

Project Deliverable H

Prototype III and Customer Feedback

Jack Lloyd, Gerika Gauthier, Cheri Reteracion, Ryan Langley, Brynn Dowson, Abdul Butt

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1. Introduction

The AOPFN and Neya Wabu Guardian program has tasked our team to design a facility to serve both as an office space and as a space for the community. From the information obtained after the initial client meeting, our team created the following problem statement:

“The AOPFN and Neya Waban Guardian Program need a multi-use indoor and outdoor facility designed for community projects, office space, and harvesting and storing plants for medicinal use, that is reflective of their cultural values. “

From this problem statement, we developed a design criteria that can be used to measure our design’s ability to solve the client’s problem. After much research, brainstorming, and meetings, the first conceptual design was developed and presented to the second client meeting.

Following our second prototype, we developed a list of improvements to implement when creating our third prototype. This document will present updated prototypes and an analysis of their capabilities based on the criteria we created in previous deliverables. Additionally, this deliverable will explore feedback given by users and the client during the third client meeting, design modifications, and any task updates.

2. Client Feedback

Following our third client meeting the clients provided more information on the necessary details to be added to the design.

- Location: 473 Kokomis Inamo Pikwakanagan, ON K0J 1X0. Can only view aerial on google maps.
- Lot dimensions: Not available at this time.
- Is there a flooding concern: No
- Wheelchair Accessible: If required for new buildings for inspection.
- Freezer Space: Walk in freezer.
- How many tools in the lab: Unknown
- Dehydrator or dehumidifier: Dehydrator
- Building Heat Source: Electric furnace.
- Exterior Design: Up to the groups. Do not want it to look like an industrial building.
- What chemicals will be used: None
- How many Offices/workspaces: Smaller is better for more offices.
- TV or Projector: TV big one.

They also provided feedback where they informed us that they liked the office space, bathrooms, meeting room in the center, the covered outdoor space, and the overall design of the building. They also enjoyed our ideas to add greenery to the roofs as well as solar panels. They indicated they wanted to include a door leading towards the outdoor space.

3. Objective for our third prototype

Our team developed the second prototype including the changes we had planned based on the prototype tests 1.

Our goals for this prototype are the following:

1. To identify the problems based on the test plan in deliverable G.
2. To make the final adjustments to our design

4. Improvements based on Prototype 2

In this deliverable, we altered the digital designs we had already constructed: Rhino design, AutoCAD plan and the security camera floor plan.

