

# Design and Development of Augmented Reality Learning Application on Dentistry

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**Abstract:** The purpose of this study was to develop a basic dental learning smartphone app for kids utilizing Augmented Reality. With the advancement of technology, the mobile application technique enables students to more simply and effectively apply their teaching and learning. Posters, pamphlets, and booklets may be outmoded due to constant connectivity through mobile devices, making them ineffective in conveying information and promoting awareness among youngsters. The raw data from interviews have been vetted by experts. This application was built utilizing Agile Methodology. The approach was designed for mobile devices and allows for easy integration of multimedia components like 3D models, music, and animation. This initiative would target primary school students aged 6 to 12 to help educate basic dental principles.

**Keywords:** Dentistry, Augmented Reality, Learning

## 1. Introduction

According to the Centers for Disease Control and Prevention Dental, hygiene is the process of keeping the mouth, teeth, gums, and tongues clean and healthy to avoid disease. Dental care is the most vital aspect of human life and it should begin from childhood [1]. The Agenda Nasional Malaysia Sihat under Kementerian Kesihatan Malaysia (KKM) is a government initiative towards improving the health and quality of life of the people has undertaken a dental hygiene awareness campaign through mass media and printings such as posters, brochures, and booklet distribution and often spread on social media such as on Twitter [2]. However, awareness is just like drowning during the pandemic Covid-19 as they focus on awareness about Covid-19, the method may no longer be relevant because nowadays people are always with mobile phones, so that may not be the appropriate method of conveying messages and awareness for children. According to research, children may readily perceive information using multimedia elements such as graphics, animation, audio, and others [3].

As children go through their early education, they will learn topics of dentistry in science classes. However, unlike in the past, when government dental clinics visited children every year, children do

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not get basic dental hygiene education during the pandemic Covid-19. Teaching children appropriate oral care at home may be tough.

This project presents a mobile learning application that leverages Augmented Reality technology to foster creativity and interaction more excitingly and creatively. This software teaches parents and teachers children about oral hygiene, dental structure, the differentiation between deciduous and permanent teeth, cross-sections of teeth, and the repercussions of inadequate dental care. Meanwhile, children may learn about basic dentistry using multimedia tools. In short, the suggested application would increase children's understanding and help them develop a solid home care routine that supports lifelong oral health. The objectives of this application are as follows:

- i. To design a mobile learning application using an augmented reality approach supporting teaching and learning.
- ii. To develop a mobile learning application using Android-based technology.
- iii. To test the developed mobile learning application to target users aged 6 years old to 10 years old.

Oral health may impact the rest of the body, the suggested application's target users are underage children aged 6 to 10, their parents, and educators. As we all know, the purpose of this initiative is to assist parents and teachers educate children about improved oral hygiene by utilizing an engaging medium. Using maker-less augmented reality, the target user may learn and comprehend the anatomy of their teeth. The 3D model also includes a cross-section of the teeth to demonstrate the names of the layers and the variations between deciduous and permanent teeth. The implications of poor oral hygiene are also discussed, along with the causes and signs. The lessons aim to increase basic dental knowledge. The second module is the activity module. This module will encourage youngsters to correctly clean their teeth.

The expectation towards the suggested application is rather high after the project. The most dreaded concern for designers is that buttons and image recognition in augmented reality don't work as planned. Therefore, all buttons in the proposed application must work correctly and do all tasks. The interface should also grab the user's attention and keep them utilizing it because the UI is the first thing a user sees when they start using an app. The suggested application is also expected to help primary school students learn about oral health and increase their understanding of fundamental dentistry concepts, which would benefit the target user. Finally, the animation in the activity module should be flawless and error-free.

## **2. Related Work**

This section will discuss the technology involved in the development of a similar type of dentistry mobile application that is related to the project.

### **2.1 Domain Background**

Dentistry deals with ailments, problems, and diseases of the teeth, gums, mouth, and jaw. Dentistry, which is often seen as vital for oral health, may also impact general health [4]. Dental hygiene is the study of preventing mouth sickness and improving health by offering educational, preventative, and rehabilitative therapies [5]. Otherwise known as oral hygiene, this preventative measure may lead to tooth decay and gum disease as well as heart disease, cancer, and diabetes if neglected [6]. Proper dental care is also necessary to maintain long-term dental health [7].

According to Innovative Pediatric Dentistry, 20% of children aged five to eleven have untreated cavities, and 13% of teens aged 12 to 19 [8]. Dental care is vital to human survival and should start early age. Education is vital for both nation and character formation. The learning process involves students, teachers, schools, and parents.

