ELECTRIC TOOTHBRUSH REPORT

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3/14/13

Team 5

Abstract

The objective of this design project was to improve on the deficiencies of the electric toothbrush that was given to us. The current model is battery powered, bulky, hard to clean, and doesn't reach all parts of the teeth. According our consumer survey, the main issues we decided to focus on were the size of the body, the price, the energy source, and maintenance. We redesigned the body of the toothbrush to make it more user-friendly, changed the plastic and the amount of materials used to lessen the price of the toothbrush, researched other energy sources, and enhanced the toothbrush head to more effectively clean teeth. We were able to get a better look at what exactly we were working with once the toothbrush was dissected. After we filled out labs one and two, we were able to conceptually enhance the toothbrush. We used pugh charts to narrow down the top concepts in order to create a new and improved electric toothbrush. In the end, our team decided that the project was a success. We were able to satisfy the needs of the customer, which included reduction of size, low price, efficient energy source, and easy maintenance. Even though we met our customer's needs, we believe that there are still some features and aspects of the electric toothbrush that we could have improved.

1.0 Introduction

The product our group was given to redesign is the Oral-B Advanced Power 400 Electric Toothbrush. The electric toothbrushes that are currently on the market are large and tend to have a great amount of vibrations and noise level. Some of the electric toothbrushes out on the market are extremely expensive as well. None of these features are pleasing to the customer so our team has decided to redesign our electric toothbrush to better fit our customer's needs. So far we have sent out a survey asking various questions about what the customer looks for in an electric toothbrush. We used a Google document survey that was sent out to the Brumbaugh Hall, McKee Hall, and Penn State Class 2016 Facebook pages. While waiting for the results of the survey, we dissected the toothbrush using a saw and a pair of pliers. We needed to dissect the toothbrush so that we could have a closer look at what the motor was and how everything on the inside worked. We also did external searches, which included patent searches and benchmarking. We did the patent search to ensure that all our concept ideas would not be copying any previous ideas. Benchmarking helped our team to visually see how the electric toothbrush has evolved since it was first brought onto the market. From the information that was gathered we were able to create our general concepts for our new design. With these concepts we created our morphological charts and pugh charts. The pugh charts helped us to narrow down what was the best selection for each concept and create our final design. By using pugh charts to select our final concepts, we eliminated the possibility of choosing the wrong design. The results from our consumer survey, patent searches, benchmarking, and all other research will be displayed. In each section there are charts, tables, and pictures to furthermore explain the process of this project.

1.1 Initial Problem Statement

The purpose of this project is to redesign an electric toothbrush that will better serve the customer. The key components that our team has decided to focus on is reducing the size of the handle, reducing the noise and vibration level, and redesigning the brush head.

2.0 Customer Needs Assessment

A customer needs assessment is typically found in the form of a survey, interviewing people or through research. The feedback from the customers helps us to understand what exactly the customers want to see in an electric toothbrush. We chose to do an online Google docs survey which we posted on the McKee Hall, Brumbaugh Hall and Penn State Class of 2016 Facebook pages.

2.1 Weighting of Customer Needs

Table 1. Initial Customer Needs List Obtained

We each had a small stack of sticky notes. We then wrote down ideas and changes that we could use for changing to design of the electric toothbrush. Then after some time we compiled the sticky notes together and came up of a list of possible changes to make to the toothbrush.

Water-proof seal for batteries
easy to clean
minimal crevices
less plastic
speed settings
more power efficient
light weight
easy to hold
low noise
interchangeable head
longer neck
more flexible head
oral-B ID
colors

Table 2. Hierarchal Customer Needs List

We split our initial customer needs list into four main categories, maintenance, Green, User friendliness, and Image. Less plastic would mean that it would be lighter and greener. By changing the head it would be more power efficient because there would be more vibrations while using the same amount of energy. Coating the metal head with silicon would decrease the noise level. Our constraints would be less plastic would make the toothbrush more flimsy and easy to break. This is not true. When opening up our electric toothbrush we discovered that there was a layer of different plastic that also served as a waterproofing layer. Another constraint would be that decreasing the amount of moving plastic parts would increase the noise level. That is not true because by adding a layer of silicon to the metal head it would sufficiently decrease the noise level produced by the toothbrush.

1 Maintenance
1.1 Water-proof seal for batteries
1.2 Easy to clean
1.3 Minimal Crevices
2. Green
C.1 Less plastic
2.2 Speed Settings
2.3 More power efficient
3. User Friendly
3.1 Light weight
3.2 Easy to Hold
C.2 Low noise
3.4 Interchangable heads
3.5 Longer neck
3.6 More flexible head
4. Image
4.1 Oral-B ID
4.2 Colors

Figure 1. AHP Pairwise Comparison Chart to Determine Weighting for Main Objective Categories

This is our AHP table. It compares the two qualities of our product and tells which one is more important. When comparing the two qualities, if the first one has a greater importance than the second one then it has a whole number on a scale from one to ten. The second quality would then get the reciprocal of that number in the area where those two qualities are compared. You figure out the weight by taking the percentage of all the totals combined. This is important because you find the real importance with each quality.

