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Purli: A Better Way to Brush

Aldyn Savage
aks5288@rit.edu

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Purli: A Better Way to Brush

By

Aldyn Savage

A Thesis Submitted in Partial Fulfillment of the Requirements for the
Degree of Master of Fine Arts in Visual Communication Design

School of Design
College of Art and Design

Rochester Institute of Technology
Rochester, NY
August 8th, 2023

RIT | College of Art and Design

Thesis Approval

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Thesis Title

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Thesis Author

Submitted in partial fulfillment of the requirements for the

degree of

The School

Rochester Institute of Technology | Rochester, New York

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Art and Design

ABSTRACT

Maintaining good oral hygiene is crucial for a healthy life, and properly tooth brushing stands out as a fundamental defense against dental issues. Unfortunately, many people do not brush their teeth properly and there is very limited technology available to assist them in compliance with the standard toothbrushing procedure. In the realm of technological innovation, augmented reality stands out as a powerful tool with boundless possibilities. Leveraging the potential of this transformative technology, we aim to utilize mirrors as a unique medium to design a captivating 3D projected model of teeth. This innovative approach aims to inspire and motivate users to elevate their brushing habits, ultimately leading to optimal oral health.

Keywords

Introduction

In the fast-paced and demanding world we live in, it is easy to lose sight of the seemingly ordinary aspects of our daily routines. One such crucial practice that often goes unnoticed and unappreciated is the act of brushing teeth. Despite being an integral part of personal hygiene, dental care is frequently overshadowed by more pressing concerns and demands. Though there are several oral health care apps that exist, there still remains a significant gap regarding a solution that is both immersive and applicable, leaving people relying on a mobile application to revolutionize oral care. What if one could leverage augmented reality to bring oral health information to users in an intuitive, fun, and immersive way? Purli was specifically created to address this challenge and provide users with a better way to brush their teeth. Using augmented reality and mirrors as a unique medium to design a captivating 3D projected model of teeth to motivate users to enhance their brushing habits to achieve optimal oral health.

Background & Research

In order to ensure the needs of real people were met, a survey of 63 people ranging from ages 15 to 67 was conducted. This survey helped understand overall habits and thoughts on personal oral hygiene. Among the survey questions, one that stood out as highly revealing was when asked on a scale from 1 to 5 on how effective they believe they brush their teeth daily. 49 of participants scaled a 1 or 2, showing the lack of awareness and efficiency for brushing their teeth. Another critical finding was when asked approximately how long do they brush their teeth for. About 81% of participants say they were unsure of the timeframe or brush until they feel satisfied, leaving only 14% of participants brushing their teeth for the recommended 2 minutes. With this interesting discovery in mind, it was important to create an engaging and effective solution for users to pay closer attention to their oral health.

This survey also helped define a set medium and provide recommended features. From the responses it was discovered that all 63 participants use a mirror to check for debris in their mouth, while only 38 use their phone. The final question of the survey asked

users what kind of features would help brushing teeth more fun and efficiently. Many specifically cited several features including cavity detection, brushing accuracy and coverage, when to throw a toothbrush out, track brushing habits, and encouragement. Discovering a set of users and features was essential before moving into technology considerations and design decisions. This allowed for the building of specific features that could be applicable to a variety of potential users.

Upon finding the needs of a target audience, a cross industry audit was conducted. Smart mirrors, monitoring technology and oral health industry interfaces were examined in order to determine what has already been done. Smart mirrors and industry interfaces helped lend a hand to building a minimal user-interface that provided all essential data without taking away from the task at hand. The oral health industry work towards sensor-based human activity recognition techniques was also a factor of this project. It was discovered that an off-body sensing solution uses a detachable Inertial Measurement Unit (IMU), attached to the handle of the brush. The sensor captures the movements of the brush while reaching different parts of the teeth. Then a machine learning pipeline is trained to predict the brushing of different parts of the teeth.[1] [2] From these findings, it became one of the most important aspects for this project to help guide the idea of an off-body sensor solution. For this project the idea is to have a sensor within the toothbrush that would follow users teeth and brush movements.