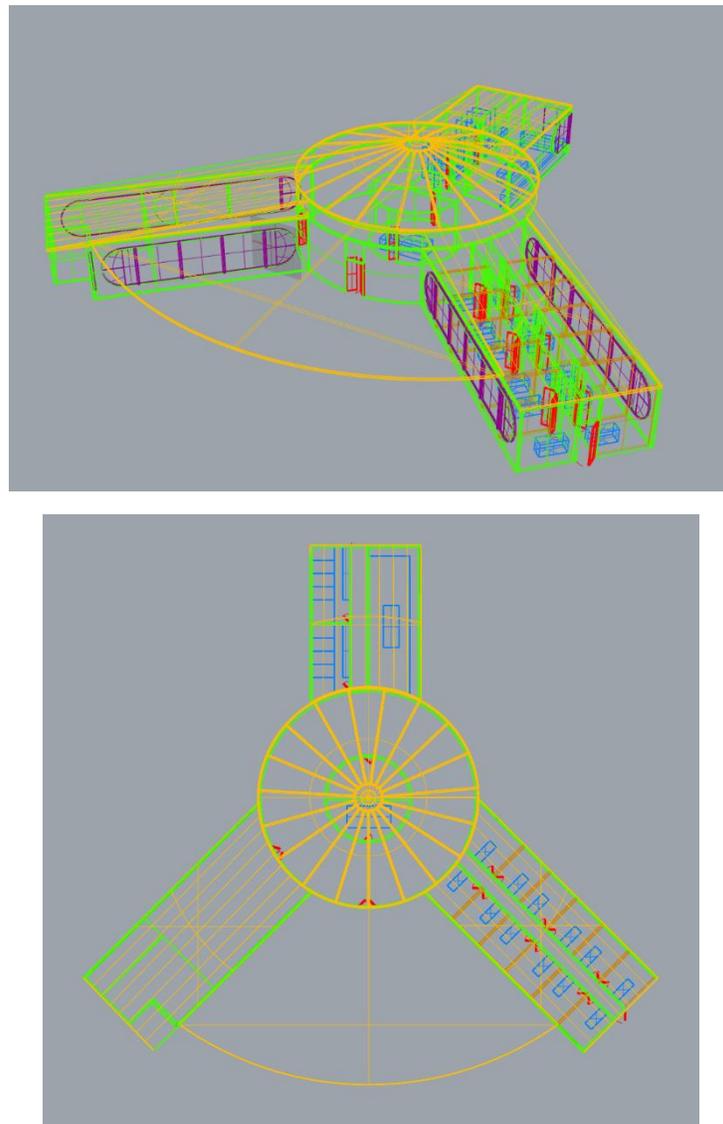


Figure 1. Improved AutoCAD design

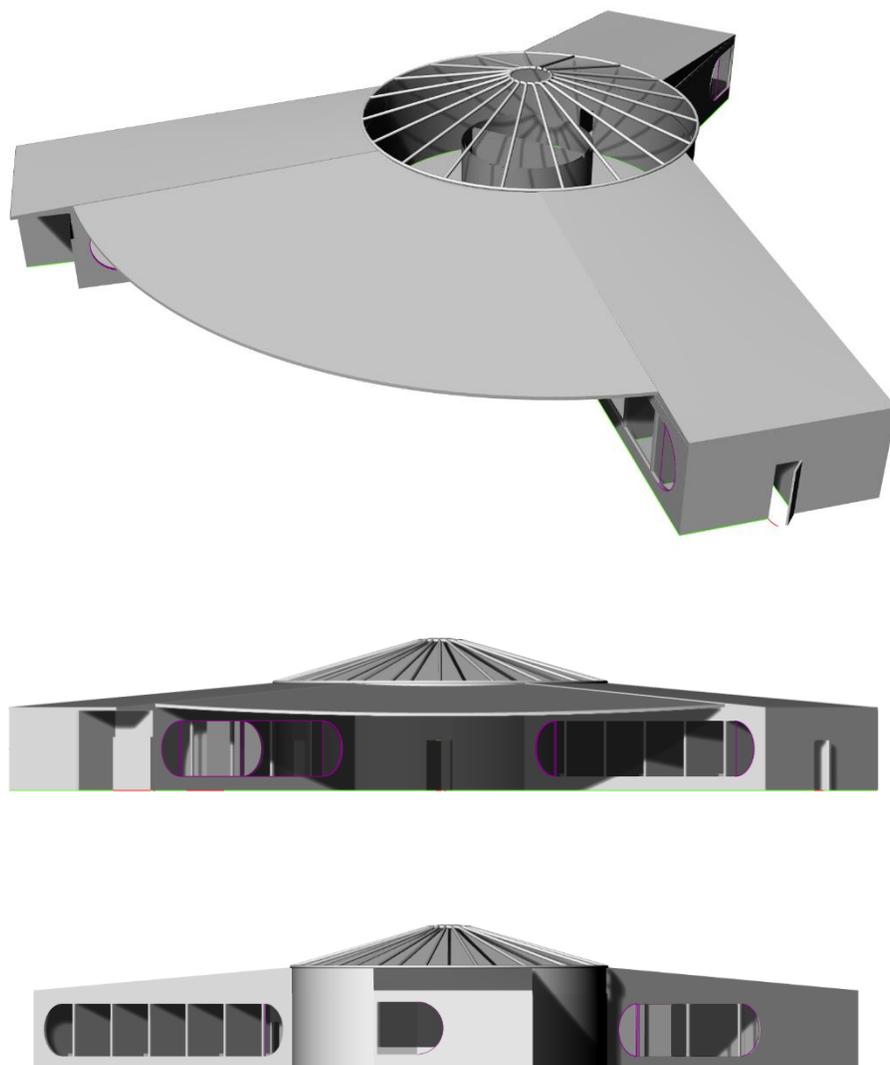


Figure 2. Improved Rhino 3D design

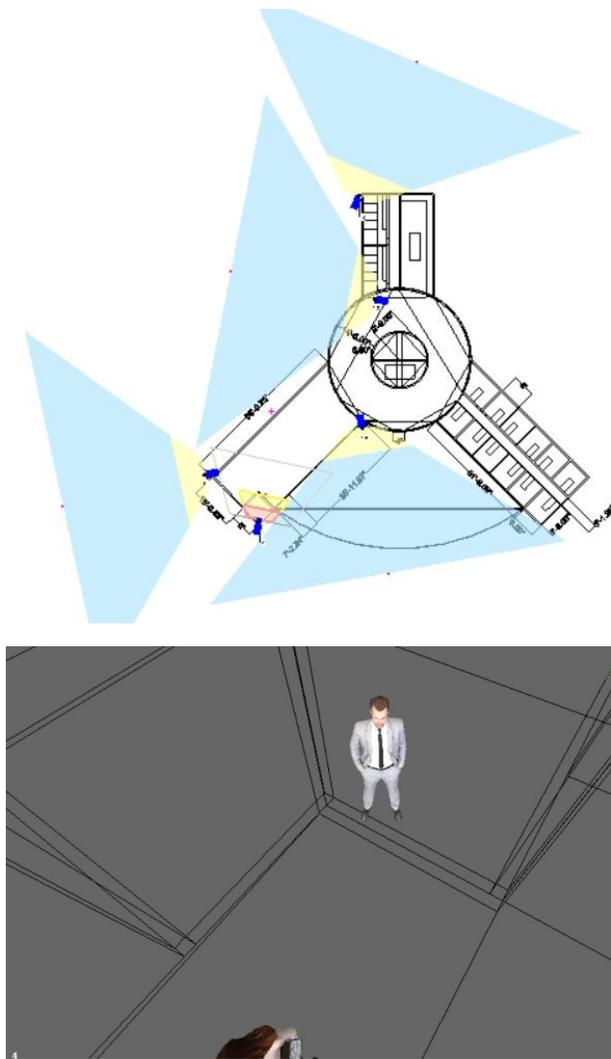


Figure 3. Improved security camera floor plan

We have thoughtfully adjusted the dimensions of our building to widen the hallways to 3 feet 1 inch wide. These hallways are located between the bathrooms and kitchenette, as well as between the various offices. This enhancement ensures that two individuals can comfortably pass through the corridors simultaneously, maintaining an adequate space between them for ease of movement. We also added a section in the lab space for a walk-in freezer and storage, which was requested by the client during the third client meeting. The practical implementations of this design can be clearly seen in our AutoCAD layout, as showcased in Figure 1.

In deliverable G, users linked the building's appearance to a UFO. In response to this feedback, we have implemented significant changes to the roof design. We've replaced the dome-shaped roof at the center with a more distinct, pointed tipi-like structure. This alteration not only addresses the aesthetic concerns but also enhances the building's cultural relevance. Additionally, we've focused on amplifying the internal lighting, which contributes to the building's external aesthetic appeal. Finally, our team decided to add more slope to the roof of each arm for easier removal of snow and rain. The updated model of our building, showcasing these modifications, is presented in Figure 2, designed using Rhino software.