	User friendly	Maintenance	Green	Image	Total	Weighting
User Friendly	1.00	0.20	6.00	6.00	12.2	0.33
Maintenance	5.00	1.00	7.00	7.00	20.0	0.53
Green	0.17	0.14	1.00	2.00	3.31	0.09
Image	0.17	0.14	0.50	1.00	1.81	0.05

Figure 2. AHP Pairwise Comparison Chart to Determine Weighting of User Friendly Sub-Objectives

For this table we compared the possible qualities that could be changed to improve the toothbrush. We chose multiple qualities derived from the consumer survey.

	Light weight	Easy to hold	Low noise	Interchangeable heads	Longer neck	More flexible head	Total	Weighting
Light weight	**1.00**	**0.14**	**0.33**	**0.20**	**0.20**	**1.00**	**2.87**	**0.05**
Easy to hold	**7.00**	**1.00**	**7.00**	**1.00**	**1.00**	**1.00**	**18.00**	**0.29**
Low noise	**3.00**	**1.00**	**1.00**	**0.20**	**0.20**	**1.00**	**6.40**	**0.10**
Interchangeable heads	**5.00**	**1.00**	**5.00**	**1.00**	**1.00**	**1.00**	**14.00**	**0.23**
Longer neck	**5.00**	**1.00**	**5.00**	**1.00**	**1.00**	**1.00**	**14.00**	**0.23**
More flexible head	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**6.00**	**0.10**

Figure 3. AHP Pairwise Comparison Chart to Determine Weighting of Maintenance Sub-Objectives

For this table we compared the possible qualities that could be changed to improve the toothbrush. We chose multiple qualities derived from the consumer survey.

	Water proofing seal for batteries	**Easy to clean**	**Minimal Crevices**	**Total**	**Weighting**
Water proofing seal for batteries	1.00	0.33	1.00	2.33	0.23
Easy to clean	3.00	1.00	1.00	5.00	0.48
Minimal Crevices	1.00	1.00	1.00	3.00	0.29

Figure 4. AHP Pairwise Comparison Chart to Determine Weighting of Green Sub-Objectives

For this table we compared the possible qualities that could be changed to improve the toothbrush. We chose multiple qualities derived from the consumer survey.

	Less Plastic	**Speed Settings**	**More power efficient**	**Total**	**Weighting**
Less Plastic	1.00	0.33	0.20	1.53	0.09
Speed Settings	3.00	1.00	0.20	4.20	0.25
More power efficient	5.00	5.00	1.00	11.00	0.66

Figure 5. AHP Pairwise Comparison Chart to Determine Weighting of Image Sub-Objectives

For this table we compared the possible qualities that could be changed to improve the toothbrush. We chose multiple qualities derived from the consumer survey.

	Oral-B ID	**colours**	**Total**	**Weighting**
Oral-B ID	1.00	1.00	2.00	0.50
Colours	1.00	1.00	2.00	0.50

Table 3. Weighted Hierarchal Customer Needs List Obtained from Focus Group and Individual Interviews

After creating the AHP pairwise comparison charts to determine the weighting of each sub-objective we put them into a more organized chart where it shows each category and the sub-objectives and the weight of each sub-objective in the main objectives.

1 Maintenance (0.53, 0.53)
1.1 Water-proof seal for batteries (0.1219, 0.23)
1.2 Easy to clean (0.2544, 0.48)
1.3 Minimal Crevices (0.1537, 0.29)
2. Green (0.09, 0.09)
C.1 Less plastic
2.2 Speed Settings (0.0225, 0.25)
2.3 More power efficient (0.0594, 0.66)
3. User Friendly (0.33, 0.33)
3.1 Light weight (0.0165, 0.05)
3.2 Easy to Hold (0.0957, 0.29)
C.2 Low noise
3.4 Interchangable heads (0.0759, 0.23)
3.5 Longer neck (0.0759, 0.23)
3.6 More flexible head (0.033, 0.10)
4. Image (0.05, 0.05)
4.1 Oral-B ID (0.025, 0.50)
4.2 Colors (0.025, 0.50)

3.0 Revised Problem Statement

The purpose of this project is to redesign an electric toothbrush that will better serve the customer. After research and data collecting it has been determined that the toothbrush is too bulky, loud, and is not user-friendly. The purpose of this project is to redesign an electrical toothbrush to decrease the size, decrease the noise and vibration level, maintain a low cost, and to create an efficient brush head. We chose to redesign the body of the toothbrush by using less plastic and a different body design, which would also keep the cost low. We chose to coat the metal inside the toothbrush with silicon to cut down on vibrations and noise. The brush head was redesigned to have two bristle heads to more effectively clean teeth. The team has decided to take a mechanical engineering discipline to improve on these issues.

4.0 External Search

For external research, we have performed multiple activities, such as, putting out a survey and looking up other mechanical toothbrushes produced by different companies. We have also done experimentation and observation to gain more knowledge about our product.

