GNG 2101 – Intro. to Product Dev. and Mgmt. for Engineers

Project Deliverable C-1: **Conceptual Design**

Faculty of Engineering – University of Ottawa

Date : September 26th 2019
Group number: Group 10
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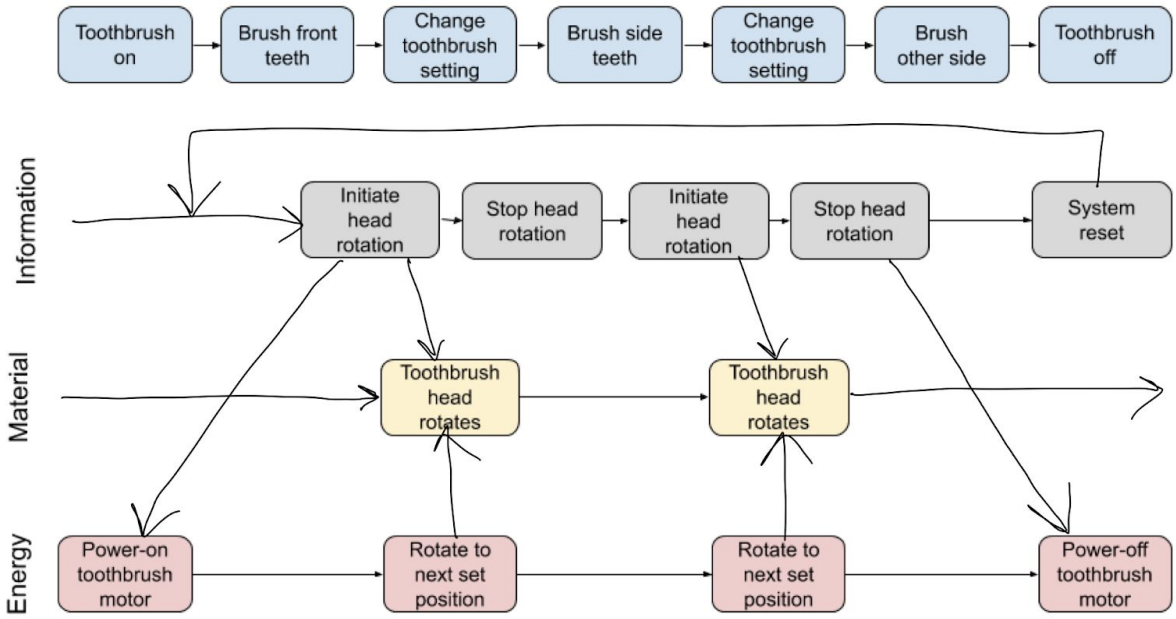
Introduction:

The objective of this deliverable is to develop a conceptual design for our product as well as to create a plan for completing multiple prototypes in time for Design Day. In order to verify the viability of our proposed concepts, we conducted a feasibility study and created a bill of materials and parts (BOM).

1. Based on customer needs, clarify core functionality by breaking down required product functions (functional decomposition) into smaller basic sub-functions, identifying external sub-system boundaries.

Functional Decomposition:



2. Provide a minimum of 3 product concepts per team member (clearly identify each concept's creator).

Lucas' concepts:

1) A device that attaches around the head while the toothbrush is inserted in the mouth. The functionality of the device will rely on the user's head movement. As our client would prefer a solution that aides, but does not replace her participation in brushing her teeth, a design such as this could incorporate our clients strengths while minimizing the necessity of their weaknesses. Potential cons for this solution would be the complexity in the setup stage, the size of the apparatus as well as its increased weight.

Pros: Relies on the client's strengths to operate the toothbrush. Requires minimal hand movement.

Cons: It would be hard to set up, and take up a lot of space. Also, depending on the materials used, weight could be an issue.

2) A longer toothbrush that has a better reach than a standard one could be a viable solution. By utilizing such a device, reaching the teeth located on the side and back regions of the mouth could be achieved without moving the users hand. Adding length to the toothbrush would inevitably increase the weight of the device which could be an issue. An increased difficulty in handling the toothbrush may also arise given the change in the devices overall form.

Pros: It would make it easier to reach the sides and back of the mouth cavities without having to move hands. This would allow the client to only rely on head movement, one of her strengths.

Cons: Weight could be an issue. Also, it could be hard to grab or use given the client's restricted hand motion.