An in-depth study of today's smart mirrors was also conducted. There are currently several types of smart mirrors already on the consumer market including general purpose, medical, and fashion. Smart mirrors are devices that can display any kind of information and can interact with the user using touch and voice commands. General purpose smart mirrors are suitable for home environments but the existing

[1] Z. Hussain, D. Waterworth, M. Aldeer, W. E. Zhang, Q. Z. Sheng and J. Ortiz, "Do You Brush Your Teeth Properly? An Off-body Sensor-based Approach for Toothbrushing Monitoring," *2021 IEEE International Conference on Digital Health (ICDH)*. November 8th, 2021.

[2] Hussain, Zawar, David Waterworth, Adnan Mahmood, Quan Z. Sheng, and Wei Emma Zhang. "Dataset for Toothbrushing Activity Using Brush-Attached and Wearable Sensors." July 6, 2021.

ones offer limited functionalities. [3] For this project, the design focused on existing smart mirrors, but ultimately developed into a more immersive and interactive experience while brushing teeth.

Lastly, there was research on how oral health industries provide personal hygiene information. Many companies rely on mobile applications to help users manage their own health and wellness, promote healthy living and gain access to useful information when and where they need it. Oral health applications were developed to use the opportunity mobile apps offer to motivate an evidence-based oral hygiene routine. [4] While the idea of a user-friendly application may be effective, studies have shown that the apps were determined to be moderate by the questionnaire, as only about half of the study participants were convinced of its effectiveness or would recommend it to others. The main reason for this was the inaccuracy of the toothbrush position detection and the time-consuming positioning of the tools for using the app. [5] These findings concluded that a mobile application is not a reliable solution for this project. Instead will provide a hands-free approach to brushing teeth, focusing on the specific task at hand.

Exploration

Purli is the solution that seeks to solve this gap in the market, combining augmented reality and mirrors to design a captivating 3D projected model of teeth to motivate users to enhance their brushing habits. Utilizing current smart mirror capabilities, augmented reality, and off-body sensors is the root of Purli's capabilities. From research and surveys conducted, three main prompts of this project were developed. The first prompt is 'move it around', which entails the idea of moving the toothbrush thoroughly around each area of the teeth until completely clean. Tracking brush movement and head movements using mirrored guidance improves coverage making sure all areas are

[3] A. Johri, S. Jafri, R. N. Wahi and D. Pandey, "Smart Mirror: A time-saving and Affordable Assistant," *2018 4th International Conference on Computing Communication and Automation (ICCCA)*. July 29, 2019.

[4] Underwood, B., Birdsall, J. & Kay, E. The use of a mobile app to motivate evidence-based oral hygiene behavior. August 25, 2015.

[5] Humm, Viviane, Daniel Wiedemeier, Thomas Attin, Patrick Schmidlin, and Stefanie Gartenmann. "Treatment Success and User-Friendliness of An Electric Toothbrush App: A Pilot Study" *Dentistry Journal* 8. June 23, 2020.

covered. When users have completed an area, they will turn white indicating the area is clean. The second prompt is 'touch it up' which highlights specific areas for additional attention to ensure full coverage and no spots are left untouched. A tooth will become highlighted, indicating a "touch-up zone" to back and brush a specific tooth or area until it is completely clean. The first two prompts are focused on covering each aspect of the teeth and leaving out no places for error. In a study conducted in 2018, the aim was to analyze oral hygiene behavior of young adults when they were asked to perform to the best of their abilities. The results showed neglect of palatal surfaces and 40% of the brushing time on lateral surfaces was spent with scrubbing movements despite opposing advice in common oral hygiene instructions.[6] Purli ensures that each part of the tooth is covered and helps reduce the risk of diseases, while creating better brushing habits.

