Tooth Brush Project

Caitlin Reamer
Ryan Moon
Julian Pecce
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Team Number 3

Abstract
The objective of this project was to analyze the present products in the market and redesign the product based on targeted customer needs. First, we researched the product which was the Advanced Power 400 Oral-B toothbrush. Some aspects of our research included literature, patent, and product dissection. Our next step was to revise the design by using the pairwise comparison chart.

1.0 Introduction

Our team has been put in charge of creating a concept for a new niche market for their sustainable electric toothbrush. We will develop new concepts for a sustainable electric toothbrush. Using all resources, we will gather information surrounding the electric toothbrush in order to determine what features will be shown in our new electric toothbrush. Also, we will compare the current product to other electric toothbrushes on the market.

We managed our project in a very efficient and timely manner. We estimated the time it would take to complete each task, so we could plan out a schedule. Tools such as the internet have helped us find the average price of the product, patents for the product, and any other general information about the product. Also, we used tools such as the clamp, screwdriver, pliers, handsaw, and razor to disassemble the product.
In the coming sections, we will discuss the initial problem statement and customer needs for our product.

1.1 Initial Problem Statement

Our initial problem statement was to design a product based on a current product in the market that will better meet the needs of the targeted environmentally conscious/green population. The main components that we considered redesigning were the materials and conservation of power.

2.0 Customer Needs Assessment

For the customer needs assessment, we made up a list of questions to ask customers about our product. Using the results of this survey, we came up with a list of the most important features that we need to emphasize in the creation of our product. We interviewed a total of twelve customers. In the tables to come, we will determine the most important customer needs and will rank them using an AHP chart. Also, we will determine the weighting of each customer need.

Table 1. Initial Customer Needs List Obtained From Team Focus Group and Individual Interviews/Surveys

A. Grip (fits in hand well)
B. Battery Length
C. Effectiveness
D. Size of Brush Head
E. Weight
F. Design Creativity
G. Safety
H. Easy to turn on and off

I. Assembly
J. Cost
K. Sustainability

2.1 Weighting of Customer Needs

Table 2. Hierarchal Customer Needs List

1. Effectiveness
1.1 Cleans teeth
1.2 Battery life
F.1 Strength
C.1 Safety
C.2 Size
2. User friendly
2.1 Low Noise
2.2 Safe
F.1 On and Off button works
F.2 Detachable parts are functioning
2.3 Instructions
3. Sustainable
3.1 Recyclable materials
4. Durable
4.1 Easy Maintenance
4.2 Lasts long

C. 3 Retails under $80

In the figure below, we will determine the importance (weighting) of each customer need.

Column1	A	B	C	D	E	F	G	H	I	J	K
A	X	1	1	1	1	-1	1	1	1	1	1
B	-1	X	1	-1	-1	-1	1	1	1	-1	1
C	-1	-1	X	-1	-1	-1	1	-1	-1	-1	1
D	-1	1	1	X	-1	-1	1	-1	-1	-1	1
E	-1	1	1	1	X	-1	1	1	-1	1	1
F	1	1	1	1	1	X	1	1	1	1	1
G	-1	-1	-1	-1	-1	-1	X	-1	-1	-1	1

H	-1	-1	1	1	-1	-1	1	X	-1	1	1
I	-1	-1	1	1	1	-1	1	1	X	1	1
J	-1	1	1	1	-1	-1	1	-1	-1	X	1
K	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	X
Total	-8	0	6	2	-4	-10	8	0	-4	0	10

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

Column1	A	B	C	D	E	F	total	weight
A	1	0.33	0.2	0.33	0.14	0.33	2.34	0.04
B	3	1	0.33	4	0.2	1	9.53	0.16
C	5	3	1	3	6	4	22	0.36
D	3	0.25	0.33	1	1	0.25	5.83	0.1
E	7	-0.2	0.17	1	1	0.5	9.47	0.16
F	3	1	0.25	4	2	1	11.25	0.19