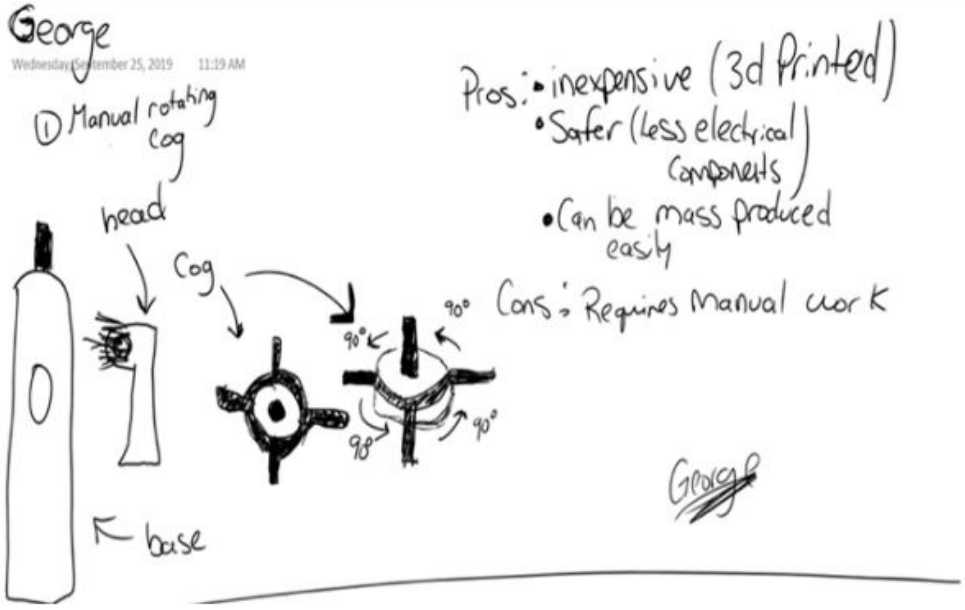
3) Device to wrap around hand to make grabbing the toothbrush. Adding optional extra length to allow to use head movement to reach sides and back of mouth cavity. A device that would assist the user by wrapping around their hand could be of potential use to our client. It would be an inexpensive tool in providing extra grip to the toothbrush while it is being operated. The attachment and removal procedure as well as the additional weight on the users hand could be an issue.

Pros: Easy to use, it would provide extra grip to help the client grab and use the toothbrush.

Cons: Again, weight could be an issue, as well as set up. If it is too heavy, it could be problematic given the client's limited hand strength.

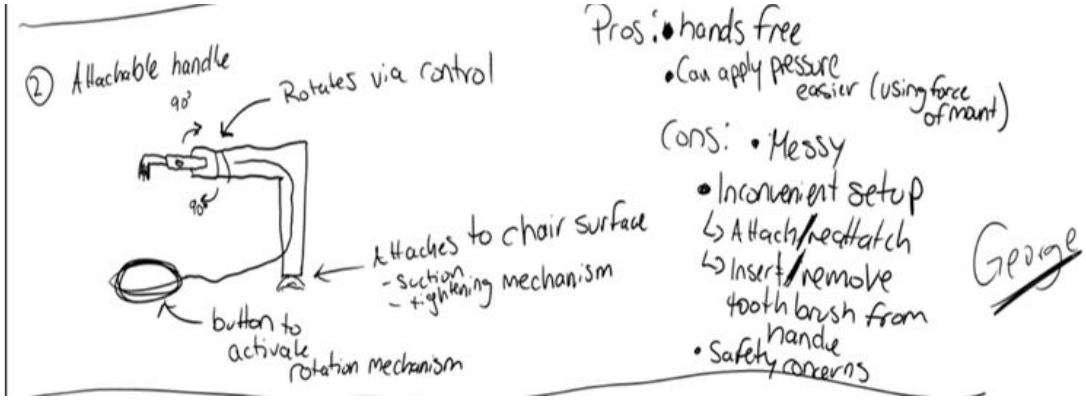
George's concepts:

1) A 3D printed piece that would attach between the base of the electrical toothbrush and the removable head. This piece would be comprised of 2-3 compartments, one being a cog. The cog would have around 4 protrusions that would be used as a gripping tool to turn the head piece. It would be designed to turn clockwise in 90 degree increments with the use of applied force. For instance, once the user has completed the task of brushing their front teeth, they would then bite on the cog and twist using both their arm and head. Upon completion, the bristles would be facing 90 degrees away from its initial position and the user may now begin brushing the surface of their bottom teeth.