The last prompt is 'check it out' which can detect plaque and cavity development, while informing users what steps are to be taken next, by setting reminders to notify and make an appointment to see a dentist. Cavities and plaque can happen to anyone at any time, but some people may wait too long or not prioritize seeing a dentist. In a previous study conducted, a core distinction that emerged from data tracked was that people constructed their own 'margins of the relevance' of oral health. For example, oral health was 'not relevant' as long as there was no pain. Another participant felt that only pain brought teeth into consciousness and he assumed that others thought the same − the norm being that: *'If you are in pain − because let's face it, that's the only time people actually think of their teeth'* (James, IT technician, age 30). In the latter case, such a person might only consider his teeth relevant, and visit the dentist, when in pain.[7] Plaque can be hidden from plain sight and cavities can only be detected by soreness or going to the dentist. With Purli, users are able to get feedback on areas where there is plaque formation as well as detect early signs of a cavity. After the detection is found, it will send a notification to your phone to arrange an appointment to see a dentist. This

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[6] Deinzer R, Ebel S, Blättermann H, Weik U, Margraf-Stiksrud J. Toothbrushing: to the best of one's abilities is possibly not good enough. BMC Oral Health. October 8, 2018.

[7] Gregory, J., Gibson, B. & Robinson, P. The relevance of oral health for attenders and non-attenders: a qualitative study. February 16, 2007.

allows users to be proactive by contacting the dentist and be careful around these areas while brushing.

Additional features were also created to give users an effective way to improve their hygiene. Items such as a pressure indicator, habit tracker and usage recognition were implemented. The pressure indicator notifies users when they are applying too much pressure to a certain area of the teeth to help protect your teeth and gums. The habit tracker gives insight on previous brushing sessions and can help users actively work on improving them. It informs users on the amount of coverage obtained, the amount of intensity used, and a streak of how long a user has been brushing their teeth correctly. Lastly is the usage recognition feature that notifies users when it is time to replace a toothbrush or toothbrush head. Proper toothbrush care is another important to oral health. Using a worn toothbrush is a less effective way of cleaning your teeth and some may not know when to throw it out. The American Dental Association recommends replacing your toothbrush every three to four months or sooner if the bristles become frayed.[8] Purli is able to track the amount of usages and reminds users of the percentage left of use after a session is complete.

Design Development

After creating each prompt, design decisions were implemented. The overall aspect of the design was simplistic because it not only needed to overlay a mirror, it needed to have minimal distractions in order to focus on the environment around users. The idea of three-dimensional teeth to display the information was explored and led to creating multiple iterations. Realistic-looking teeth and cartoon-like teeth were considered, but the question asked was what is the best way to give users the information they need? The first process of visualizing what the teeth may look like was the realistic teeth. After finalizing the design, they gave more area of the teeth than needed and the idea of realistic teeth felt too complex. The second iteration was the cartoon-like teeth, which felt too unrealistic and did not give off the right aesthetic. While compromising in the middle, the design was decided. Teeth that are slightly detailed fit best with the design

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[8] "Toothbrush Care, Cleaning and Replacement." *The Journal of the American Dental Association*. 2006.

because it gives users the right amount of information needed. Utilizing the color on top of the teeth was also an important aspect of the design. The teeth start all out as purple, indicating that they have yet to be cleaned. While brushing over the area, the opacity of the purple will decrease giving the proper amount of time used on that area and will eventually turn to white. As they turn white, fun shapes will appear showing the area of the tooth/teeth are clean. This gives users clear guidance of what areas are complete and what areas are not, giving them the correct full coverage. The creation of the UI on the smart mirror was simple, minimizing distractions and creating a truly immersive experience. The UI layout consisted of toothbrush information, time/date, brush timer and the teeth in line with your head while brushing. Making the teeth the center of the sight area allows users to focus on the task at hand and not be distracted with other features while brushing.