## 2.2 Augmented Reality

Augmented reality (AR) is a digitally augmented depiction of the actual physical world [9] (Hayes, A. 2021). Trending among businesses involved with mobile computing, especially commercial applications. Nowadays, the most popular AR apps employ smartphones to show digitally Augmented Reality. The fact that digital behemoths like Facebook, Google, Microsoft, and Apple see AR as a lucrative investment opportunity bodes well for these technologies' future [10]. These tools may help contemporary classrooms and provide students with additional learning options. In all cases, AR and VR will certainly change the way we interact with the real world in the future years and will be widely embraced across all fields. The study's papers show that Augmented Reality may improve students' theoretical comprehension while working with actual industrial automation equipment in specialized labs [11].

## 2.2 Comparison of related application

The features and characteristics of the three mobile applications, Magic Timer [12], BoneBox-Dental Lite [13], and Tooth Brush [14] are compared with TeeCare. The comparison result is tabulated in Table 1.

**Table 1: Comparative analysis between existing applications**

| Comparison Item | Magic Timer  | BoneBox-Dental Lite   | Tooth Brush   | TeeCare   |
|-----------------|--|---|---|---|
| Content         | The Disney Magic Timer is created in collaboration with Oral-B to urge children to clean their teeth twice daily for two minutes.              | The real-time 3D medical education and patient communication tool features incredibly detailed anatomical models of the human dental anatomy.   | Learning applications using gameplay that users can interact interactively with children.       | - Learning applications that consist of basic knowledge about dentistry and awareness include the details about dental problems.                          |
| Activities      | - Report card features allow a user to track their brushing activity.<br>- Tooth brushing activity that uses animation and music with a timer. | - True real-time 3D so the user can place the highly realistic detailed dental anatomy in any position and zoom in to explore all of the anatomical structures.<br>- Simple quiz about dental anatomy | - Simple game promoting brushing teeth.<br>- Tooth brushing activity that the user can control. | - A activity module that aims to teach the appropriate method of brushing teeth.<br>- Learning module reveals basic dentistry and awareness for children. |
| Strength        | - The gorgeous visual.<br>- Colorful interface, beautiful soundtrack.  | - The 3D human dental anatomy model is very realistic and detailed.   | - Very interactive for children.<br>- Colorful interface, beautiful soundtrack.                 | - The stunning graphics.<br>- Using multimedia elements such as audio, animation, and text.<br>- an interactive interface that                            |

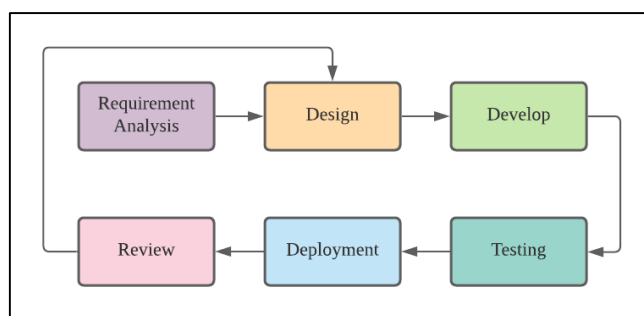
**Table 1: (cont).**

| Comparison Item  | Magic Timer   | BoneBox-Dental Lite  | Tooth Brush  | TeeCare   |
|------------------|---|--|--|---|
| Strength         |   |  |  | suitable for children and adults.   |
| Weakness         | <ul style="list-style-type: none"> <li>- Do not have a learning module.</li> <li>- The activity is slightly hard to control.</li> </ul> | <ul style="list-style-type: none"> <li>- The interface is not suitable for children.</li> <li>- Unattractive interface.</li> <li>- Lack of content about dentistry.</li> </ul> | <ul style="list-style-type: none"> <li>- Lack of content about dentistry</li> <li>- Pointless inconsistency of interface.</li> </ul> | <ul style="list-style-type: none"> <li>- There is an excessive amount of content and it is quite detailed.</li> </ul> |
| Operating System | Required Android version 4.1 and above.   | Requires iOS 6.0 or later.   | Required Android version 7.0 and above.  | Required Android version 7.0 and above.   |

### 3. Methodology

The Software Development Life Cycle (SDLC) is a strategy for creating and delivering software applications to improve software quality and the whole development process [15]. The SDLC is used to design, develop, and build high-quality, reliable, and cost-effective software solutions [16]. The Agile technique fosters regular inspection and adaptation to produce software projects that allow for fast revisions, quick delivery, and risk minimization [17]. Agile software development emphasizes planning, learning, improvement, teamwork, and early delivery [18]. Less control and management concerns are alleviated. Its flexibility enables it to adapt to new regulations without disrupting its normal operation [19].

The agile technique adapts to changing customer needs and can manage cost, scope, and software quality. The Agile SDLC is a hybrid model that combines interactive and incremental models, focusing on process adaptability for rapid delivery of high-quality software, and a business approach that aligns development with customer requirements and company goals [20]. The Agile approach involves six phases: requirement analysis, design, development, testing, deployment, and review. Each step from requirement analysis through review will be termed an iteration. The incremental process is the flow from one iteration to the next. A modified Agile Software Development Model Figure 1.