4.1 Lab 1 and Lab 2 Reports

In lab one, we observed the materials and parts of the toothbrush. From this we made a chart detailing the materials and parts. We next did online research to find out how the product is marketed and its shelf cost. For lab two, we measured how loud the vibration sound is with a decibel meter. It was found to be up to 66.6 decibels loud four inches away from the decibel meter. The batteries' voltage was then measured and it was concluded that they both used a little over 1.5 volts. Last, the toothbrush was dissected, weighed; the pieces were researched, as to how they were made and their cost, and labeled. Using pictures we showed what the pieces looked like.

(This is the observational data of each detachable piece)

(This is the observational data taken during lab one)

Features of the Toothbrush

Getting Ready for Dissection: Part I (cont.)

Piece observation

Getting Ready for Dissection: Part I

Manufacturer/Model Number: Oral-B Advanced Power 400 D 4010 Type 4739

General Product Information:

How many detachable pieces the product has? 4

Part number:	Part name:
1	tooth brush cover
2	replaceable tooth brush head
3	battery cover
4	batteries

Describe the pieces including their functions and their materials.

Part number:	Material & Functional Description:
1	plastic, covers head of toothbrush to keep it clean
2	cleans teeth, is replaceable, head spins to clean teeth
3	covers batteries, rubber ring keeps the water out
4	powers the tooth brush

Is it easy to detach each part?

Part number:	Detachment (Easy, difficult, use of force etc.):
1	easy to detach, snaps on
2	easy to detach, snaps on
3	a little more difficult to detach, takes more strength to push; buttons to release cover
4	extremely easy, they slide in and out

Describe the packaging. Is it easily opened? Describe the opening procedure.
The packaging is thick plastic. It was difficult to cut and pull the toothbrush out of the packaging. The user would cut the plastic across the top with scissors. Then the user would cut down the side. This would then allow the user to pull the toothbrush and batteries out of the packaging.

Product Features: Provide team's collective opinion related to features of the product using the following list as a starting point.

Packaging (including information insert)	It is packaged in sealed hard plastic. The information insert provides information about how the toothbrush functions. It states that the toothbrush uses 3 volts of

	energy. It informs that it is an advanced toothbrush because of the materials and bristles. One the inside of the packet, there are directions as to how to use the toothbrush. Batteries were included with the product.
Aesthetics (multi-color, etc.)	The toothbrush is smooth and has a cone-like figure up until the head. It has three colors. Blue bristles, white bristles and a white and green base.
Cleaning	It requires no cleaning. The head is replaceable. To protect the head bristles and keep them clean there is a plastic shield included to place over the head.
On/off switch location	The on and off switch location is located where the users thumb would be as the user is holding and using the toothbrush.
Battery location	The battery inserts in the bottom of the base of the toothbrush. It is held within the base of the toothbrush.
Ease of switch use	The switch button is easy to reach and press. If it is pressed in, the toothbrush will turn on and continue to vibrate until the button is pressed again. The button can also be pushed and held in. When let go, the vibration stops.
Handle (Ergonomics)	The grip feels nice in the users hands. It is comfortable. The shape is oval to match how the device will be held. The size of the shell is sized so that the base can be held by little kids, as well as adults. The handle/base vibrates. This is uncomfortable.
Quality	The quality seems average. The device works as advertised. There is a limited warranty of two years. This may imply that Oral-B believes that the product is of a good quality and will last two years. The part that keeps the battery in is not completely sealed. Water may be able to leak in and, over time, affect how the energy is transferred to the motor.
Safety	All of the edges are rounded. This would make it hard to scratch the user's self on. When replacing the toothbrush head, the motor piece, that causes the vibration, sticks out. This piece is metal and somewhat sharp. This part can be considered dangerous. The very tip of the metal piece has a triangular shape, leading to a small point.
Versatility, attachments	Attachments include: The toothbrush head, the toothbrush head protector. It has interchangeable heads. The body of the toothbrush is much bigger than non-electric toothbrushes. It takes up more space and is therefore less versatile while storing it. The toothbrush is not flexible so it is hard to use on back teeth and the back sides of front teeth.
Weight with batteries	0.296 Lbs

Environmental friendliness	None
Other features	The color of the bristles fades when the toothbrush head needs replacement.

Online product research	
Getting Ready for Dissection: Part II	
Cost (Be prepared to record multiple values and sources)	Replaceable Head - $18.99 – Soap.com Replaceable Head - $19.95 – Ob.factoryoutletstore.com Electric toothbrush - $24.95 – Ob.factoryoutletstore.com Cheapest other electric Oral-B toothbrush recommended by oralb.com - $32.99 – Kmart.com
How long has the product been in the market?	Since 2003
Target population	General Public The adult public with the normal white and green/blue colors The children public with fun designs. Examples are superheroes and princesses designed on the handle of the toothbrush.
Versions of the product (Previous versions of the product)	Any electric toothbrush before the date of 2003
What are improvements between versions of the product?	Bristle technology and noise reduction.
How is it sold (TV infomercial, drugstores, etc.)	Tv infomercials, drugstores, magazine adds, on-line, supercenter stores (Walmart, Bestbuy, K-mart)
Patented Features (Please include patent dates).	None