Conclusion

In this era of rapidly advancing technology, Purli stands at the forefront of the oral care revolution. By turning oral care into an enjoyable activity, Purli fosters long-lasting habits that promote lasting oral health. By harnessing the potential of augmented reality, this innovative solution bridges the gap between awareness and action, encouraging users to prioritize their dental hygiene in a way that has never been experienced before. Through this interactive and engaging experience, users are transported into a virtual world where they can witness a life-like representation of their teeth. This real-time visualization offers a deeper understanding of their oral structure and the significance of proper brushing techniques.

Purli has only broken the surface regarding augmented reality experiences, but those experiences barely integrate the digital and real worlds. Further exploration can be done into the merging of augmented reality and dental hygiene as well as current limitations of existing mobile applications. However, this is not a call for blame but rather an opportunity for growth and change. By delving into solutions, we can cultivate a greater sense of responsibility for our dental well-being. Practical tips for incorporating oral care

into busy schedules, the importance of proper dental education from a young age, and the role of technology in reminding us of our daily dental responsibilities are just a few of the avenues awaiting to be explored.

Appendix A

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    (ICDH)*. November 8, 2021.
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    EkbBAwi-ca9mqabkCS

Z. Hussain, Zawar, D. Waterworth, A. Mahmood, Q. Z. Sheng, and W. E.
    Zhang. "Dataset for Toothbrushing Activity Using Brush-Attached and Wearable
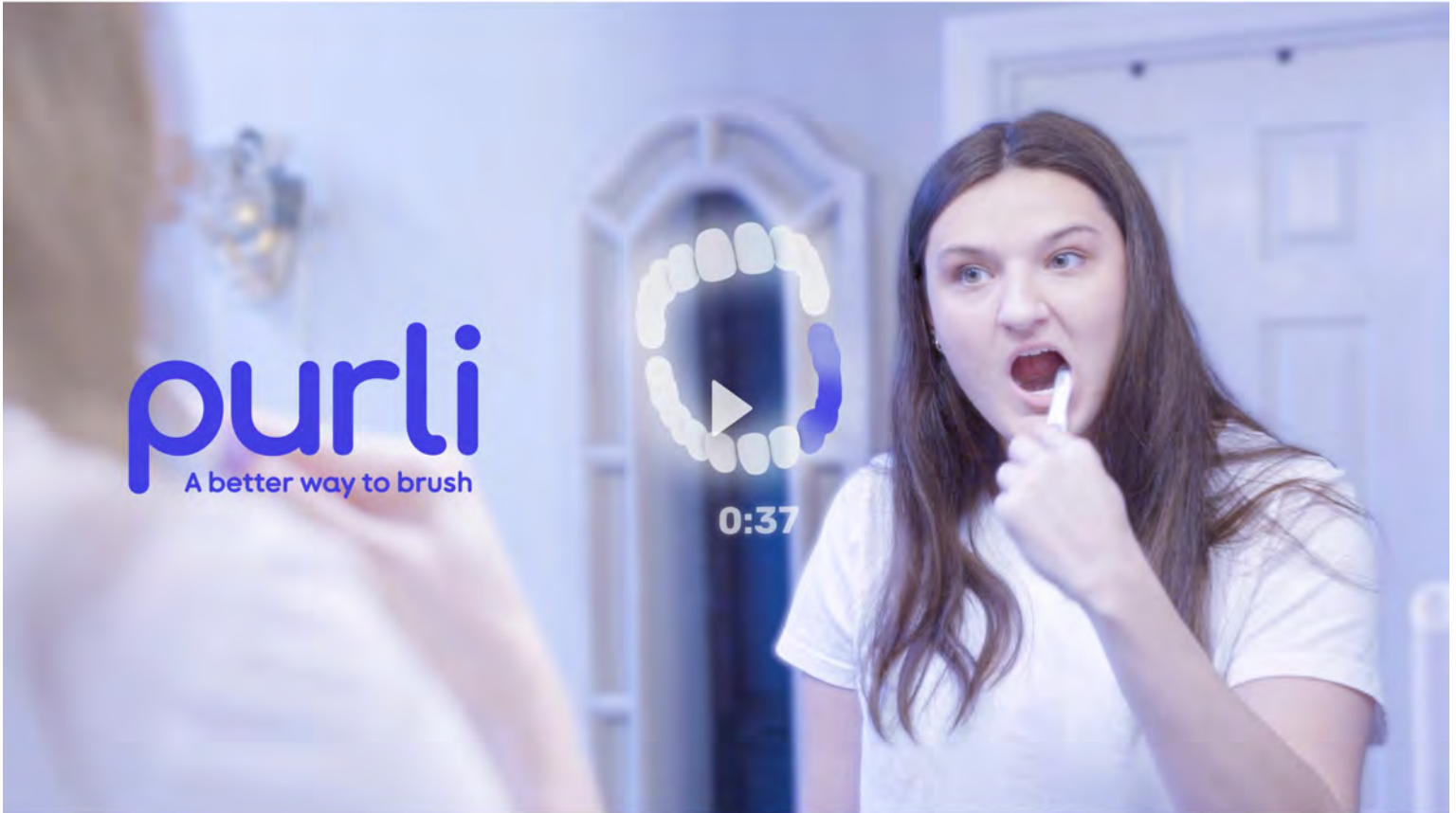   Sensors." July 6, 2021.
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Appendix B