**Figure 1: Adapted Agile Methodology Software Development Model [21]**

#### 3.1 Requirement Analysis Phase

The first step of the Agile SDLC is requirement analysis. The initial phase in application development is requirement analysis. Observations, interviews, and online research are used to acquire data. This

phase will contain three types of analysis: user, functional, and non-functional. Without a comprehensive study, the final product will not be used by the end-user due to a lack of functionality. Without analysis, the product would be substandard. During this phase, the development system's needs were defined. 30 target users, all students at SRITI Tahfiz Al Farabi Ketereh - Sekolah Rendah Integrasi Teras Islam, were provided the user needs. This survey may help to learn more about the target user's preferences and wants. The evaluations were used to identify faults and drive improvements. To minimize misunderstanding throughout the design phase, each interface's navigation has been analyzed. An interview with a subject matter expert, Dr. Dayana Hazwani Ahmad of The Dental House Klinik, is also conducted to further understand the topic. This interview focuses on the problem of basic dentistry and the instructional material. Many questions were asked on dental hygiene, dental care, prevalent dental problems in youngsters, and basic dental knowledge. The interview with the subject matter expert and survey result is tabulated in Table 2. The functional, and non-functional are tabulated in Table 3 and Table 4.

**Table 2: The interview with the subject matter expert and survey result**

| Category  | Comment Receive   | Action   |
|---|---|--|
| SME Name:<br>Dr. Dayana<br>Hazwani binti<br>Ahmad | <ul style="list-style-type: none"> <li>• Add information about dental problems.</li> <li>• Add information about teeth structure, a cross-section of teeth, and the difference between deciduous teeth and permanent teeth.</li> <li>• Add information about the appropriate technique for brushing teeth.</li> </ul> | <ul style="list-style-type: none"> <li>• Including information on several subjects related to dental problems.</li> <li>• Classify all of the information according to subject matter.</li> <li>• Demonstrates how to brush teeth with the use of 3D animation.</li> </ul> |
| Questionnaire                                     | <p>Do you believe that studying dentistry utilizing technology such as Augmented Reality will pique your or your children’s interest in dental care and awareness?</p> <ul style="list-style-type: none"> <li>• Yes (48.4%)</li> <li>• No (32.3%)</li> <li>• Not sure (19.4%)</li> </ul>                              | <p>The majority of respondents agree that studying dentistry utilizing technology such as Augmented Reality technology will pique their interest in learning dental care and awareness. As a result, the technology can be applied into the application.</p>               |

**Table 3: Functional analysis**

| Category         | Detail  |
|------------------|---|
| User Interaction | <ul style="list-style-type: none"> <li>•The system shall provide users with the ability to give input by touch screen on their Android Mobile platform.</li> <li>•The system shall provide users with the ability to navigate through the application by using appropriate buttons.</li> <li>•The system shall provide users with the ability to display the 3D model with information based on the selected topic.</li> <li>•The system shall provide users with the ability to initialize and generate a virtual plane.</li> <li>•The system shall provide the users with the ability to visualize and place the selected 3D model on the virtual plane.</li> <li>•The system shall provide the users with the ability to enter AR sessions through the AR view button.</li> <li>•If the user clicks the button, the system shall display what they click.</li> <li>•In the setting menu, the user can click the volume slider to adjust the sound volume.</li> <li>•If the user clicks the exit button, the system shall show a popup message “Do you want to exit?” and the user can choose yes or no.</li> </ul> |

**Table 3: (cont).**

| Category          | Detail  |
|-------------------|---|
| Autonomous System | <ul style="list-style-type: none"> <li>• While running the AR view, the system shall generate feature points to generate a virtual plane.</li> <li>• While running the AR view for the first time, the system shall ask the user for camera permission.</li> <li>• While the user does not press on the virtual plane, the system shall continue to search for new virtual planes via feature points.</li> <li>• After launching the app for the first time, the system will display the Start Menu.</li> </ul> |