	Bill of Materials

Product Manufacturer/Model Number: Oral-B

Date: January 31, 2013

Disassembly method: Take apart
Subtract and Operate Procedure (SOP): Yes, No. *Force (Energy) Flow Diagram: Yes, No.*

Team leader name(s)	**Part #**	**Part Name**	**QTY**	**SOP** Effect	**Function**	**Mass** (oz, g)	**Material**	**Manuf. Process**	**Dimensions**	**Cost**	**Time to Complete Part Dissection**
Elana	1	Brush Head	1	Yes	Brush teeth	0.0012	Plastic, nylon, metal	Plastic—injection Metal—punch, nylon—extruding	1.625 x 0.5 x 0.75	$1.00	15 min
Avery	2	Battery Cover	1	Yes	Protect from water, hold batties	N/A	Plastic	Injection	2.5 x 0.875 x 0.875	$0.10	0 min
Alex	3	O-Ring	1	Yes	Seal out water from batties	N/A	Rubber	Purchased	0.06 x 0.875 x 0.875	$0.02	0 min
Jasmin	4	Battery	2	No	Power toothbrush	0.108	Alkaline	Purchased	1.9375 x 0.5 x 0.5	$1.25	0 min
Avery	5	Motor	1	No	Provides motion for driveshaft	0.074	Plastic and metal	Purchased	4.5 x 0.625 x 0.5625	$1.50	5 min
Jasmin	6	Casing	1	Yes	Houses batteries and motor	0.022	Plastic and rubber	Plastic—injection Rubber—injection	5.5 x 0.8125 x 0.8125	$0.50	30 min
Avery	7	On-off switch	1	Yes	Turns on and off toothbrush	N/A	Plastic	Purchased	1.25 x 0.5 x 0.125	$0.10	5 min
Alex	8	Brush Head Cover	1	Yes	Protects bristles when not in use	0.006	Plastic	Injection	3.8125 x 0.75 x 0.75	$0.08	0 min
Avery	9	Driveshaft Rod	1	Yes	Motion for brush head	N/A	Metal	N/A	3.8125 x 0.125 x 0.125	$0.20	2 min
Alex	10	Spring Piston	1	Yes	Moves bristles from driveshaft motion	N/A	Plastic, Metal Spring	Plastic—injection Spring--purchased	1.75 x 0.25 x 0.1875	$0.50	10 min

(This is the table describing the cost, mass, dimensions and manufacturing process of each piece that was dissected)

(The component, subassembly and assembly hierarchy)

Electric toothbrush

Assembly Level

Batteries, plastic cover, battery compartment cap, tooth brush head

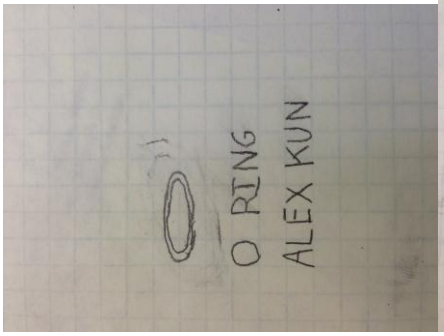
O-Ring, spring piston, metal rod, metal piece for battery cover, outer casing

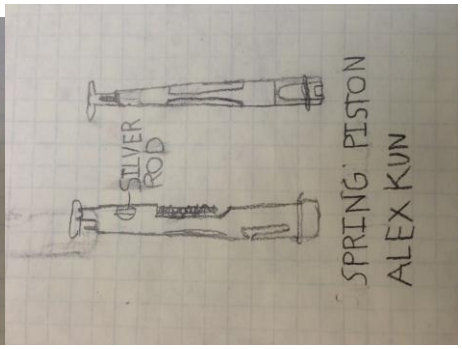
Sub-assembly Level

Plastic, metal, wires, bristles, rubber/silicone

Component Level

(Pictures of the pieces)

