C. Problem Definition, Concept Development, and Project Plan

Group A13

C.1.3 Problem definition

Listing and prioritizing of client needs.

#	Needs	Importance*
1	Device is affordable	3
2	Device is portable and lightweight	1
3	Device emits alarm sound that is loud enough	5
4	Device has a large size that must fit on a bedside table	5
5	Device is durable	5
6	The client wants bright contrasting colors.	3
7	Device blocks the light from the charger	5
8	The client wants wood texture.	2
9	Device is installed with fewer wires for the safety of cats.	2
10	Device is simple to use	4

*Needs are prioritized through a scale of importance from 1 to 5 (5 being at the highest priority)

C1.2Problem statement:

Design a device which encloses hearing-aids and enhances features of apparentness through increased size, contrasting aesthetic and loud alarm sound for patients who forget to wear their hearing-aids in the morning. The design will be cost effective, durable, grasp the user's attention when alarm sounds but remain discrete when not activated.

C.1.3 Need inspired metrics

Provide a list of need inspired metrics with appropriate units, and conduct benchmarking on similar solutions (can satisfy some or all needs). Provide descriptions and pictures when possible.

Relation of needs to metrics and units

#	# Needs	Metric	Unit
1	2	Weight is not too heavy for easy portability	kg
2	4	Proper Dimensions so it is large enough to fit what is needed	in
3	3	Loud enough to wake up sleeping person with low hearing	dB
4	2,5	Thick enough so it can withstand drops	in
5	1	Low overall cost of product	$
6	5	Sustainable materials	1-5 scale
7	5	Reliability of electronics	1-5 scale
8	6	Aesthetic and contrast	1-5 scale

Description and pictures of competitive products with references

Product 1: Black wooden Box	**Product 2:**
-Box opens on two metal hinges (60$)	-Simple digital clock (89.99$)
Amazon.com: Large Wooden Box with Hinged Lid - Wood Storage Box with Lid - Black Wooden Storage Box - Decorative boxes with lids (Matte Black) : Home & Kitchen	Westclox Digital Electric Tabletop Clock with Alarm & Reviews - Wayfair Canada
	

Benchmarking of metrics based on competitive products

#	# Needs	Metric	Unit	Product 1	Product 2
1	2	weight	kg	1.315	0.2268
2	4	dimension	in	10.75 long 8 wide 5 tall	4.29 height 6.9 wide 2.12 depth
3	3	sound	dB	N/A	Roughly 80
4	2,5	thickness	in	0.5	N/A
5	1	Low cost	$	60	89.99
6	5	Sustainable	1-5 scale	4	2.5
7	5	Reliability of electronics	1-5 scale	N/A	5
8	6	Aesthetic/ contrast	1-5 scale	2	3

C.1.4 Target Specifications

Develop a set of target specifications (both ideal and marginally acceptable values). Provide reasons for your choices.

Assignment of marginal and ideal values

#	Metric	Unit	Marginal Value	Ideal Value
1	Weight of box and alarm combined	kg	<1.8	1.35
2	Dimensions of box (not including alarm attached)	in	<7 long <5 high <5 depth	6 4.5 4.5
3	Maximal sound of alarm clock	db	<85	80
4	Thickness of box only	in	<1/2	1/4
5	Cost of our final product	CAD $	<100	85
6	Sustainability	1-5 scale	<3	4
7	Reliability of electronics	1-5 scale	<4	5
8	Aesthetic/contrast	1-5 scale	<4	5

C.2 Concept development

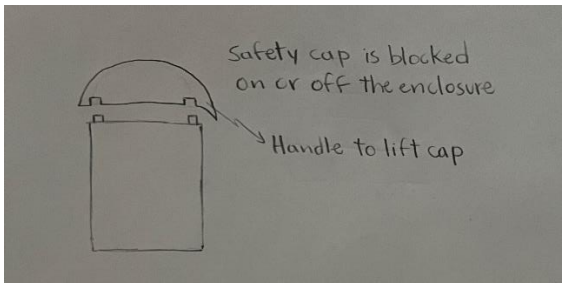
1. Based on your problem statement, develop final prototype concepts for each subsystem, as well as the entire assembled system required to solve the problem.