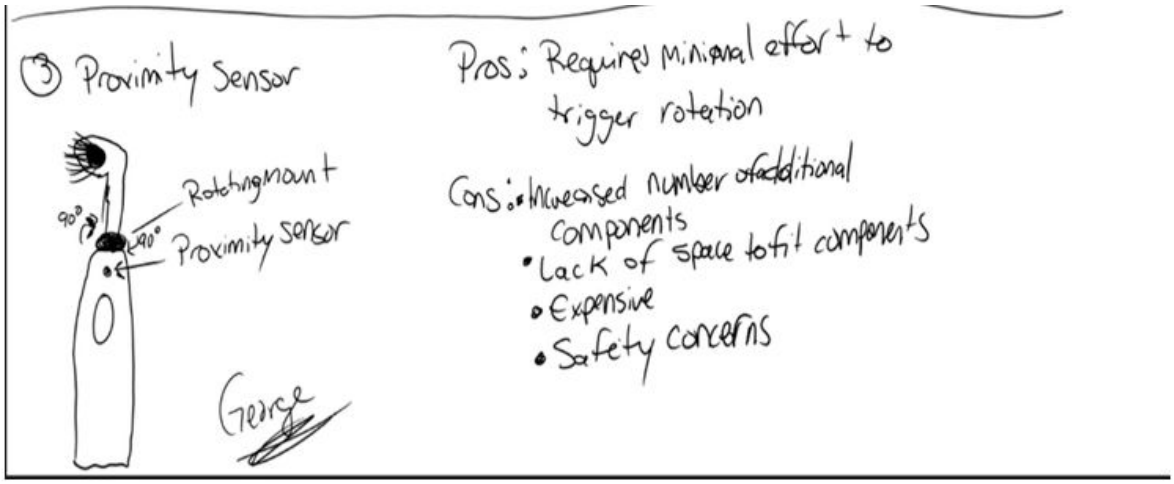


2) An attachable handle that would rotate via a control. The Handle would attach to the chairs surface or bathroom sink and grip the toothbrush when being operated. An easy to use button that would require minimal pressure would be in the users reach. When the button is pressed, the rotational mechanism would be

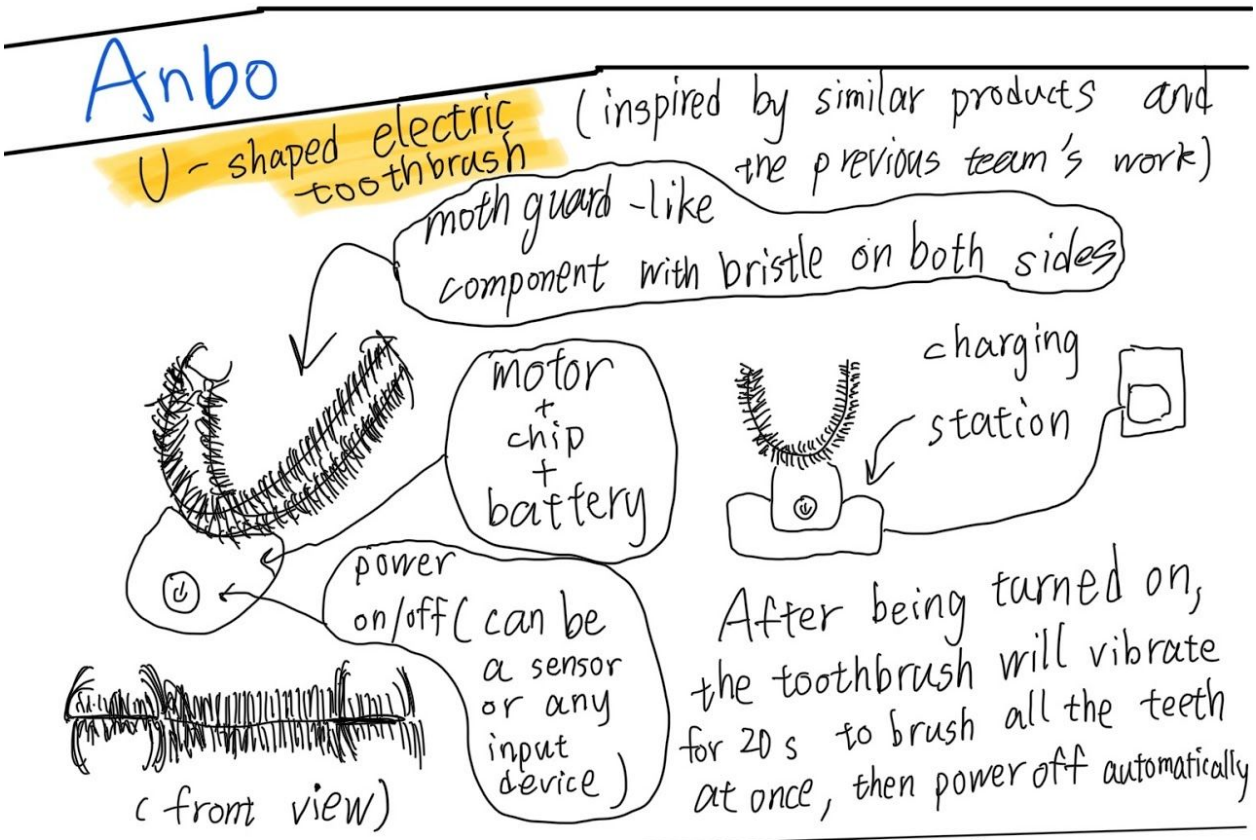
activated. An additional feature to turn on/off the toothbrush could be added to increase the overall process.



