to minimize the number of materials used and the overall cost | Successful printing process according to the measurements of the designs. | 1 or 2 days Second session with robot arm |

| | | | | |
|---|---|---|---|---|
| **14** | Test code and user interface with newly 3D printed pieces and arm | Pieces are printed and the end-effectors are assembled, everything can be wired and plugged into the Arduino in its respective place, and the code can be tested on the arm and the user interface. If any errors occur, the code and user interface will have to be modified accordingly | Consistent with prototype testing. Five consecutive test trials with no errors. | 1 or 2 days Once robot and 3D printer is accessible |
| **15** | Make sure attachments and necessary scenarios are compatible with end-effectors and code | The final test will entail putting all pieces together for one last test, running multiple scenarios with the user interface, arm and all the end effectors to simulate the users' experience and ensure that it is possible, simple and easy to understand for the high school students who will most likely be running the interface and interchanging the end effectors | Consistent prototype testing. Five consecutive test trials with no errors. | 3 days Second last step, leave time to fix mistakes and get feedback |
| **16** | Adjust all necessary things and create the final versions of end-effectors, code and user interface | Once the group and client have settled on a final version and has been through the tests previously mentioned, it is time to bring it to life and create the final version of everything necessary, test it on the robot arm and if all goes well, there will no longer be any need for prototyping | Either run out of time or be satisfied with the final product before design day | 1 to 3 days Last step, must be before design day |

*Table 3. Prototype testing plan with test method and date*

# Conclusion

It is critical to plan our prototypes accordingly as design day is quickly approaching. Our team is dedicated to producing the best product possible, covering all our clients' needs. Planning responsibly according to delays, changes, and unexpected, unforeseen circumstances is essential. After the client meeting, the team took the feedback and prepared our bill of materials, prototype test plan, and final design drawings. The next stage of the design process will be creating our first prototype, and we are excited to get started.