Subsystem 1

Hearing aid enclosure: This subsystem considers the safe storage of the client's hearing aid.

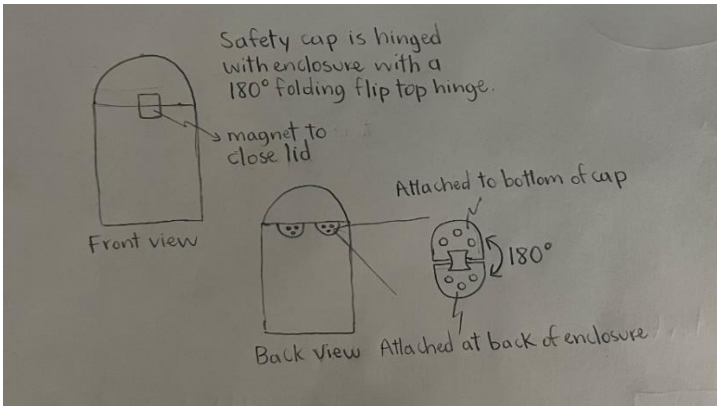
- Materials: Choose a durable and lightweight material to safely protect client's hearing aid. Current options include plywood. Plywood is a sustainable, cheap material that is easy to laser cut during manufacturing and assembly.
- Safety: Design a system to easily insert and remove the hearing aid and a system to open and close the cap to protect it safely.

Concept A



Pros
Ease of manufacturing
Cons
Possibility to lose the cap.
Cap is not strongly secured.

Concept B



Pros
All in one structure
Cap is secured tightly on enclosure
Cons
Hinges can loosen overtime

https://www.amazon.ca/Degree-Folding-Durability-Install-Computer/dp/B0C49Q2LCZ?th=1

Concept C

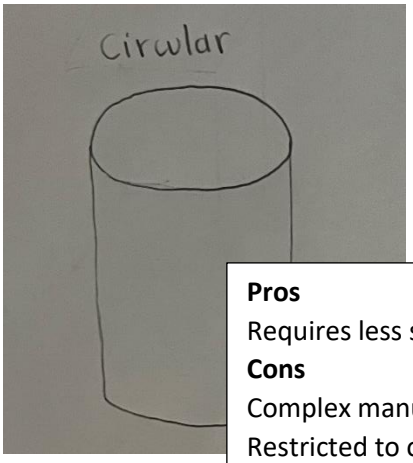
Automation of concept B: Depending on availability of resources and time, automation of the cap mechanism is desirable. The idea is that the cap will open up automatically at the set alarm time.

Subsystem 2

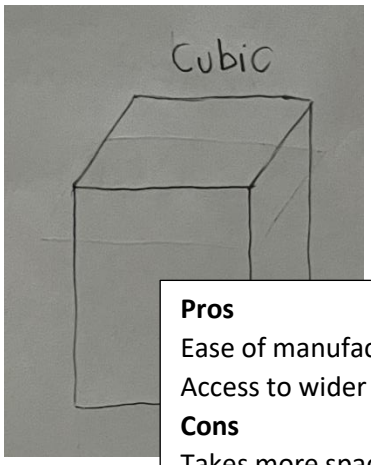
Design: This subsystem is concerned with the visual part of the enclosure.

- Design: Design with colours and sizes that users can always notice.
- User Interface: Design that users can intuitively set settings through a GUI or touch screen or voice recognition interface.
- Customization: Provides visual appeal by providing various colours or patterns to suit the user's taste. Also, choosing a colour and pattern to suit the user's taste ensures that the user does not forget to wear their hearing aid.