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

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

A. Size(0.04)
B. Weight (0.16)
C. Strength (0.36)
D. Cost (0.10)
E. Availability (0.16)
F. Manufacturability (0.19)

3.0 Revised Problem Statement

As stated in the initial problem statement, the two components of the product that we are looking to change are the materials and the power consumption in order to create a more environmentally friendly product. In the customer needs assessment, we decided that the main feature that customers want in an electric toothbrush is that it cleans teeth well. Also, seventy-five percent of customers said that the environmental friendliness in a toothbrush matters at least a little bit to them. Using these results, we decided that the features that we wanted to change in our initial problem statement are still consistent with the customers' responses. As a result, we must change the materials and limit the energy consumption of the product while making sure the product can still clean teeth very efficiently.

4.0 External Search

In this section, we will discuss our external searches on things such as the patent search and the product archaeology.

4.1 Lab 1 & Lab 2 Reports

4.2 Patent Search

In the patent search, we looked up patents for certain functions of our product. The reason why we conducted this search is so we don't violate any copyright or infringement rights. We gathered patent data from a google patent search.

Table 4. Art-Function Matrix for Electric Toothbrush

FUNCTION		**ART**			
	rotating bristles, drive shaft, cam	stub rod, spring, coil	gear, orbiting members, spurs	polycrystalline alumina sintered body	
brush head	US 6574820				

bristle fastening structure		US 5138734			
toothbrush motor			US 6721986		
no-slip grip				US 5628082	

As shown above, we determined the components and patent number of each function. The brush head consists of rotating bristles, a drive shaft, and a cam. The components of the bristle fastening structure include a stub rod, a spring, and a coil. A gear, orbiting members, and spurs are located in the toothbrush motor. Finally, the single component of the no-slip grip is the polycrystalline alumina sintered body. For our final product, we determined that we will use all of these functions.

4.3 Product Archaeology

In this external search, we researched the history of the electric toothbrush and used this information to help determine what features our product should and should not exhibit. Since when they were first introduced, electric toothbrushes have gained in popularity and over 150 models have been sold. The first electric toothbrush, the Broxodent, was developed in Switzerland in 1939. This model plugged into a standard wall outlet and ran on AC line voltage. It was initially created for people that were unable to brush their teeth, and for orthodontic patients. The U.S. didn't acquire the electric toothbrush until 1959 and it didn't sell them until 1960. Electric toothbrushes in the U.S. did not become popular until the rechargeable electric toothbrush was invented. These were invented in 1961. Both the Broxodent and the rechargeable electric toothbrush had their pros and cons. The rechargeable electric toothbrush was powered by rechargeable NiCad batteries and was cordless unlike the Broxodent. However, the NiCad batteries weren't a very good power source and often times ran out of power before brushing was complete. Some good features of the Broxodent are that it never ran out of power and that it could last twenty years or longer. On the other hand, it was bulky and was not portable. Other companies started making their own versions of the electric toothbrush, which proved to be competitive to the Broxodent. Eventually, the Broxodent became unpopular in the U.S. and most models were only sold online.

Today, electric toothbrushes are split up into two categories according to the type of action that they employ: vibration or rotation-oscillation. One new feature in modern electric toothbrushes is contactless inductive charging, which makes it easier to charge them. Some other new optional features include a brushing timer and an LCD display screen. The newest development in electric toothbrushes is the ultrasonic toothbrush. This new feature uses ultrasonic waves to clean the teeth. Here is a chart that compares some modern day models of Oral B toothbrushes

Show below is an old advertisement for the broxodent electric toothbrush.

Is your son the "once-over-lightly" type of toothbrusher?

Does he give his teeth a "lick and a promise" instead of a thorough cleaning? If he's this type, he'll brush his teeth *better* with BROXODENT, the automatic-action brush for teeth and gums from Squibb, leader in dental research.