Semplice Project Page

https://designed.cad.rit.edu/vcdthesis/project/purli

purli

purli
A better way to brush

0:37

THE PROBLEM

Dental health is an overlooked piece of overall health.

APPLIED SOLUTION

Design a **3D projected model of teeth** that **motivates** users to **enhance their brushing habits** to achieve optimal oral health.
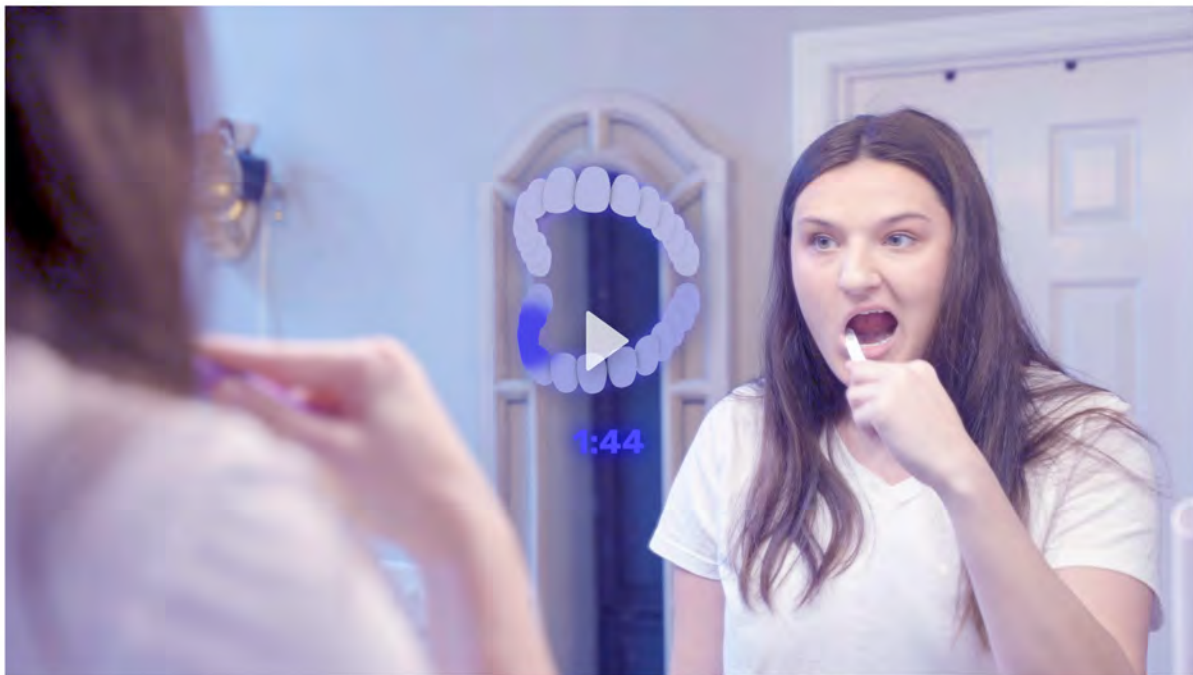
PROMPTS