2.1 - Shape

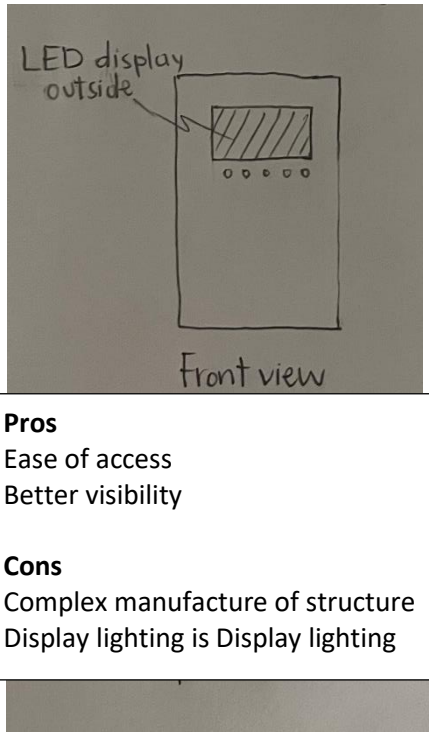


Pros
Requires less space, better storage
Cons
Complex manufacturing
Restricted to only certain materials



Pros
Ease of manufacturing
Access to wider range of materials
Cons
Takes more space

2.2 - User interface



Pros
Ease of access
Better visibility

Cons
Complex manufacture of structure
Display lighting is Display lighting

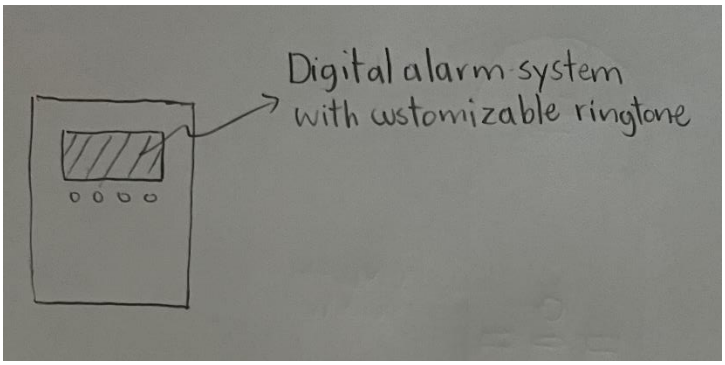
Pros
Display is hidden
Cons

Subsystem 3

Alarm system: This subsystem focuses on notification systems for users.

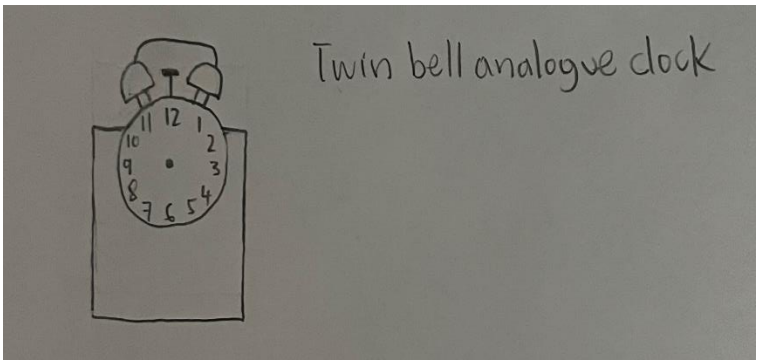
- Time: Create a system that alerts the user at a time set by the user to remind them to wear hearing aid.
- Sound: Develop a loud reminder sound to remind people to wear their hearing aid.
- User Interface: Develop an interface that allows users to easily set notifications and turn off alarm sounds.

Concept A



Pros
Advanced technology
Personalization options with ringtones and display colours
Cons
Expensive
Programming bugs and issues