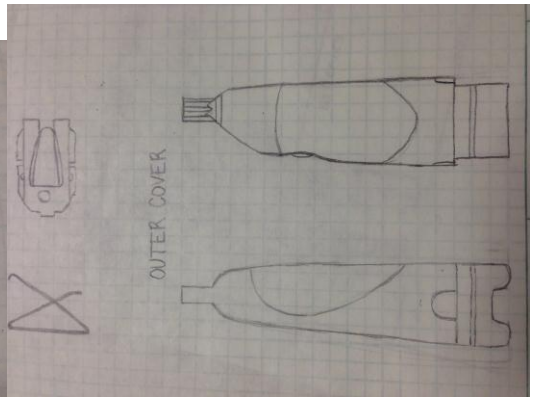


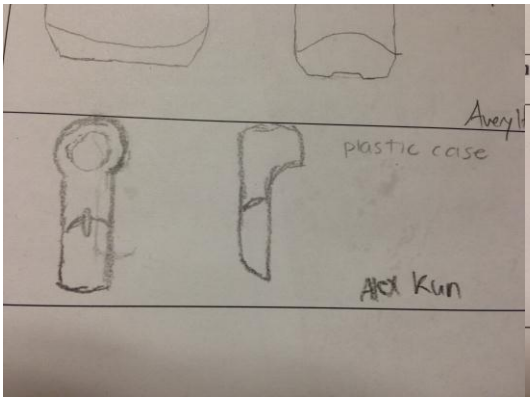


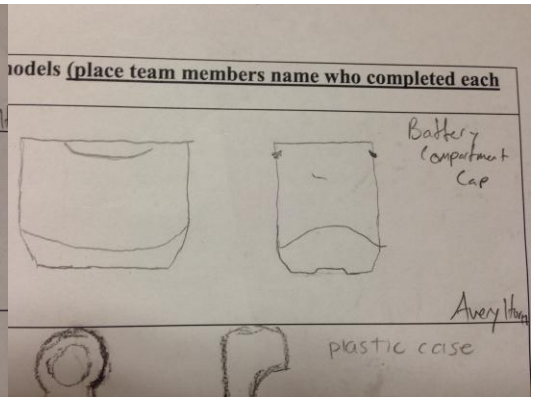
MOTOR
ALEX KUN

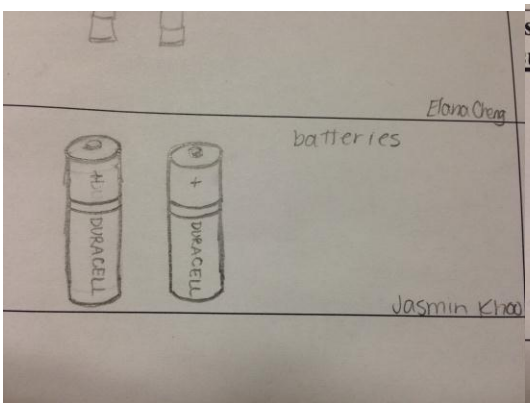
BATTERY RELEASE SPRING

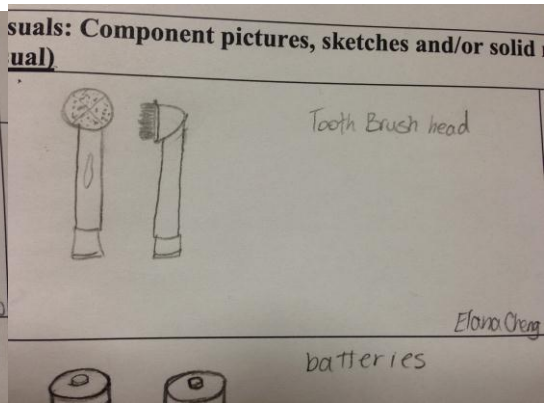
METAL PIECE FOR BATTERY COVER


OUTER COVER


plastic case
Alex Kun


odels (place team members name who completed each
Battery Compartment Cap
plastic case


Elana Cheng
batteries
DURACELL
DURACELL
Jasmin Khoo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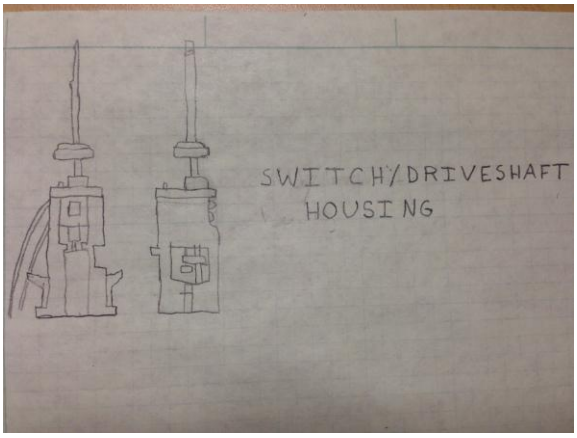
Tooth Brush head
Elana Cheng
batteries



4.2 Patent Search

We did external research on patents to determine which features of the toothbrush were able to be used in our redesign. By finding the circular tooth brush head patent, we were able to change the design, which included two brush heads instead of one. The rest of the patents had expired and were available for use. The table below shows the patents that were found for each design aspect of the electric toothbrush.

Table 4. Patent Search Matrix for Electric Toothbrush

FUNCTION		**ART**			
	On and off switch	Toothbrush motor	Circular Toothbrush head	Removable, replaceable toothbrush head	Bar anchorage
Turns device on and off	US 5943723				
Motorize toothbrush		US 2310626			
Vibrates and cleans teeth			US5862558		
To replace bristles				US 5247716	US5918934

4.4 Benchmarking

This table was set up to compare three different electric toothbrushes to each other. The features of each toothbrush are located on the left side of the table while the type of each toothbrush are located at the top of the table. Each product is rated on a scale from one to five with five being the best possible score.

Table 5. Benchmarking of Three Products

Feature	**Oral-B**	**Crest Spinbrush pro Clean**	**Phillips sonicare**
Aesthetics	Rubber coated so it has a non-slip grip. (1)	Bulky body, formed to fit hand. Slippery (2)	Slim head. (4)
Colors	A few color choices (3)	Multiple choices (4)	White with teal on off button (2)
Ease to clean	Yes (5)	Slightly difficult (3)	Yes (5)
Convenience of on/off switch	Convenient (4)	Slightly difficult at times to turn on/off (3)	Very easy (5)
Head shape	One round head (3)	Round and rectangular base (4)	Oblong (4)
Price	$10-$20 (5)	$10-$15 (5)	$100-$200 (2)
Total Rating	21	21	22

According to our table, some of the tooth brushes did better than others in certain areas. We decided as a team to take the best features of each toothbrush to create our new design.