MOVE IT AROUND   TOUCH IT UP   CHECK IT OUT

MOVE IT AROUND

Tracks and improves coverage making sure all areas are covered with a timed-session and encouragement.

MIRRORED GUIDANCE

Follows teeth and brush movement for a more intuitive brushing experience.

TOUCH IT UP

Highlights specific areas for additional attention to ensure full coverage and no spots are left untouched.

1:09

1:56

PRESSURE INDICATOR

Alerts if you brush an area of teeth too hard to help protect your teeth and gums.

CHECK IT OUT

Detects plaque and cavity development that becomes
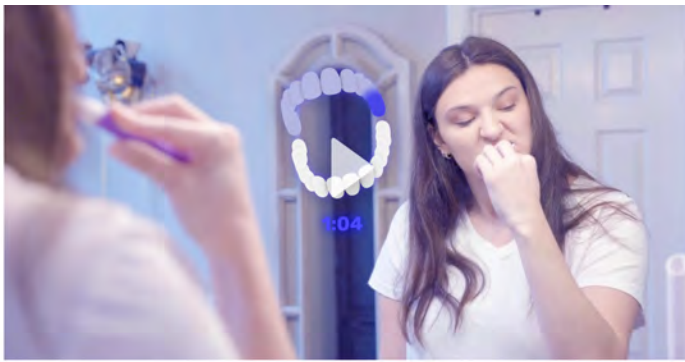stored information for future brushing sessions.

PLAQUE DETECTION
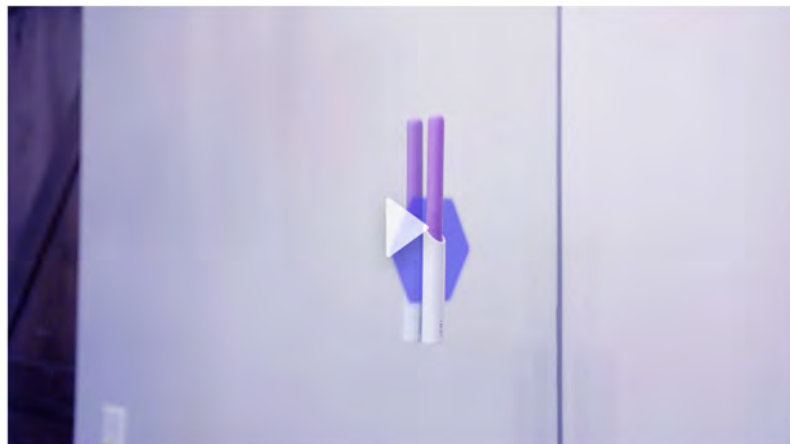

0:58

CAVITY DETECTION

Log Out   bar

1:04

SMART REMINDER

Informs what the next steps are, sets a reminder to notify and make an appointment to see a dentist.

ADDITIONAL FEATURES

8:52 AM
Friday, April 9th

HABIT TRACKER

View previous brushing habits to actively work on improving them.

It let know the amount of coverage you

Coverage   Intensity   Brush Streak

obtained, the amount of intensity you used, and a streak of how long you have been brushing your teeth correctly.

