

GNG2101 Deliverable E.2

Prototype 2

Introduction to Product Development and Management

GNG 2101

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Group Z13

François-Nasr Kharrat 300315604

Nusaibah Rashid 300334452

Justin Saikali 300072671

Jieying Yang 300103978

Jessica Young Spice 300160284

Abstract

In this deliverable, we will focus on the development of the second prototype. We have updated our detailed design by summarizing the latest client feedback. It will be used to test key features and specifications and compare them to our target specifications. This will allow us to validate some of our assumptions and help us have a better understanding of how we will achieve our ultimate goal of developing our product. Overall, the prototype build was a success, as it matched our CAD model very well, and met all of our important target specifications.

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Introduction

After gathering feedback from the client, we have made some minor modifications to our current design based on these suggestions. We defined the most critical product assumptions that we had not yet tested and built a second prototype, documenting its test plan and interpreting the results. The second prototype will be a more refined version of the first prototype and will be a bridge between the first and final prototype.

The goal of this deliverable is to construct and test our second prototype. We will evaluate the second prototype for restrictions, physical attributes, target specifications, and functionality in order to conduct a full prototype analysis and inspection. We will include photographs of the physical prototype, as well as data collected from the prototype testing and analysis of the test results.

Client Feedback

We have shown our client both the detailed design we used to build our first prototype and the updated detailed design we plan on using for our second prototype. The client liked our design overall and thinks it will work except for a few concerns. The first was that there is a slight bump at the edge of Nikki's tray on the bottom side and hence the client wasn't sure if the clamp subsystem would secure the cup holder properly. The second concern was that Nikki's straw for drinking might not reach her and she has to use that straw because it is food safe. Furthermore, the client mentioned that it would be nice to have a purple cup holder because purple is Nikki's favorite color and a purple design would appeal to her. His priority is function before aesthetics though. We will take the client's concerns and remarks into consideration for our third prototype.

Critical Assumptions

Despite already having conducted testing, we still have product assumptions that have not yet been tested. These cannot be tested with our current prototype because it is still not the final design. We have not yet seen the wheelchair tray in person during the client meeting, so it would not provide us with a functional analysis. These tests are essential as well and will be carried out over the next two weeks.

1. Compatibility of the cup holder. The clamp part of the cup holder should match the tray of the customer's wheelchair, and the size of the cup holder could be matched to the size of the client's cup. This assumption ensures that the cup holder system can be easily attached to the wheelchair with significant modifications or adjustments.
2. Stability of the cup holder. While mounted to the wheelchair, the cup holder should be solid and secure, even while the wheelchair is moving or crossing an uneven surface. This test will be performed after the rubber mat has been installed. This assumption assures that the liquid in the cup will not tip over or spill.
3. Accessibility of the cup holder. The cup holder should be set in such a way that it is easily accessible to wheelchair users (the length of the current straw used by the client still applies), and the device will not hit the client's arm or endanger her safety. This assumption considers the user's convenience as well as the safety of the users.
4. The adaptability of clamps and the cup holder. Since the cup holder size of our first prototype was not as big as expected, we needed to re-print it after changing the dimension of the cup holder. So the dimensions of the clamp and cup holder joints still need to be tested to see if they match.

Potential Future Prototypes

Our project is progressing very well, and we are achieving our objectives at the right pace. Looking ahead, we will develop a series of future prototypes to enhance the quality of our final product and refine certain aspects of our design.

Firstly, we plan to 3D print multiple cup holders, each with a different shape. The aim is to find the optimal design that can accommodate a wide variety of cups and mugs while specifically providing a snug fit for the cup our users currently have. Here is one of the potential designs:

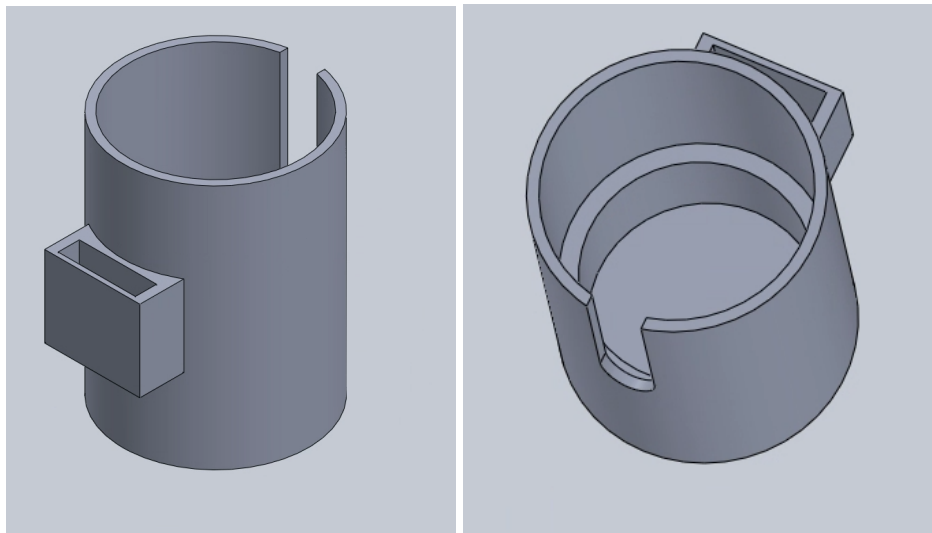


Figure 1. Potential Cup Holder Design

Additionally, we will focus on creating prototypes of the subparts that are crucial to the ideal functionality of our system. The two primary components we intend to test are the rubber grip and the magnet system. The magnetic tape will be utilized to secure the cup holder in place. One part will be applied to the aluminum surface, while the other will be positioned beneath the cup holder. When connected, they will attract each other, ensuring stability. The rubber pad will be placed under the upper arm of the clamping system, thereby adding extra friction when clamped to the tray.



Figure 2. Magnet Tape

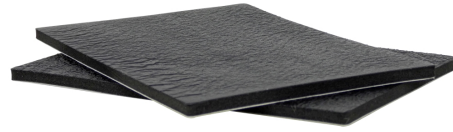


Figure 3. Rubber Pads

These future prototypes will help validate some of our critical assumptions. The cup holder will be tested to ensure compatibility with a wide range of common cups and mugs. The magnet tape prototype will enable us to verify its effectiveness in strengthening the connection between the cup holder and the clamp. Similarly, we will conduct testing on the rubber grip to determine its ability to enhance friction in our clamping system.

Detailed Design for Prototype 2

Prototype 1 was the 3D printed cup holder subsystem and was considered a medium fidelity physical prototype. With that prototype being a success, it was time to move onto the prototype for the two other subsystems of our product: the thumb screw, and the clamp. This prototype is also a physical one, but can be considered higher fidelity as it resembles our final product's subsystems very closely. It consists of an aluminum flat bar, an aluminum c-channel, a bolt, 3 small screws, a thumb screw grip, and a swivel head tip. As seen in the figures below, the physical prototype we manufactured resembles very closely the detailed CAD model in solidworks. A few machining processes were omitted from the prototype as they were not important for the sake of testing the prototype. These include chamfers at the end of the flat bar, a rounded end on the c-channel, and shortening of the screws.