3) A proximity sensor would be installed near the upper base of the electrical toothbrush. When the user desires to rotate the head, they may simply cover the sensor using their whatever is most convenient. Once they have achieved their desired angle, they must simply cease covering the sensor.



Anbo's Concepts:



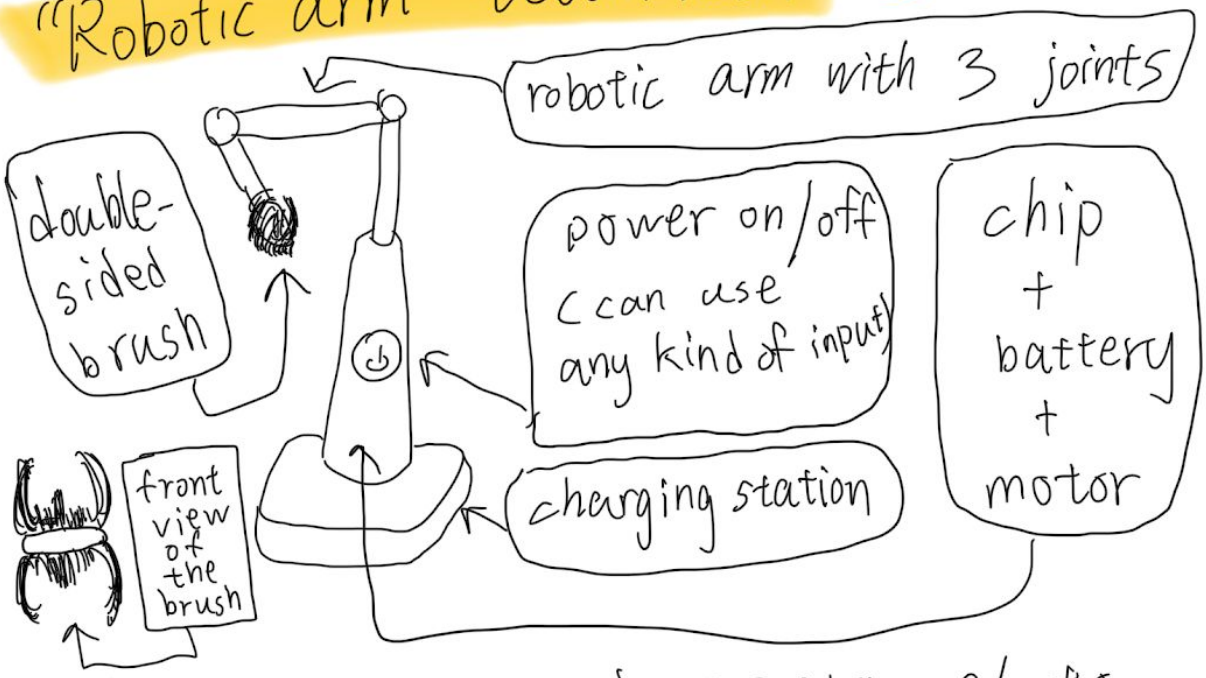
Advantge:

- The brushing process is fast.
- It is easy to operate because brushing is done automatically.
- It is wireless, which gives user more room.

Disadvantge:

- The toothbrush needs to cover the user's teeth seamlessly, which is hard to do.
- Less involvement means less sense of accomplishment to the user
- The components may be hard to build

"Robotic arm" toothbrush by Anbo



The robotic arm is programmed to brush one side of the teeth from one end to another. The brush is double-sided so it can brush both sides of the upper teeth and the lower teeth