USAGE RECOGNITION

The toothbrush tracks how long a brush head is used as well as toothrbush battery, to alert when it's time to replace.
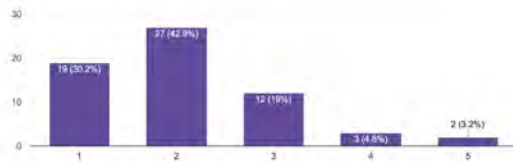

RESEARCH & PROCESS

INTERVIEWS

63 participants who were not familiar with my project were interviewed. The results of the survey provided useful data that guided decisions for Purli.

How important is brushing your teeth?
63 responses

Identifying how important brushing teeth is in their daily lives. On a scale of 1-5, the majority of participants said that brushing their teeth was a 1 or 2, which means that it is not very important to them.

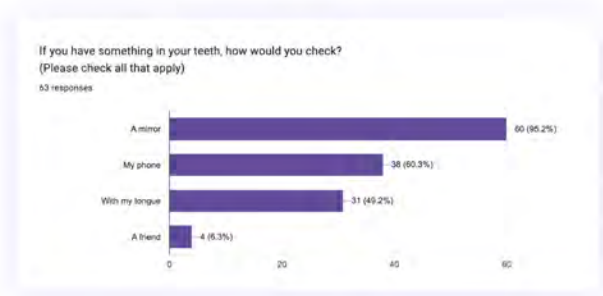Approximately how long do you brush your teeth for?
63 responses

- 30 seconds
- 1 minute
- 2 minutes
- Unsure
- Until I feel done
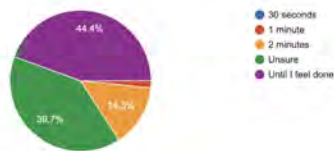
The recommended time for brushing your teeth by a dentist is 2 minutes. More than half of the particpants said that they are unsure how long they brush for or they brush until they feel they are done. Only 14% of particpants brush for the recommended 2 minutes.

How confident are you that you brush your teeth effectively each time?
63 responses
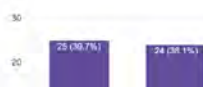
More than half of the participants said that they are unsure or how effectively they are brushing their teeth.

If you have something in your teeth, how would you check?
(Please check all that apply)
63 responses

The majority of particpants use a mirror in order to check debris in their mouth.

What kind of features would help make brushing your teeth more fun and efficient?

Information on my previous brushing habits

to know when to throw my toothbrush out!

How to know when my toothbrush needs to be charged or not

cavity detection or when to go to the dentist

CONTACT MY DENTIST

Maybe something that lets me know what teeth i missed

show exactly where i am brushing

Encouragement

a timer

will tell you if you have a cavity or other dental issues

know when a certain area of my teeth are all clean

brushing accuracy

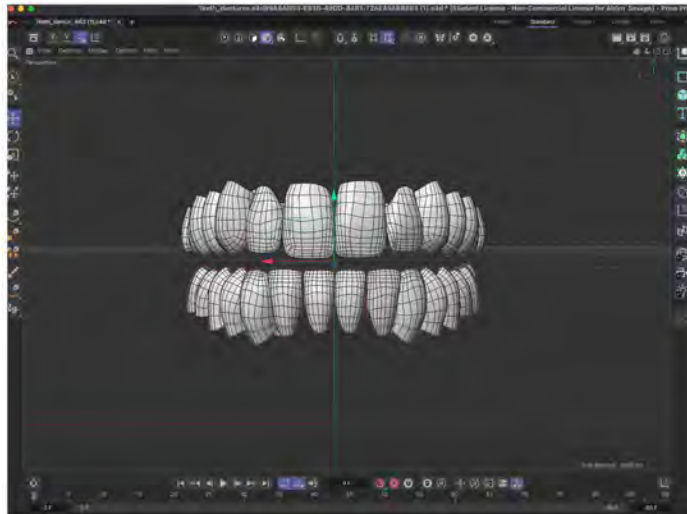A timer to know how long i have left

Track my brushing habits

The final quesiton on the survey from particapnts helped validate features that can be used within Purli

TEETH ITERATIONS

Realistic Version

This was my first process of visualizing what the teeth may look like. It felt too realistic and did not fit my aesthetic.