Additionally, due to the relocation of the garage door to the lab space, the security camera monitoring that area had to be moved. Originally, the precise camera was attached to the roof of the outdoor space and is now simply attached to the shelter above the outside of the garage door, as shown in Figure 3.

To optimize the natural light in the area, we strategically placed our windows. This limits the amount of artificial light that needs to be generated throughout the day, and allows the sunlight to be used for both heat efficiency and natural light.

5. Choice of Materials

Materials and energy calculations were done using the BIM Energy Evaluation software developed by StruSoft. This is linked in the References section of the deliverable.

5.1. Roof

The roof is composed of 0.02 m of roof covering and 0.5 m of mineral wool 33 between 45 mm wooden studs, sandwiched between two 0.028 m slabs of wood. This leads to a total width of 0.568 m. This composition, displayed in Figure 3, has a very low U value of $0.08 \text{ W/m}^2\text{K}$. With very low heat loss to the environment, the roof is significant in maintaining the temperature within the building.

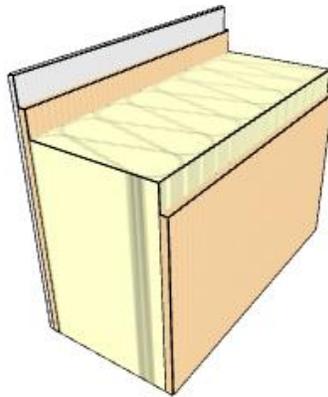


Figure 4. Cross-section of roof composition

5.2. Exterior Wall

The exterior wall is composed of 240 mm of mineral wool 33 and 45 mm wooden studs sandwiched between two slabs of wood at 0.028 m thickness. This leads to a total width of 0.296 m. This composition is displayed in Figure 4. This results in a U-value of $0.16 \text{ W/m}^2\text{K}$, which indicates low heat loss to the environment.

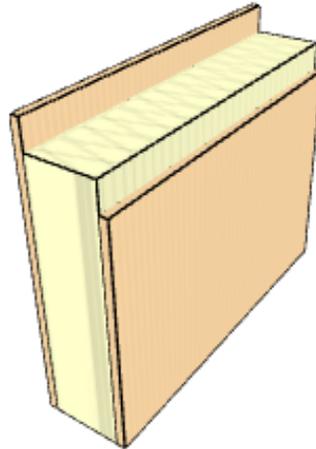


Figure 4. Cross-section of exterior wall composition

5.3 Interior Wall

The interior wall is composed of 95 mm of mineral wool 33 and 45 mm wooden studs sandwiched between two 0.013 m slabs of gypsum board, also known as drywall. This leads to a total width of 0.121 m. This composition is displayed in Figure 5. With the low U-value of 0.38 W/m²K, the interior wall is satisfactory in maintaining temperature within the building.

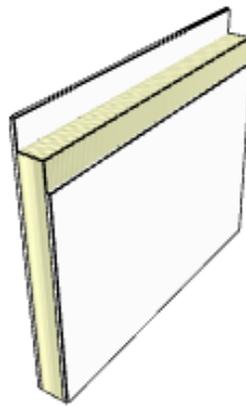


Figure 5. Cross section of interior wall composition

5.4. Windows

The windows of the building will be triple-glazed, argon-filled windows with selective coating. Three panes of glass will compose one window. Each glass pane has a gap, filled with the insulating gas, argon. Selective coating will only allow for certain portions of the solar spectrum to enter a building. Daylight will therefore be able to enter easily, while solar radiation is limited. This choice of window will overall lead to better heat retention—leading to improved energy efficiency—and noise reduction.

5.5. Interior Floor

The interior floor is composed of 0.07 m of mineral wool 33 and 45 mm wooden studs, sandwiched between two 0.028 m slabs of wood. This leads to a total width of 0.126 m. The overall composition, shown in Figure 6, has a U-value of 0.45 W/m²K.