Concept B



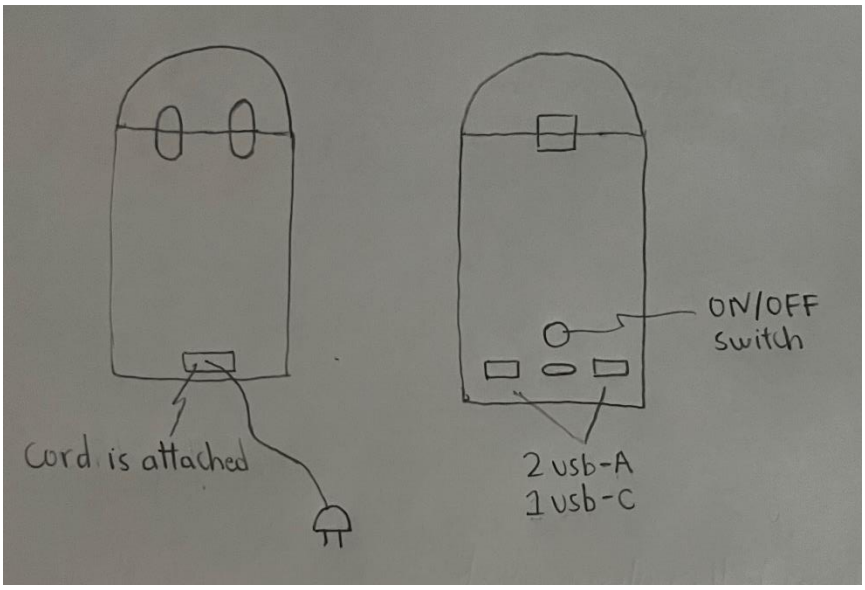
Pros
Simplicity
Cost-effective
Energy saving
Cons
Only 1 option for alarm sound
Outdated style

Subsystem 4

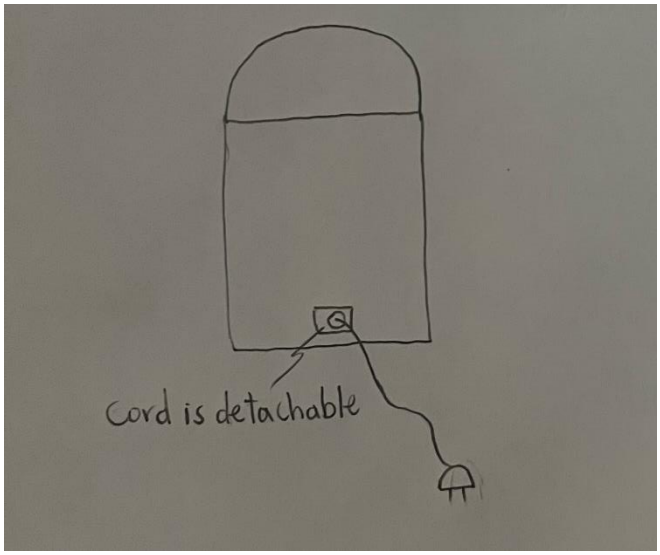
Charging: This subsystem focuses on helping users charge their hearing aid and managing the power of the enclosure.

- Power: Physically design a power switch at the bottom to turn the enclosure on and off.
- Charging system: Design capable of using multiple types of USB connectors.
- Battery life: Optimize battery life so users can use their enclosure for as long as possible.

Concept A



Concept B



2. Analyze and evaluate all concepts against the target specifications you defined. Use simple calculations and/or simulations to make decisions. Justify the process and methods used for analysis and evaluation.

For each subsystem, the generated concepts were evaluated against 8 selection criteria using a scale of 1 to 5, 5 infers that the concept perfectly aligns with the criteria specification. These criteria are defined as the set target specifications. The goal is to determine the best combination of concepts from each subsystem that matches the client's needs, aligns with the specifications and takes into consideration the pros/cons. After grading all concepts, the concept resulting in the highest score will be selected to be part of the solution.

Subsystem 1: Hearing aid enclosure materials and safety

Selection Criteria	Concept A: Lift Cap	Concept B: Hinge cap	Concept C: Automatic
Weight of box and alarm combined	4	4	2
Dimensions of box (not including alarm attached)	4	3	3
Maximal sound of alarm clock	N/A	N/A	N/A
Thickness of box only	4	4	3
Cost of our final product	5	3	1
Sustainability	2	2	2
Reliability of electronics	2	2	5
Aesthetic/contrast	1	4	4
OVERALL	22	22	20

Both concept A and B have the same score. To allow the team decide, the pros and cons were compared. It was clear by all members of the team that the pros of the hinge cap overweight the pros of the lift cap as it has a better safety feature.