5.0 Concept Generation

5.2 Concept Generation

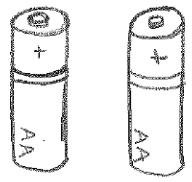
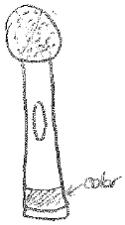
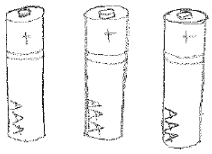
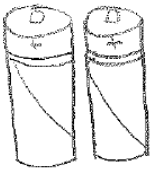
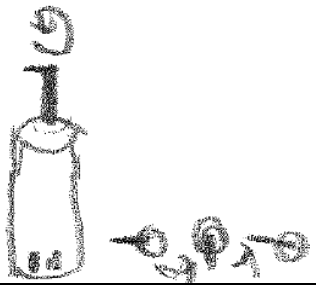
When coming up for different concepts we first made a plan. In our plan we listed our resources, the steps for coming up with concepts, and who would think of concepts for each of the four different criteria. For our resources we had listed iPads/iPhones, the progress report, our four brains, and the online book. For our plan we had planned out that we would first think of ideas individually, exchange ideas, plan a concept, and then finally draw and write out possible designs. There were eight different concept areas on each of the eight packets of concept criteria we had. There were two packets of each of the four criteria: Human factors body design, power generation and power accessories, energy mechanism for brush head, and brush head design. Since there were four people in our group we all decided to split up the work and choose two of the concept criteria concepts that we had ideas for. After splitting up the work evenly we got to work on concepts.

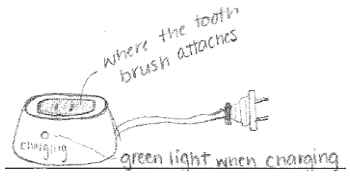
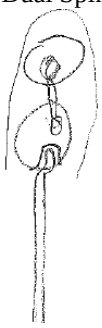
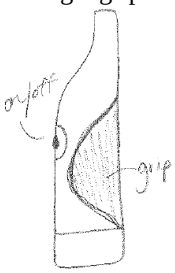
**see attached for concept ideas.

6. Concept Selection

After narrowing down our concepts based on our consumer needs survey, we made a morphological chart. After making a morphological chart we made Pugh Charts for each of the four main categories. When making Pugh Charts we made two iterations to confirm which of the concepts were ranked first among the other concepts.

Figure 6. Morphological chart
Our morphological chart was made by narrowing down our concepts based on our consumer needs survey. In each category we have the concept and a sketch based on each idea.

Power generation	Energy mechanism for brush head	Brush head design	Human factors body design
Battery(AA) 	Spins 360°	Color band 	Thick gel grip (full)
Battery(AAA) 	Up& down	One stationary one spins	Power button
Chargeable battery 	Back &forth 	2 spinning	Form to hand shape

Outlet 	Dual Spin 	One spin one up and down	Twist power control
		Top and bottom stationary, middle moves side to side	Half gel grip 
		One spinning	
		One moves up and down	
		One moved side to side	

Pugh Charts

The results from our pugh charts allowed us to choose the best design for our electric toothbrush. We concluded that the best designs for each category are to use AA batteries for the power generation, the energy mechanism for the brush head is the dual spin, the brush head design is dual spin brush head and color id, and the body design was a form to hand handle with a power button.

Table 1. Power Generation Pugh Chart

We made two Pugh Charts to confirm that the top ranked concept was truly the best concept that we used for power generation for our electric toothbrush.

Iteration 1:

	Size	Cost	Weight	Sum	Rank
Relative Weight	0.25	0.25	0.25		
Concepts					
2AA batteries	0	0	0	0	1
3AAA batteries	-1	-1	0	-0.5	2
Chargeable	-1	-1	0	-0.5	2
Charging dock	0	-1	-1	-0.5	2

Iteration 2:

	Size	Cost	Weight	Sum	Rank
Relative Weight	0.25	0.25	0.25	0.25	
Concepts					
2AA batteries	+1	0	+1	0.5	1
3AAA batteries	0	0	0	0	2
Chargeable	-1	-1	-1	-0.75	3
Charging dock	-1	-1	-1	-0.75	3

Table 2. Energy Mechanism for Brush Head

We made two Pugh Charts to confirm that the top ranked concept was truly the best concept that we used for energy mechanism for brush head for our electric toothbrush.