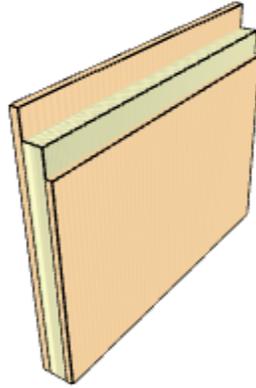


Figure 6. Cross section of interior floor composition

5.6. Foundation

Slab-on grade is the chosen foundation for this building. There were numerous benefits for this choice, such as reduced construction and excavation costs; reduced use of materials; and greater speed of construction. There were initial concerns about this choice, since slab-on grade is best fit for environments wherein the ground does not freeze. With this in mind, we have chosen to adapt the foundation with the use of drainage materials and thermal insulation, as directed in *Insulated Slab-on-Grade Foundations* from the Government of Canada, Department of Canada Mortgage and Housing Corporation.

The slab-on grade is composed of 0.15 m of drainage course aggregate, 0.24 m of cellular plastic 36, 0.12 m of concrete, and 0.022 m of wood. This results in a width of 0.532 m, and an overall U-value of 0.14 W/m²K. This composition is displayed in Figure 7.

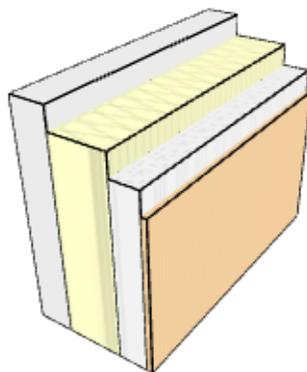


Figure 7. Cross section of slab-on grade

6. HVAC System

Our team has chosen an exhaust and supply air ventilation system. This will be connected to the water heating system, and the exhaust air heat pump.

The lowest supply air temperature, that is, the temperature range in which cool air is distributed to the building, is activated when the outdoor temperature is between 10°C - 20°C. The cool air itself is at 15 °C. The highest supply air temperature is activated when the outdoor temperature is between -20 °C to 10 °C. The supplied warm air itself will be at 20 °C.

For efficiency reasons, heat exchange will be activated alongside recovery options. With recovery, heat is the exhaust air is used to heat the incoming ventilated air in the winter. The opposite occurs in the summer, with the cool exhaust air being used to absorb the heat and humidity from the incoming warm air. This allows for energy consumption to be minimized and for the heating and cooling loads on the HVAC system to be reduced. For the same reason, air recirculation is activated in this HVAC system.

The client established that heating will be done through an electric furnace. No further changes will be therefore made regarding the heating source. In terms of cooling, we have chosen a passive cooling approach to the building due to the previous decisions made regarding heating, ventilation, and design. In short, we have chosen renewable sources—such as the sun—to provide cooling and ventilation to the building.

7. Solar Panels

To add renewable energy sources to the building and optimize energy efficiency, we added solar panels to the roof of the building. The following calculations will demonstrate how many panels can be implemented.

An average commercial solar panel 78 inches by 39 inches (6'5" by 3'3")¹ and the size of the roof space over the office is 13' wide and 51' 6" long on one side and 58' long on the other. Additionally, there needs to be 4-7 inches of space between solar panel rows and at least a 12" gap between the edge of the roof and the last row of solar panels.

Length: 7 solar panels with 12" at the end of the roof. $7 \times 6'5" + 12" = 45'9" < 51'6"$

Rows: 3 rows of solar panels with 4 inches between the rows and 12 inches on each side of the roof

$3 \times 3'3" + 2 \times 4' + 2 \times 12" = 12'5" < 13$

Total: 7 solar panels x 3 rows = 21 solar panels

Thus 21 panels can be placed on the roof of the office and lab space sections. Leaving room for green space on the top of the third "arm" of the building.

¹ [Solar Panels for Commercial Buildings \(Future Proof\) - Solar Panel Installation, Mounting, Settings, and Repair. \(solvoltaics.com\)](https://www.solvoltaics.com)

8. Summary of Emissions and Supply

Using the BIM Evaluation Software, we calculated various emissions and supplies. This information is summarized in the table below.