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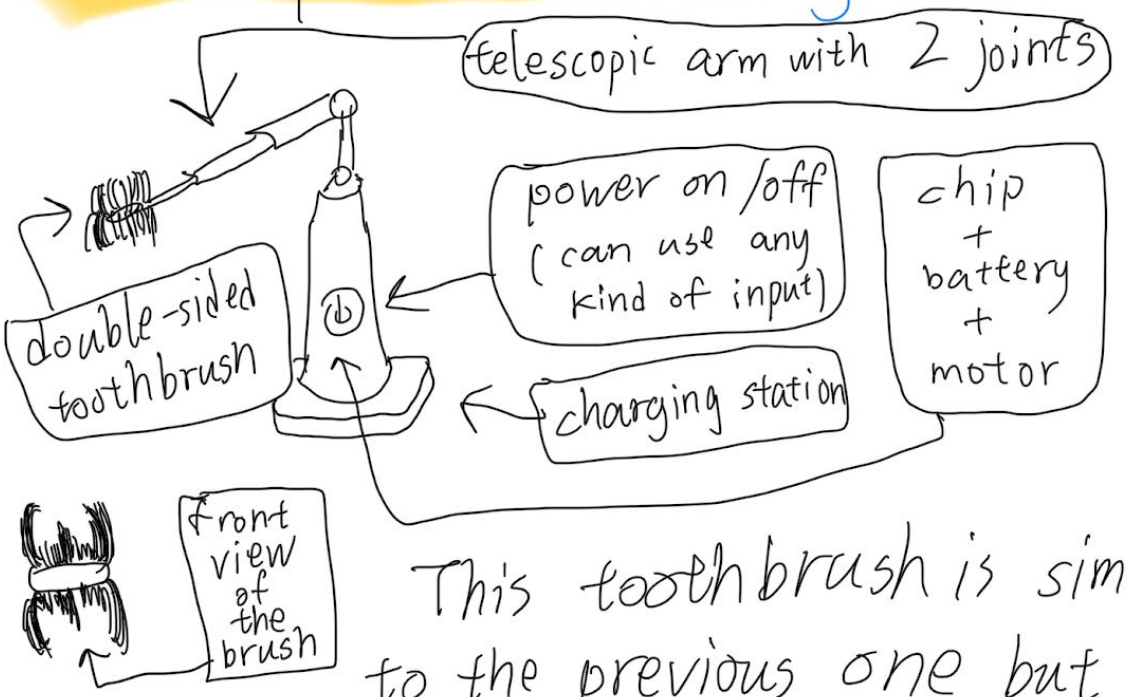
Advantage:
- The toothbrush is wireless
- The toothbrush can be modified from an ordinary toothbrush since the bottom structure is similar.

Disadvantage:
- The arm may be difficult to build.
- The software may be difficult to program.

Telescopic toothbrush by Anbo



This toothbrush is similar to the previous one but it has a telescopic arm.

Advantage:

- This toothbrush takes less space and is more balanced when the thinnest part of the arm slides into the lgrest one.

Disadvantage:

- The telescopic structure may be more difficult to build and control.

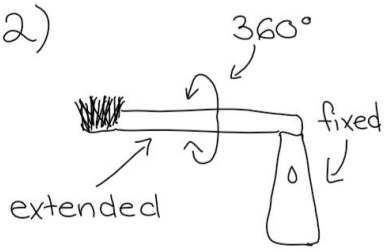
Kate's Concepts:

1)

- toothbrush rotates in 2 places
- bristles surround teeth so less mobility needed
  ↳ no need to adjust for front & back of teeth
- 4 "positions" would be needed to get all 4 quadrants of the mouth

-Kate Ford

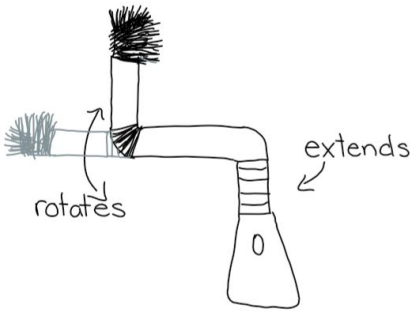
2)



- Only 1 point of rotation
- extended head allows reach to the back teeth
  ↳ when needs to do front pull arm away
- 6 positions would be needed to get front, back, and bottom/top of all teeth

- Kate Ford

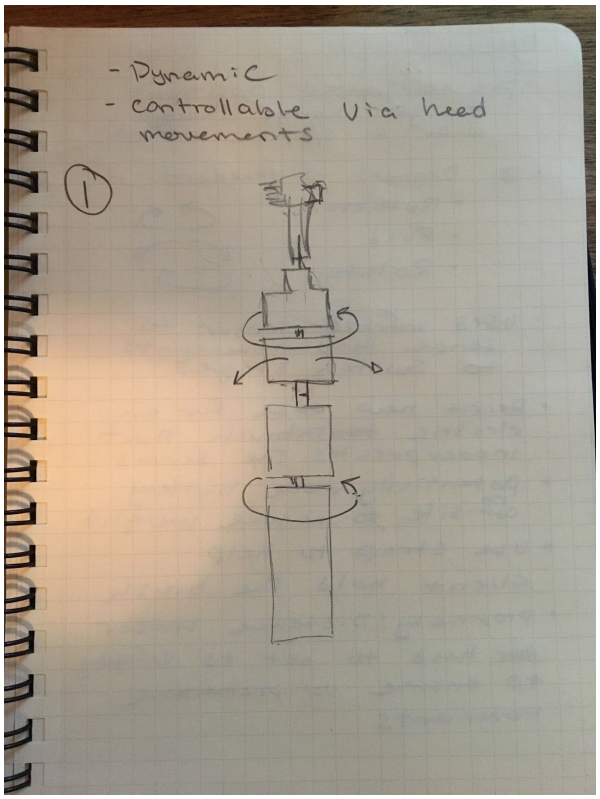
3)