Using Cinema 4D to render realistic teeth

Cartoon Version

This was my second process of visualizing what the teeth may look like. This was my initial idea but as I was creating other assets, the cartoon-feel did not fit.
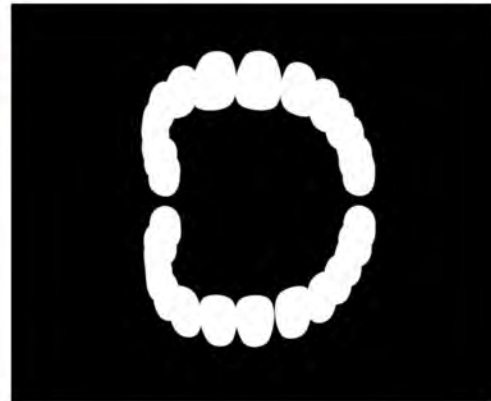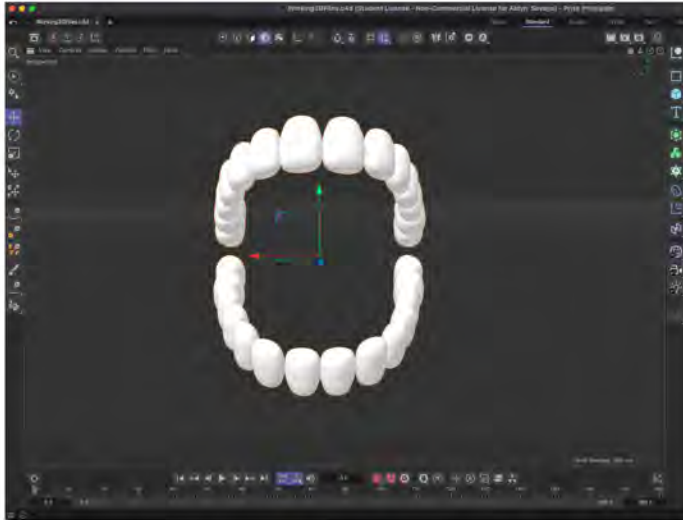
Version A   Version B

Using Sketch and Toon within
Cinema 4D to render cartoon style.

Finalized Version

Using multi-pass renderer with Cinema 4D

VISUAL IDENTITY

Why Purli?

The concept behind "Purli" originates from the
playful notion of cherishing those impeccably
gleaming 'pearly whites'. This inspiration led to
the creation of the term, encapsulating the
essence of radiant smiles and oral care.

The Hexagon Concept

Imagine a hexagon as a multifaceted symbol of oral health,
with each of its sides representing a key aspect of brushing
teeth. Just as a hexagon has six sides working together
seamlessly, brushing teeth encompasses six crucial elements
that harmoniously contribute to dental well-being. From proper
technique and toothpaste selection to frequency, duration, and
reaching every corner, each facet of the hexagon represents a
vital component of maintaining a healthy and radiant smile.

Comfortaa Bold

Como Bold

Sofia Pro Medium

IMAGINE RIT & TAKEAWAYS

It was an amazing experience sharing my thesis at Imagine RIT. I was very impressed with the amount of people who were very interested in using my product and had a lot of positive feedback.

Prototype Visualization

I created a prototype of what the teeth would look like on a mirror. It was great to see everyone interact and engage with the mirror.

THANKS FOR SCROLLING!

Portfolio
aldynsavage.com

Email
aldynsavage@gmail.com

**Visual
Communication
Design
MFA**

Communication
Interaction
Motion & 3D
Design Studies

About the Program