Section	Name	Value	Unit
Emitted Energy	Transmission	27 607	kWh/year
	Infiltration	117	kWh/year
	Ventilation	57 626	kWh/year
	Waste water	1 096	kWh/year
	Cooling	7 473	kWh/year
Supplied Energy	Solar energy through windows	4 825	kWh/year
	Process energy room	25 558	kWh/year
	Heat supply	50 079	kWh/year
	Electricity use	1 792	kWh/year
	Human heat gain	6 264	kWh/year
	Latent energy	3 132	kWh/year
	Photovoltaic power	2 275	kWh/year
Heat Supply	Heat supply (hot tap water)	868	kWh/year
	Heat supply (heating system)	32 070	kWh/year
	Heat supply (ventilation)	17 141	kWh/year
Electricity	Electricity use exhaust air fan	1 114	kWh/year
	Electricity use supply air fan	678	kWh/year
Photovoltaic Power	Electricity supply (photovoltaic)	252	kWh/year
	Occupancy energy, internal (photovoltaic)	746	kWh/year
	Exported energy (photovoltaic)	144	kWh/year
	Electricity heating, room (photovoltaic)	611	kWh/year
	Electricity heating, hot tap water (photovoltaic)	228	kWh/year
	Electricity heating, ventilation (photovoltaic)	437	kWh/year

8. Feedback

Question	User A	User B	User C	User D
Does the user feel that the building is pleasing aesthetically?	YES	YES	YES	YES
Does the user feel that there are ample windows?	YES	YES	YES	YES
Comments				

9. Prototype Test Plan

The table below depicts our previous test plan and whether they accomplished their goal. Highlighted in light green are the tests that have been satisfied in the prototype 1 and 2; dark green are the test that have been satisfied in our third prototype; yellow are the tests that need to be improved on, but have met the minimum requirements; red are tests that were not fulfilled.

Test ID	Test Objective	Description of Prototype used and of basic test Method	Description of Results to be Recorded and how these results will be used	Estimated Test duration and planned start date
1	Verifying the culture design incorporated in the building by getting personal feedback.	<p>Focused Prototype: Online drawing and designing what the building will look like from the outside.</p> <p>Testing will include personal feedback from users.</p>	<p>The results should include the answers to the following questions: Does this include enough cultural significance? Are the selected shapes accurate for the cultural aspect?</p>	November 6 th , 2023
2	Test functionality of outdoor space (i.e. use for cultural events and parking lot. Test if the location of the garage door is plausible for truck accessibility)	<p>Focused and Physical Prototype: Tangible model of the outdoor space connected to the lab.</p> <p>Visually evaluate the space and use model of cars and humans to scale and verify its ability to use the area.</p>	<p>The results should include the answer to the following questions: Is the space large enough? Is the garage placed correctly or does it need to be moved to a better angle? Does the garage door obstruct the other uses of the space?</p>	November 4 th , 2023
3	Test general safety of the building	Comprehensive Prototype:	The test will be successful if the building follows the	November 5 th , 2023

		<p>Detailed virtual representation of the building.</p> <p>Compare the digital model to safety codes for one story office buildings.</p>	<p>regulations like those of the safety hazard section of office-safety-general.pdf (ccohs.ca).</p> <p>Such a building is equipped with fire escapes, has enough doors and windows, and has enough space for safe movement between rooms.</p>	
4	Test security of building	<p>Analytical Prototype Online model of security cameras and outside shape.</p> <p>Calculation of the area of vision of the cameras compared to where they are placed on the model.</p>	<p>The test results should include the total area of visibility of the cameras to make sure the surroundings of the building are covered, especially the lab, and whether there are any blind spots.</p>	November 5 th , 2023
5	Test for sustainability and energy efficiency	<p>Focused Analytical Prototype Online model of the building</p> <p>A calculation of the energy emitted by and energy supplied to the building using software</p>	<p>The test results to be recorded include the emitted energy (transmission, infiltration, ventilation, wastewater, cooling) and supplied energy (energy recovery ventilation, energy recovery heat pump, solar energy through windows, heat supply, electricity use, latent energy, human heat gain, process energy room). Overall, the building should meet comfortable conditions for the inhabitants.</p>	November 14 th , 2023
6	Test for flow of the building and office space. (Space Utilization)	<p>Using a detailed floor plan of the building we will test if everything is at accessible distance of each other by developing a flow diagram</p>	<p>The tests will be successful if the flow diagram demonstrates a reasonable distance for each subsection and a wide enough space for multiple people to use the halls at once.</p>	November 11 th 2023