Iteration 1:

	Size	Cost	Weight	Sum	Rank
Relative Weight	0.25	0.25	0.25		
Concepts					
Dual Spin	0	0	0	0	1
Up & Down	-1	0	0	-0.25	2
Back & Forth	-1	-1	0	-0.5	3
Spin 360°	-1	-1	0	-0.5	3

Iteration 2:

	Size	Cost	Weight	Sum	Rank
Relative Weight	0.25	0.25	0.25		
Concepts					
Dual Spin	+1	-1	0	0	1
Up & Down	0	0	0	0	1
Back & Forth	-1	0	0	-0.25	2
Spin 360°	+1	-1	-1	-0.25	2

Table 3. Brush Head Design

We made two Pugh Charts to confirm that the top ranked concept was truly the best concept that we used for brush head design for our electric toothbrush.

Iteration 1:

	Size	Cost	Weight	Sum	Rank
Relative Weight	0.2	0.2	0.2		
Concepts					
Color ID	0	0	0	0	1
One Spinning	0	-1	0	-0.2	2
Dual Spin	0	-1	+1	0	1
1 move 2 stationary	-1	-1	-1	-0.6	3
Side to side	-1	-1	-1	-0.6	3

Iteration 2:

	Size	Cost	Weight	Sum	Rank
Relative Weight	0.2	0.2	0.2		
Concepts					
Color ID	+1	+1	+1	0.6	1
One Spinning	+1	0	-1	0	2
Dual Spin	+1	+1	+1	0.6	1
1 move 2 stationary	0	0	0	0	2
Side to side	0	0	0	0	2

Table 4. Human Factors Body Design

We made two Pugh Charts to confirm that the top ranked concept was truly the best concept that we used for human factors body design for our electric toothbrush.

Iteration 1:

	Size	Cost	Weight	Sum	Rank
Relative Weight	0.2	0.2	0.2		
Concepts					
Twist Power	0	0	0	0	3
Form to Hand	0	+1	+1	0.4	1
Gel Handle	0	+1	0	0.2	2
Thick Gel	0	+1	-1	0	3
Power Button	0	+1	+1	0.4	1

Iteration 2:

	Size	Cost	Weight	Sum	Rank
Relative Weight	0.2	0.2	0.2		
Concepts					
Twist Power	0	-1	0	-0.2	2
Form to Hand	0	0	0	0	1
Gel Handle	0	0	-1	-0.2	2
Thick Gel	0	-1	-1	-0.4	3
Power Button	0	0	0	0	1

6.0 Final Design

The final design of the toothbrush has some significant differences than the original toothbrush presented. The first and most noticeable change is the brush head and bristles. Our final design had two circular bristle heads, instead of one. These two circular bristle heads rotate in opposing directions to scrub the teeth more efficiently than one bristle head. The bristles on each head are made of a nylon fiber, but consist of different strengths. The bristles on the outer-most ring of the circle are the longest bristles, but they are also the weakest. They are long so that they can reach the very bottom of each tooth and between each tooth. They are weak because they are the bristles that directly touch the gums and are the bristles that could potentially damage the gums. The second ring of bristles is a little shorter than the outside bristles. They are also a little firmer. They are shorter because they do not need to reach around each tooth. They clean the top outside halves of each tooth. They are firmer because they must scrub off most of the plaque. The last ring of bristles, found at the center of the circular bristle head, are the shortest and the strongest. These bristle come in contact and clean the top and inside top part of the teeth.

The shape was changed from a conical shape to a cylindrical shape. The grip that covered half of the body was changed into a full grip that surrounds the body. This grip is a thicker, more gel-like rubber as opposed to the original, hard rubber. It is more form fitting and is more comfortable to the user than hard rubber.

To make the brush more environmentally friendly, we had the brush molded from Polyether Ether Ketone. This is a highly resistant plastic that is durable, but when presented in sulphuric acid at room temperature it dissolves completely (1).
The metal rod that oscillates up and down is coated with a silicone layer to reduce vibrations during use. By coating the metal rod with silicone, we avoided the metal on plastic vibrations and turned them into a silicone on plastic vibration that is much quieter.

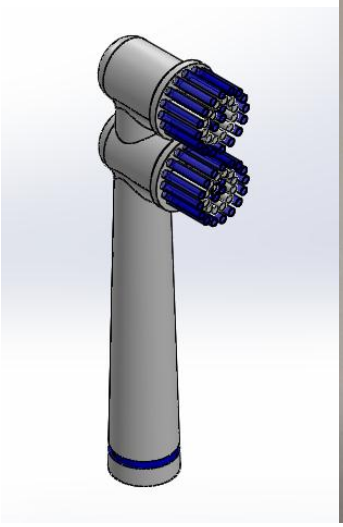
6.1 Design Drawings, Parts List and Bill of Materials

This section has the different CAD drawings of the final design. It includes each part that we changed from the original electric toothbrush. It also includes a bill of materials, the rest of the materials are the same as the original electric toothbrush which can be found in section 4.1. Beside each CAD drawing is a sketch of the toothbrush.