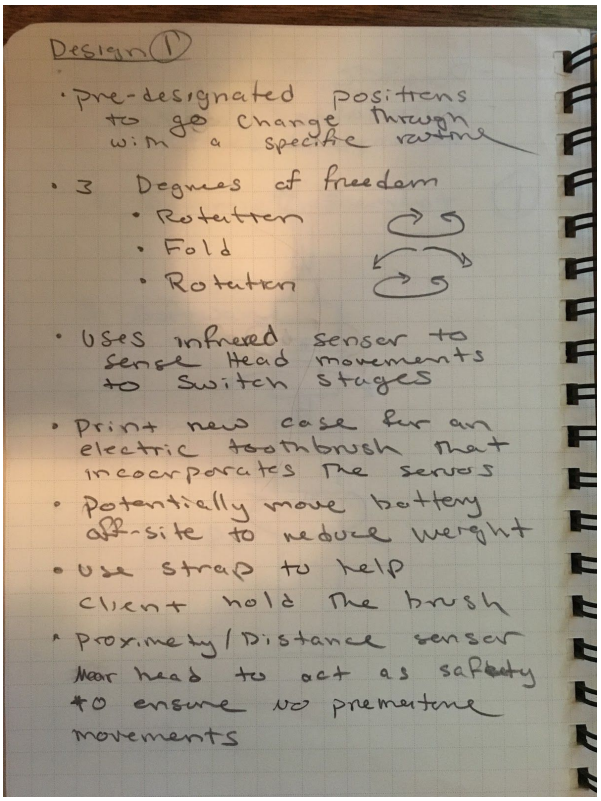


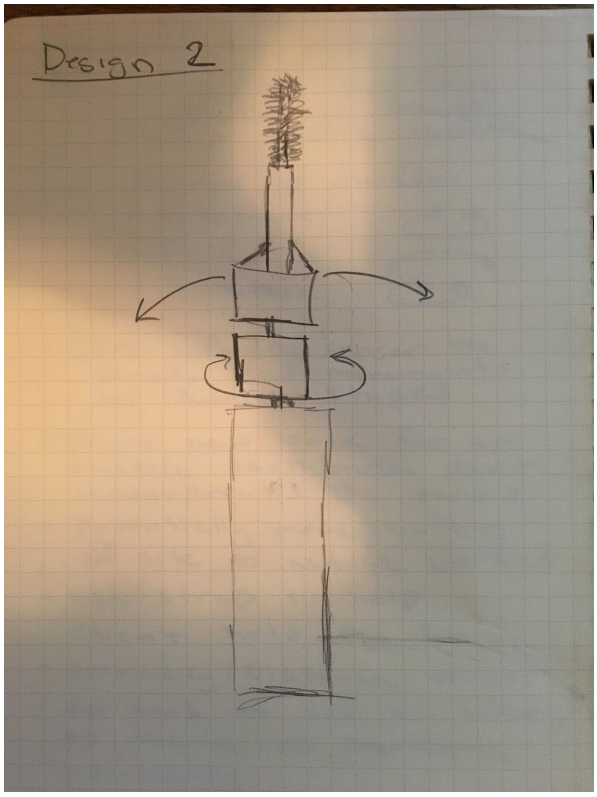
- One rotational aspect and one extendable aspect
- Bristles on 2 sides of the head
- allows for many settings and spots to make the process easy

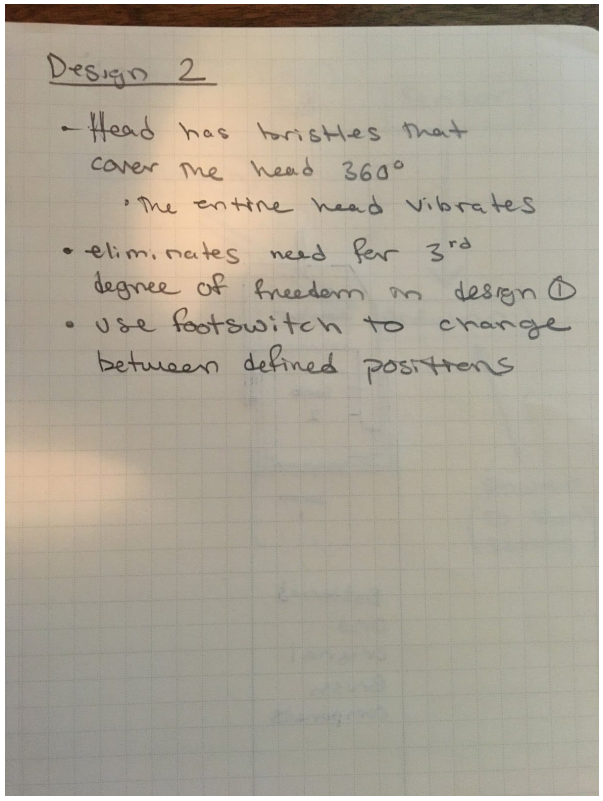
- Kate Ford

Andre's Concepts:

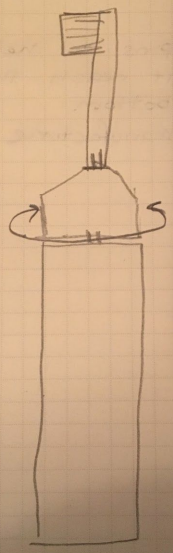








Design 3



Design 3

- has one degree of Rotation
- only requires one servo
- Brush spins to help the client reach the top and bottom
- easy to manufacture

3. Analyze and evaluate all concepts provided by each team member based on the target specifications of Project Deliverable B. Use simple calculations and/or simulations to make decisions. Justify the process and methods used for analysis and evaluation.

Upon reviewing Mana's comments for Deliverable B, we have refined our metrics and target specifications for our solution. In order to best analyze and evaluate all concepts provided by each team member, we created a decision matrix. By doing so, we are able to systematically identify, analyze, and rate each design criteria in relation to the selection criteria. The values for our matrix are set to 1 being not ideal and 5 being ideal.

Lucas' Concepts

Selection Criteria	**Concept 1**	**Concept 2**	**Concept 3**
Ease of Use	3	3	4
Size & Weight	1	2	2
# of Adjustments per cycle	2	4	1
Safety	3	4	4
Durability	4	3	4
Cost Estimate	4	4	3
Is it Realistic	3	3	3
Total	20	23	21

George's Concepts

Selection Criteria	**Concept 1**	**Concept 2**	**Concept 3**
Ease of Use	3	4	2
Size & Weight	5	1	1
# of Adjustments per cycle	3	2	3

Safety	3	2	2
Durability	3	2	2
Cost Estimate	5	2	2
Is it Realistic	4	3	2
Total	26	16	14

Anbo's Concepts

Selection Criteria	**Concept 1**	**Concept 2**	**Concept 3**
Ease of Use	4	3	3
Size & Weight	3.5	3	3
# of Adjustments per cycle	4	3	3
Safety	3	3	3
Durability	3	3	3
Cost Estimate	2.5	3.5	4
Is it Realistic	4	3.5	3
Total	24	22	22

Kate's Concepts

Selection Criteria	**Concept 1**	**Concept 2**	**Concept 3**
Ease of Use	4	3	2
Size & Weight	3.5	4	3
# of Adjustments per cycle	4	2.5	3
Safety	3	3	3

Durability	3	3.5	3
Cost Estimate	3	3	2
Is it Realistic	3	3	2
Total	23.5	22	18

Andre's Concepts

Selection Criteria	**Concept 1**	**Concept 2**	**Concept 3**
Ease of Use	5	4.5	2
Size & Weight	2.5	4	4.5
# of Adjustments per cycle	4	5	4
Safety	3	2	3
Durability	2.5	4	4
Cost Estimate	2.5	3	4
Is it Realistic	3.5	3	3
Total	23	25.5	24.5

4. Choose one or a few promising solutions you wish to develop further based on your evaluation.

After analyzing each concept provided by our team, we have chosen 5 of the best performing concepts to further analyze . Using the same values found in question 3, we created a new decision matrix only containing our highest scoring ideas.

Selection Criteria	**Option 1 Anbo's Design #1**	**Option 2 Andre's Design #3**	**Option 3 Kate's Design #1**	**Option 4 George's Design #1**	**Option 5 Lucas's Design #2**
Ease of Use	4	4	4	3	3
Size & Weight	3.5	3.5	3.5	5	2
# of Adjustments per cycle	4	4	4	3	4
Safety	3	4	3	3	4
Durability	3	3	3	3	3
Cost Estimate	2.5	4	3	5	4
Is it Realistic	4	4.5	3	4	3
Total	24	27	23.5	26	23

Option 1:
The U-Shaped electric toothbrush is a promising concept. It is an innovative device with a brushing process that is fast, easy to operate and can be operated without being plugged into an outlet. Disadvantages noted were the cost, safety and durability.