7	Test the HVAC of the building (heating, ventilation, and air conditioning)	The prototype will be a Model HVAC system that depicts the heating, cooling, and ventilation systems in the building.	The test will be successful if the air flow of the building is safe and comfortable.	November 12 th , 2023.
8	Renewable energy	The next prototype should include renewable energy sources. Calculations of how much energy we can generate with renewable energy (solar panels, etc.)	The test will succeed if we can generate a large amount of energy.	November 14 th 2023

The following table outlines the updated Bill of Materials. A few changes have been made since the last deliverable:

- We are no longer using 3D printing to create our physical model, and are instead opting for a mixture of materials with cardstock.
- We no longer need the OnShape software for the same reason.

Item Name	Description	Units of Measure	Quantity	Unit Cost	Extended Cost	Link
Rhinoceros 3D	3D computer graphics and CAD software to develop a 3D version of the design	Free subscription trial of 90 days (about 3 months)	1	0	0	https://www.rhino3d.com/
AutoCAD	Design software for detailed designs of floor layouts, building overview	Included as a member of the uOttawa community	1	0	0	https://www.autodesk.com/ca-en/products/autocad/overview
BIM Energy	Building energy analysis software for	Free license available for Students	1	0	0	https://bimenergy.com/

	the calculation and simulation of energy					
Hammermill White Cardstock, 110 lb, 8.5 x 11	Heavyweight cardstock to create the physical model	sheets	200	22.01	0	https://www.amazon.com/gp/product/B08DCF5B4P/ref=ox_sc_act_title_2?smid=A3DWYIK6Y9EEQB&th=1
X-Acto Z-Series No.1 Precision Knife with Cap	Precise cutting knife to be used with materials during the creation of the physical model	-	1	7.04	0	https://www.amazon.com/gp/product/B00GGBI0H2/ref=ox_sc_act_title_3?smid=A3DWYIK6Y9EEQB&th=1
Elmer's Glue-All Multi-Purpose Glue, 225ml	All-purpose glue to be used with materials during the creation of the physical model	ml	225	3.72	0	https://www.amazon.com/gp/product/B007Z7PEDO/ref=ox_sc_act_title_1?smid=A3DWYIK6Y9EEQB&th=1
Total product cost (without taxes or shipping)					\$32.77	
Total product cost (including taxes and shipping)					\$40.00	

10. Conclusion

For this deliverable the objectives were the following:

1. To identify the problems based on the test plan in deliverable G.
2. To make the final adjustments to our design

The problems outlined in deliverable G were corrected in our third prototype and the last set of tests were completed. The final changes were implemented in order to achieve a final product that is well thought out and thoroughly tested.

11. References

Canada Mortgage and Housing Corporation. (1998). Your House: The Outside. Retrieved from https://publications.gc.ca/collections/collection_2011/schl-cmhc/NH15-457-1998-eng.pdf

BIM Energy. <https://bimenergy.com/>

12. Wrike Snapshot

<https://www.wrike.com/frontend/ganttchart/index.html?snapshotId=DN2ONjyTBOXiuWgYul2Q28J2pwGo5pMo%7CIE2DSNZVHA2DELSTGIYA>