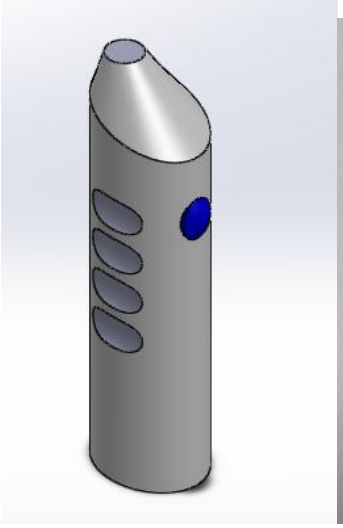
Bill of Materials:

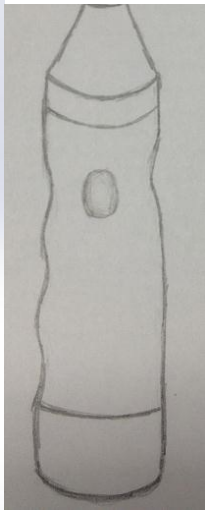
Part #	Part Name	Qty	SOP Effect	Function	Material	Manufacturing Process	Dimensions
1	Body (Electric housing)	1	Protect moving parts and batteries	Hold the motor and batteries	Polyether Ether Ketone	Injection-molding	2.17” x 1.42” x 6.00”
2	Circular Bristle Head	2	Spin 180 degrees back and forth	Clean teeth	Nylon	Injection-molding	0.5” Diameter
3	Grip	1	Molds to hand shape when gripped	Provide comfortable surface to grip	Gel	Injection-molding	N/A
4	Color ID	1	Manufactured in different colors	Differentiate toothbrush heads for different family members	Polyether Ether Ketone	Injection-molding	0.125”

Brush Head:

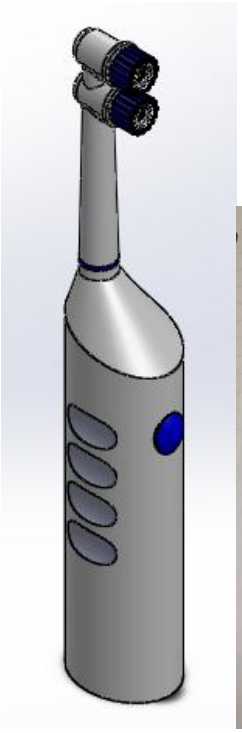


Body:





Full View:



6.2 How does it work?

The toothbrush functions very similar to any standard electric toothbrush. While it has many of the same parts as the standard electric toothbrushes, it has a few modifications. The original toothbrush's body was design in a cone like fashion. It was wider at the bottom and it sloped upward slightly. We designed the body to be cylindrical. This makes the toothbrush look more aesthetically pleasing. The better the toothbrush looks, the more people will enjoy buying and looking at it.

We changed the surface area of the body as well as the shape. We added a gel-like grip that forms to the user's hand. The grip wraps completely around the body of the toothbrush starting at where the battery cap connects and ending where just above the on and off button. This makes the toothbrush more comfortable to hold. Because people must brush their teeth for two minutes, they will want a comfortable toothbrush to hold. The gel-like grip also provides friction so that the user does not drop the toothbrush if it gets wet.

The toothbrush bristle design was also changed. Another circular set of bristles was added above the original set. This allows the toothbrush to have two different circular sets of bristles that both spin thirty degrees both counter and not counter clockwise from resting position. The added bristles will be able to scrub another tooth while the first set scrubs the first tooth. This will speed up brushing a little bit and make sure that plaque is brushed off more thoroughly. The two bristle heads are positioned close to each other. This allows the edges of the circular bristles to also scrub between teeth while the others scrub around the outside of the user's teeth. This is to prevent cavities from the crevices between each tooth.

The energy source was not changed. Batteries provide an ample amount of energy, and considering the short amount of time the toothbrush is on, the batteries will last long enough to avoid creating a rechargeable pack and recharger. This saves some money.
The AA batteries power our toothbrush's motor. The motor then oscillates a rod up and down. This rod connects to the brush head and the inside of the bristle head at an angle. This angle allows the motor to spin the circular brushes while it oscillates up and down. The top circular bristle set is attached to the bottom set by a small plastic rod at the same angle that the motor's rod attaches to the first bristle set. When the first bristle set spins, the rod that attaches to the second bristle set is pulled and the other bristle set spins in the opposing directions. This allows the bristles to scrub the teeth.

7.0 Conclusions

We as Team 5 believe that overall our redesign of the electric toothbrush was a success. We changed what we needed to be changed according to our results from the consumer survey. From our survey we found that the consumers wanted something that was slightly small in size, on the lower end of the price range, had a green energy source, and easy to maintain. The toothbrush that our group designed had all of these features and was also made to be user-friendlier. We also added in some more features such as the color band and the gel-like grip to make our design stand out from others.

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"PEEK." *Wikipedia*. Wikimedia Foundation, 02 Aug. 2013. Web. 25 Feb. 2013.

Appendix

Questions from survey:

- What's the number one thing that you look for in a toothbrush?
- Do you look for speed settings when buying an electric toothbrush?
- What's your price range for an electric toothbrush?
- Do you currently use an electric toothbrush? If you don't why not?
- Do you look for ″green″ products when buying things?
- Does appearance matter to you?
- How often do you replace your toothbrush?
- How often do you brush your teeth?

- If you do use an electric toothbrush, do you find it hard to reach some areas in your mouth. If you do, where?
- What do you prefer?