BROXODENT brushes gently up-and-down —120 times a second. Dislodges even tiny food particles, refreshes gums, leaves mouth feeling tinglingly clean. There's constant power—no batteries to run down. Convenient on-off switch. BROXODENT was tested 4 years in dental clinics. Ask your dentist about BROXODENT. Supplied with four different colored snap-on brushes. Additional brushes available. At your druggist's.

Whatever his type, he'll brush his teeth better with Broxodent

Broxodent™ from SQUIBB

Here is a picture of the box that the original broxodent came in.

WHICH ORAL-B TOOTHBRUSH IS RIGHT FOR YOU?	Oral-B® Vitality™ Precision Clean	Oral-B Vitality Dual Clean	Oral-B Professional Care® 1000	Oral-B Professional Care 3000	Oral-B Professional Care Smart Series™ 4000	Oral-B Professional Care Smart Series 5000	Oral-B Pulsonic
Gentle on Teeth and Gums	✓	✓	✓	✓	✓	✓	✓
Timer Helps You Brush for Recommended Two Minutes	✓	✓	✓	✓	✓	✓	✓
Whitens Teeth by Removing Surface Stains	✓	✓	✓	✓	✓	✓	✓
Reduces Plaque to Help Prevent Gingivitis	✓	✓	✓	✓	✓	✓	✓
Pressure Sensor Alerts When Brushing Too Hard			✓	✓	✓	✓	
Sensitive Mode for More Gentle Cleaning				✓	✓	✓	✓
Polish Mode Removes Stains				✓	✓	✓	
In-Handle Smart Display Provides Feedback for Better Brushing					✓	✓	
Wireless SmartGuide™ Helps Maximize Your Routine						✓	

.
Here is a chart that compares different models of Oral-B electric toothbrushes.

4.4. Benchmarking

In this table, we will compare four different models of present-day electric toothbrushes. We will list certain customer needs and will rate them on a five point scale: 1- strongly disagree, 2- disagree, 3- neutral, 4- agree, 5- strongly agree. These will be rated for each toothbrush and will be compared to our expectations in our product. For each cell rating, we will compare features of the four products to what we expect in our features for our finished product. For example, a rating of 1 for length of charge means that the length of charge for the indicated product is very short compared to the length of charge that we expect in our final product.

Table 5. Benchmarking of Four Products

Feature	**Oral-B ProfessionalCare SmartSeries 4000**	**Crest Spinbrush Pro Clean**	**Colgate 360 Sonic Power**	**Oral-B ProfessionalCare 1000**
Packaging	1	4	5	2
Aesthetics	2	3	4	2
Ease to clean	5	4	3	4
Convenience of on/off switch	5	2	5	4
Length of charge	5	4	3	2
Grip (fits in	4	4	5	4

hand well)				
Price	1	5	5	1
Cleans teeth well	5	3	3	4

4.5 Design Target

In our external search, we looked at the history of electric toothbrushes and compared different models of modern day electric toothbrushes. After all of this research, we decided that we need to make sure that our toothbrush holds a long charge, is easy to use, is easily gripped, uses the least amount of power possible, and uses the least amount of materials possible to help conserve the environment.

5.0 Concept Generation

5.2 Concept Generation

Brush Head Design	**Body Design**	**Power Generation**	**Energy Mechanism**
Dual Brush Head	Retractable	DC Motor	Gear
Double Rotation	Brass Knuckles	AA Battery	Crank
Circular and Back and Forth	Grooves	Solar Panel	Circular pin Motion

Figure 5. Morphological chart

For *each function or customer need or user action,* develop concepts that should be explained through a combination of sketches and accompanying text. Document the morphological chart that was developed from the different concepts for each function (Figure 5). More information and an example can be found on pages 182-185 of the course text. All sketches should be should be in digital format (if drawn manually please add scanned sketches in your report).