Concept C is desirable only if time and availability of resources allow us

Subsystem 2: Design, User Interface type

	Shape		User Interface	
Selection Criteria	Concept A: circular	Concept B: cubic	Concept A: LED display outside	Concept B: LED display inside
Weight of box and alarm combined	3	3	3	3
Dimensions of box (not including alarm attached)	2	4	2	4
Maximal sound of alarm clock	N/A	N/A	N/A	N/A
Thickness of box only	N/A	N/A	2	4
Cost of our final product	1	5	3	3
Sustainability	3	4	3	3
Reliability of electronics	N/A	N/A	3	3
Aesthetic/contrast	3	5	3	4
OVERALL	12	21	19	24

For subsystem 2 which focuses on aesthetics and physical design, 2 important elements were determined essential: shape and user interface design. In all criteria, the cubic shape wins over the circular. For user interface, it is wanted for the LED display to be located inside the enclosure as this is a crucial need for the client (hide any lights/LED).

Subsystem 3: Alarm system

Selection Criteria	Concept A: Digital alarm	Concept B: analogue
Weight of box and alarm combined	4	1
Dimensions of box (not including alarm attached)	2	5
Maximal sound of alarm clock	5	2
Thickness of box only	N/A	N/A
Cost of our final product	2	5
Sustainability	1	5
Reliability of electronics	5	1
Aesthetic/contrast	5	2
OVERALL	24	21

For this subsystem, both options, the digital alarm and the analogue clock are interesting. However, the digital alarm being more modern allows flexibility for ringtone type, volume and other features. An analogue clock interface is also possible meeting all the client's needs but with no flexibility in personalization. The decision will depend on client feedback.

Subsystem 4: Charging: Power, Charging system, Battery life

Selection Criteria	Concept A: cord attached	Concept B: cord detachable
Weight of box and alarm combined	3	4
Dimensions of box (not including alarm attached)	3	3
Maximal sound of alarm clock	N/a	N/a
Thickness of box only	3	4
Cost of our final product	4	4
Sustainability	3	4
Reliability of electronics	5	4
Aesthetic/contrast	3	3
OVERALL	24	26

This subsystem is still in the works and requires more development. However, based on the generated concepts, the one with a detachable cord seems to be better than the one with attached cord. Having less wires is more practical and convenient for the client. Although this is not a priority, after client feedback, the challenge of making a device wireless will have to be addressed.

3. Based on target specifications and analysis of pros and cons, potential concepts were carefully selected for each subsystem that will be further developed and combined all together to build the complete solution.

	Selected Concept
Subsystem 1	B
Subsystem 2.1	B
Subsystem 2.2	B
Subsystem 3	A
Subsystem 4	B

4. Concept design

The concept design will be a square enclosure with a hinged lid. The decision to go with a square design allows us to work with a wider range of materials especially during the prototype stage. The lid will be hinged so that it is easier to use and has less components that could cause problems during the enclosure's lifespan. The majority of the design will be wood with the inside components being made out of a contrasting colour of acrylic. The user interface will be an LED display and push buttons on the inside of the enclosure, in order to simplify the interface. The alarm system will consist of two parts, the first is an led light strip at the bottom of the box to provide a visual alarm, and the second will be an audible alarm that can be turned off. The system will be powered by a standard power cord and would be able to charge the hearing aid charger. Additionally, it will have 4 USB ports for charging other devices. The device will be powered as long as it is plugged in, but the speaker for the alarm will have an on and off switch.