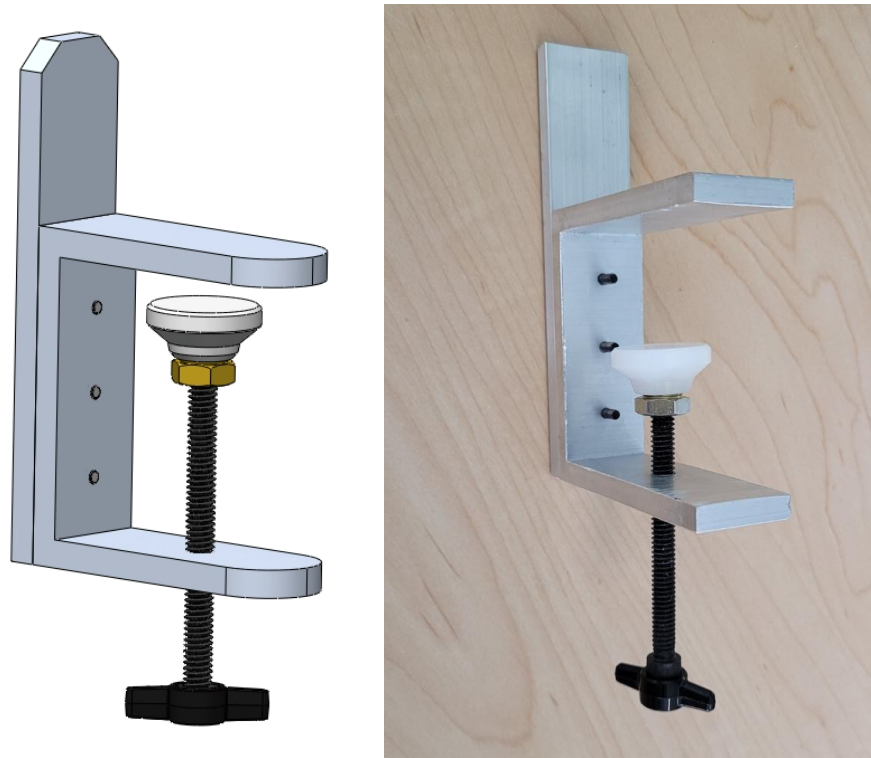


Figure 4. Solidworks Design vs. Physical Prototype

The purpose of this prototype is to test many aspects of the system to see if it meets our target specifications. While the CAD model can give us good indications in terms of size and functionality, it is not until a physical prototype is manufactured that we can know for sure. It is also worth noting that the prototype was manufactured by our team. Therefore, certain limitations in skill can end up affecting the prototype more than if a professional manufactured it, making the difference between the CAD model and the physical prototype larger. That is why it is important to have physical prototypes instead of simulated or virtual ones, as uncertainties in manufacturing can deviate our prototype away from the design. Thankfully, the manufacturing was a success and the physical prototype turned out as expected and very close to our CAD.



Figure 5. Physical Prototype in Use

The prototype functions as follows: turn the thumb screw down to enable a larger opening for the clamp, then slide the clamp onto a table or tray, then turn the thumb screw up until the swivel tip touches the table and tighten the thumb screw until secure. That is the simple function of this prototype. In future prototypes, we will integrate the cup holder and magnet, as well as the rubber pads for grip. This will not change the functionality of the prototype, but simply enhance the prototype's function and take us one step closer to the final product.

Prototype Testing

Testing our current prototype, figure 6, we have found that it meets most of our target specifications and that it meets all of our most important specifications.



Figure 6. Prototype 2

Table 1. Target Specifications

Target Specification	Desired Value	Actual Value	Target met?
Material	Hydrophobic	Hydrophobic	Yes
Ease of use	N/A	Easy to use	Yes
Height	5-10 cm	12.2 cm	No
Minimum opening	2.55cm	4.5 cm	Yes
Cost	<\$50	\$12.12	Yes
Time to assemble	<15 seconds	=15 seconds	Yes
Time to complete	8 hrs	4 hrs	Yes

The current prototype meets all target specifications except for the total height. This value is still acceptable, as the additional height has been added to the upper portion of the clamp which the cup holder slots onto. This additional height will allow for less risk of the

3D printed portion of the cup holder from accidentally coming off of the clamp. The most important values that we wanted to ensure were met for this prototype was the clamp opening dimension and the time to assemble. The prototype met both of these specifications. Another important prototype specification was the cost. We needed to ensure that the total price was less than \$50. The prototype cost \$12.12 to make, so it met the cost specification quite well.

Conclusion

Based on the feedback we got on client meeting 3, we confirmed that we are going in the right direction in terms of prototyping. We successfully finished assembling our second prototype for this deliverable. Our second prototype's assembly is the most crucial because it is the critical component that decides whether the entire apparatus is stable. In general, the second prototype we designed is easy to use, quick to assemble, cheap, and reliable. In addition, we have tested our target specification and also made our critical assumptions. We have set up a strong base for continuing to work on our design so that it is ready and fully functional for the final prototype.