6. Concept Selection

Below is our Pugh Chart for the Human Body Design of our electric toothbrush. Here we used two datums, the Retractable and Knuckle Grooves, in order to make an effective pugh chart that gives us a rank of the best design. We compared the size, weight, durability, and safety of each desgin to the datum. Overall we found that The Retractable ranked number 1 in both iterations.

Pugh Chart 1

	Size	Weight	Durability	Safety	Total	Rank
Weighting	**0.2**	**0.2**	**0.3**	**0.3**		
Concepts						
Iteration 1						
Brass Knuckles	-1	-1	1	0	-0.1	2
The Retractable	0	0	0	0	0	1
Knuckle Grooves	1	0	-1	-1	-0.4	3
Iteration 2						
Brass Knuckles	-1	-1	1	1	0.2	2
The Retractable	-1	0	1	1	0.4	1
Knuckle Grooves	0	0	0	0	0	3

6.0 Final Design

In our final design, we incorporated various concepts such as the dual brush head, the retractable brush head, and rechargeable AA batteries. The on/off button is just one button. The brush head retraction function is completely manual; the user must push the head down into the body when the toothbrush is not in use. To prepare for use, the user must pinch the sides of the brush head that are made accessible through the gaps on the side of the body and pull up. The head snaps in place so that it does not move while the user is brushing their teeth. To move the head the user must use some force to override the snap mechanism.
Discuss details of the final design. This should be well illustrated with *multiple* 3-Dimensional models, as well as dimensioned part drawings for each component redesigned. These drawings completed in SolidWorks should be placed in appendices.

6.1 Design Drawings, Parts List and Bill of Materials

Drawings should have scale information and must include

6.2 How Does It Work?

Power and Charge: The toothbrush uses 2 rechargeable AA batteries and uses inductive charging. Also, we added in a way of manually charging the battery. If there is not much battery charge left, all one has to do is shake the toothbrush. After about 30 seconds, it will have created just enough energy to power the toothbrush for about3 minutes. The toothbrush is powered by a small battery.

Toothbrush Head: We decided to use the multi-head feature for our product. In this feature, there are 6 microbrushes that clean the top and bottom teeth at the same time. This results in a significantly faster time it takes to brush one's teeth. The time it takes is between 30 and 40 seconds. The toothbrush head wraps around and hugs the gums to ensure that all the teeth are cleaned very effectively.

7.0 Conclusions

Overall, we designed a super efficient electric toothbrush that should meet at least 4 out of the 5 most important customer needs. It is made out of the most sustainable materials, is extremely safe to use, is more effective than any other electric toothbrush ever made (because of the dual brush head), and should be affordable. All in all, our toothbrush should succeed very well and should become the new best toothbrush on the market.

References

Anderson, Arnold. "History of the Electronic Toothbrush." *EHow*. Demand Media, 18 May 2009. Web. 12 Oct. 2012. <http://www.ehow.com/about_5031763_history-electronic-toothbrush.html>.

West, Larry. "Can You Recycle YourÂ Toothbrush?" *About.com Environmental Issues*. About.com, n.d. Web. 12 Oct. 2012. <http://environment.about.com/od/earthtalkcolumns/a/toothbrush.htm>

"UsingÂ A Rechargeable Electric Toothbrush." *UsingÂ A Rechargeable Electric Toothbrush by Oral-B*. N.p., n.d. Web. 12 Oct. 2012. <http://www.oralb.com/topics/using-a-rechargeable-electric-toothbrush.aspx>.