5. CAD model

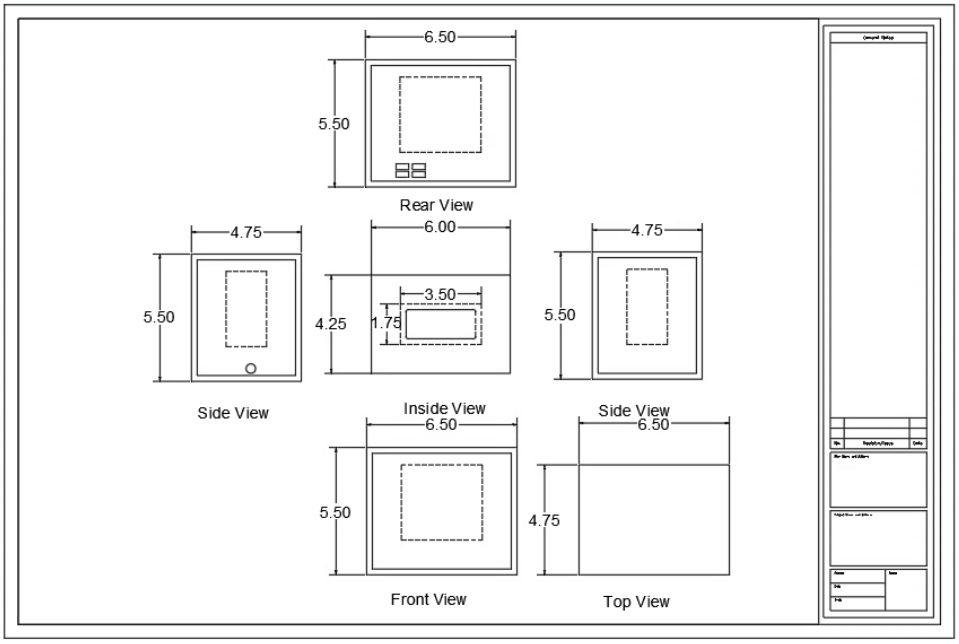


Figure : detailed view of system

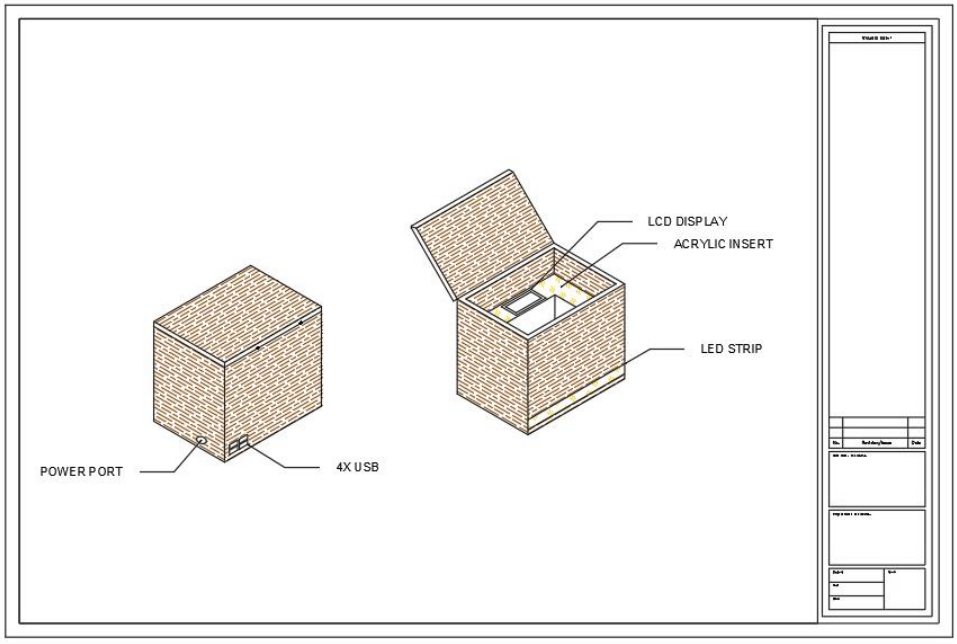


Figure : isometric view.

6. The above figures show a detailed view and an isometric view of the system. The thickness of the box is ¼ inch and the electronic components are implemented using Raspberry pi with Arduino planned as a backup. With these two parameters meeting our target specifications it will mean that we will also meet our target weight of 1.35kg. As shown in the detailed figure our dimensions are 5.5h x 6.5w x 4.75 deep. This is slightly larger than the ideal value, but it is within our marginal value, and it may be possible to adjust these specs after prototyping. The construction of the box will be made from wood and acrylic. These materials, including the electronics, are sustainable materials for the current situation and they will be easily replaceable with more sustainable pieces if repairs are needed. Lastly the project meets our criteria for aesthetics because it is designed with contrasting colours and clean lines being a priority.

C.3 Project plan

https://www.wrike.com/frontend/ganttchart/index.html?snapshotId=f9tA55eYPhDodmyKg89lDt2aXJqCgxiQ%7CIE2DSNZVHA2DELSTGIYA