Option 2:
Andre’s 3rd design is a simple yet effective way to tackle our clients’ needs. It requires only one servo which slightly increases its weight, though ranks high in safety, ease of use and cost.

Option 3:
Kate’s 1st design combines the idea of a mouthguard like toothbrush and a conventional toothbrush. I requires 4 preset positions to allow the client to reach all four quadrants of her mouth, making it user friendly and cuts down on time. The biggest disadvantage with this design would be the cost and that it would be very hard to achieve in the short time frame and constraints we were given.

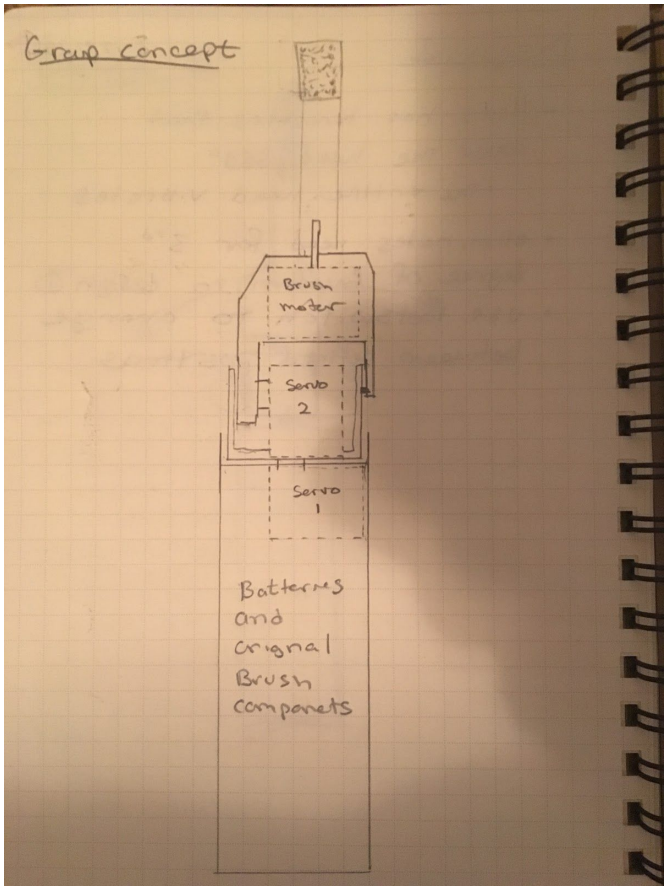
Option 4:
George’s 1st design is a very inexpensive and simple way in implementing a rotational component on a standard electric toothbrush. Given its lack of features, it can be more strenuous for the user to achieve the desired angle. Constantly using one's teeth to bite and rotate the brush will result in quicker abrasion over time.

Option 5:
Lucas’ 2nd idea of a longer toothbrush is a very realistic design. The additional length would allow the client to reach the back of her mouth with ease and does not require additional servos or technical adjustments. The downfall to this is that the added weight would make it awkward and could be challenging given the clients limited dexterity and gripping abilities.

5. Develop a group design concept which is either an integration or modification of the promising concepts chosen in the previous step, or a brand-new concept created from these ideas. Justify your approach.

The team has decided on a concept that is a combination of small features from multiple designs. Although there was not one design that met satisfactions originally, the team combined multiple small features and used the rotating toothbrush design as a base to improve. The resulting team concept is an electric toothbrush that has three degrees of freedom but only requires 2 servos. The design achieves this by rotating 180 degrees and then flipping over to go from the bottom jaw to the top. The toothbrush uses a regular commercial brush head to ensure the brush is safe for the clients mouth.

6. Visually represent (sketch, diagram, CAD model, etc.) your group concept.



7. Provide a few lines explaining your concept's relationship to the target specifications, as well as its benefits and drawbacks

Our brush design was decided upon as we believe that it gives our team the best possibilities for achieving our target specifications. While other concepts may have been more effective in function, they were not feasible for our projects limitations. The concept design our team decided upon is what we believe to be a good combination of effectiveness and feasibility.

We also had our target specifications for weight of the device in mind while creating this concept. The fact that we can reduce three degrees of freedom to only servos allows to cut down on weight while still keeping the ease of use that is necessary for the client.

Using only two servos also makes our timing goals more achievable because it simplifies the designing and manufacturing process as well as helping to keep the cost low and within our target specifications. In addition, reducing the amount of joints present in the device reduces the areas where error or failure is most likely to occur.

Conclusion:

After coming together to discuss the multitude of ideas our group had, we worked together to find an effective solution to the problem at hand. By breaking down the required product functions, we were able to develop and analyze concepts that directly solved our problem statement. Using the advice given to us regarding the selection criteria in deliverable B, we were able to further evaluate each design and ensure that all needs were satisfied in the creation of our final design.