Appendix

Pugh Chart 2

	Size	Weight	Safety	Effectiveness	Total	Rank
Weighting	**0.2**	**0.2**	**0.3**	**0.3**		
Concepts						
Iteration 1						
Dual-Flex Head	-1	1	1	1	0.6	1
Double Rotation	0	0	0	0	0	3
The Classic (concept 2)	1	0	0	1	0.5	2
Iteration 2						
Dual-Flex Head	-1	1	1	0	0.3	1
Double Rotation	-1	0	0	-1	-0.05	3
The Classic (concept 2)	0	0	0	0	0	2

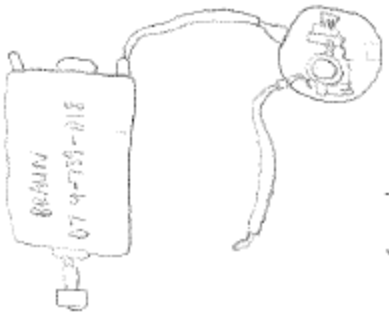
Pugh Chart 3

	Size	Weight	Power	Sustainability	Total	Rank
Weighting	**0.2**	**0.2**	**0.3**	**0.3**		
Concepts						
Iteration 1						
Shake Coil	1	1	-1	1	0.4	1
Rechargeable Battery	0	0	0	0	0	2
DC Motor	1	-1	1	-1	0	2
Iteration 2						
Shake Coil	0	0	0	0	0	1
Rechargeable Battery	-1	-1	1	-1	-0.4	2
DC Motor	1	-1	1	-1	0	1
Iteration 3						
Shake Coil	-1	1	-1	1	0	1
Rechargeable Battery	-1	-1	-1	1	-0.4	2
DC Motor	0	0	0	0	0	1

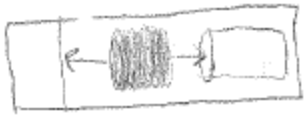
Pugh Chart 4

	Size	Weight	Effectiveness	Cost	Total	Rank
Weighting	**0.2**	**0.2**	**0.3**	**0.3**		
Concepts						
Iteration 1						
Crown Wheel	1	-1	-1	0	-0.3	3
Rack and Pinion	0	0	0	0	0	2
Slider Crank	1	0	1	-1	0.2	1
Iteration 2						
Crown Wheel	1	-1	-1	-1	-0.6	3
Rank and Pinion	-1	-1	-1	1	-0.4	2
Slider Crank	0	0	0	0	0	1
Iteration 3						
Crown Wheel	0	0	0	0	0	3
Rack and Pinion	-1	1	1	0	0.3	2
Slider Crank	1	1	1	-1	0.4	1

Student Name Ryan Moon Team 3

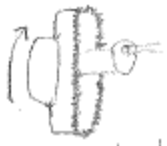
	Power generation and power accessories (function)
Concept 1	 - DC motor RM
Concept 2	- AA battery RM
Concept 3	- AA rechargeable battery RM
Concept 4	- solar panel - could be mounted on side of toothbrush RM

Student Name Ryan Mann

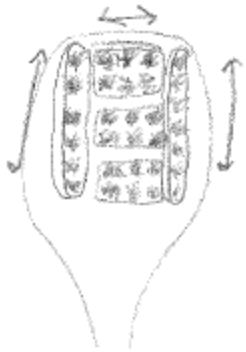
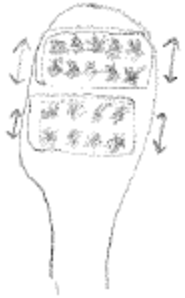
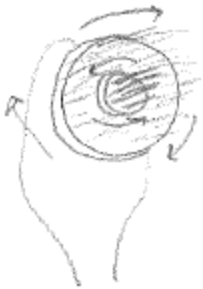
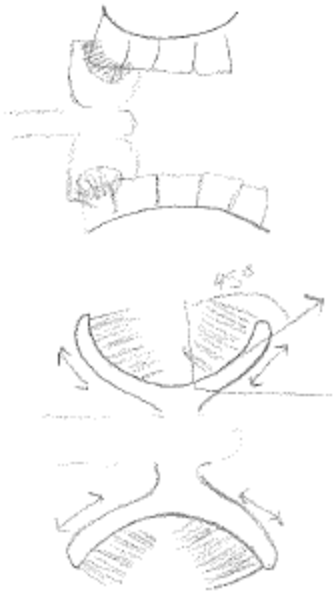
	Power generation and power accessories (function)
Concept 5	 shake toothbrush to create energy RM.

Student Name Ryan Muon

Energy mechanism for brush head (function)

Concept 4	Concept 3	Concept 2	Concept 1
circular pin motion - Rotary "Sliotch Yoke" Mechanism RM	 - slider crank - creates oscillating motion in toothbrush head RM	 - crown wheel gear RM	 - pinion and gear - converts motor motion into oscillating motion RM

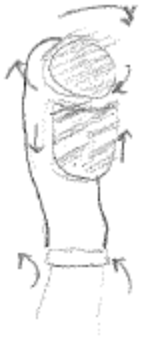
Student Name Caitlin Rainer

Concept 8	Concept 7	Concept 6	Concept 5	
 - up & down - back to back	 - up & downward moving planes	 - double rotation	 - brushes top & bottom teeth at the same time - 40 seconds to brush → saves energy - 810 times per min.	Brush Head Design (form and function)

2AA batteries

Student Name _____

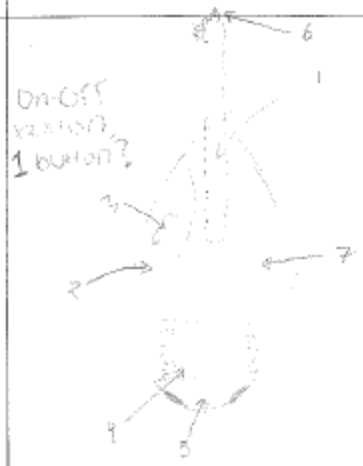
Brush Head Design (form and function)

Concept 1	Concept 2	Concept 3	Concept 4
- Top part moves while bottom does not.	 - Circular rotation - up & down motion - bendable neck	- inward pointing bristles - Rotation	- bristles length changes - up and down motion

CR

Student Name Julian Perez team 003

Human Factors Body Design (form)

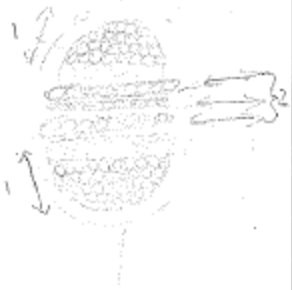
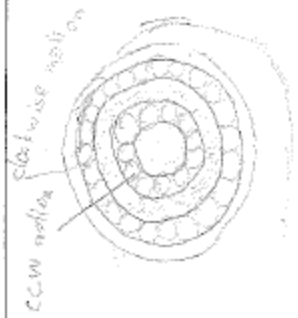
Concept 4	Concept 3	Concept 2	Concept 1
 1. Dual pinch-grip on/off switch. When applied pressure to both tabs, motor is activated; when released motor is deactivated. 2. battery compartment 3. battery cover ↳ batteries can be on top of each other, not just next to each other	 1. 3-finger hole handle for user comfort 2. on/off switch 3. no-slip grip on handle 4. cord or charger source	 1. compartment for retractable brush head 2. battery cover 3. battery compartment 4. slider to push brush head out of compartment 5. on/off button 6. slight curvature on body for better fit in users' hand	 1. compartment within body for retractable brush head 2. No-slip polycrystalline grip 3. user-friendly on/off button 4. battery compartment 5. battery cover 6. pinch-grip to pull out brush head from compartment 7. spherical body for comfortable fit in hand

Student Name Julian Pecce team 003

	Human Factors Body Design (form)
Concept 5	 1. Heat sensitive on/off switch; when body heat is detected, brush motor is activated. 2. battery compartment 3. battery cover

Student Name Wilson Pecce Team 003

Brush Head Design (form and function)

Concept 1	Concept 2	Concept 3
1. Heat sensitive on/off switch; when inside of mouth, brush activates motor	 1. vertical linear motion in sections of brush head 2. horizontal linear motion in middle sections of brush head	 opposite-direction rotating discs that are packed with bristles.