**Table 4: Non-functional analysis**

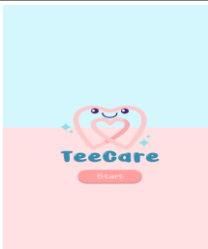
| Category       | Detail   |
|----------------|--|
| Usability      | <ul style="list-style-type: none"> <li>• The application’s interface must be user-friendly and easy to use.</li> <li>• The application should be able to be used anytime.</li> </ul>   |
| Performance    | <ul style="list-style-type: none"> <li>• The average response time between click and reaction should not be more than one second for users.</li> <li>• The time to generate a virtual plane should not be more than two seconds.</li> <li>• The visualization time of the 3D teeth model should not be more than two seconds.</li> <li>• The application shall be able to operate completely offline.</li> </ul> |
| Cultural       | <ul style="list-style-type: none"> <li>• The application will use a simple English language.</li> </ul>  |
| Implementation | <ul style="list-style-type: none"> <li>• The application shall be able to run using the Android platform.</li> <li>• The application can be run on any available platform in Unity.</li> </ul>   |
| Security       | <ul style="list-style-type: none"> <li>• Users can only edit their data.</li> <li>• No data can be accessed without authentication.</li> </ul>   |
| Operational    | <ul style="list-style-type: none"> <li>• The application shall be able to operate on any Android device as long as it is Android 8.0 and newer.</li> </ul>   |

### 3.2 Design Phase






Throughout the design phase, the application will be developed. During this phase, assets like buttons, backdrops, logos, and 3D models will be developed. The created assets will be included in the proposed application and positioned in line with the previous phase's design. The app will be constructed using Unity and Vuforia software. A flowchart is created as a representation of an algorithm of the application to explaining the program flow, refer in Figure 2.

This section will detail all of the application's user interfaces. The design should take the intended user's nature into account. It should be visually attractive and easy to use. Table 5 details the user interface design.


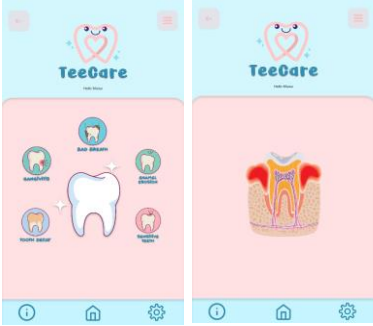
**Table 5: User interface design**

| User Interface  | Description  |
|---|--|
|  | <ul style="list-style-type: none"> <li>• Start page will appear right after user open the application</li> </ul> |

**Table 5: (cont).**

| User Interface  | Description   |
|---|---|
|    | <ul style="list-style-type: none"> <li>Main page in the application contains main menu section such as Info button that will display the information or about, setting button that enable players to adjust their preferable volume, learning button to enable user entering the learning topic, activity button to enable user to the activity module.</li> </ul>                |
|    | <ul style="list-style-type: none"> <li>Activity Page represents the topic about brushing teeth to the players. In this page, players are able to understand the about the appropriate technique for brushing teeth. The home button, home button, settings button and quit button are consistently put in each page.</li> </ul>   |
|  | <ul style="list-style-type: none"> <li>Learning Page represents the whole topic about basic dentistry and dental problem that divide to the four topics to the players. In this page, players are able to choose the topic such as teeth structure, cross-section of teeth, the different between deciduous teeth and permanent teeth and the types of dental problem.</li> </ul> |
|  | <ul style="list-style-type: none"> <li>Learning page for first topic represents about the teeth structure that deliver using maker-less Augmented Reality technology. User can see the teeth with information thru their face. Name of each tooth are labeled.</li> </ul>   |
|  | <ul style="list-style-type: none"> <li>Learning page for second topic represents the cross-section of the teeth in 3D model. Name of each layer of the tooth are labeled.</li> </ul>  |

**Table 5: (cont).**

| User interface  | Description  |
|---|--|
|  | <ul style="list-style-type: none"> <li>Learning page for third topic represents the different of deciduous and permanent teeth in 3D model. Name of each tooth are labeled.</li> </ul>   |
|  | <ul style="list-style-type: none"> <li>Learning page for fourth cover the topics about five common dental problem, there five. Each type of dental problem consists information such as signs, causes, and effects.</li> </ul> |

### 3.3 Develop Phase

Two elements must be considered throughout the primary function development phase. The initial phase is to incorporate prototype features and enhance existing functionality. To improve the application's usability, the application's buttons or assets, such as photo sliders and animations, will be enhanced with new functionality. During this time, code will be written.

### 3.4 Testing Phase

During this step of testing, the application will be tested on the Android operating system once the function has been verified. For testing, the programmed will be exported as an.apk file. There will be two sorts of tests: alpha and beta. Reversing the methodology's flow and restarting the major function development stages if the beta testing findings are unsatisfactory. Thus, the software will be upgraded and tailored to the target user's demands. Nonetheless, when the beta testing is over, the project's constraints and future development will be discussed and finalized.

### 3.5 Deployment Phase

The Agile methodology's fifth stage is deployment. The application is now fully deployed and being utilised formally. The software will be accessible via the Android app store. During this phase, the developer continues to monitor the system's performance. During this step, the only thing to check is if the software ran smoothly on the chosen platform. It is always feasible to enhance an existing product or add new features iteratively.

### 3.6 Review Phase

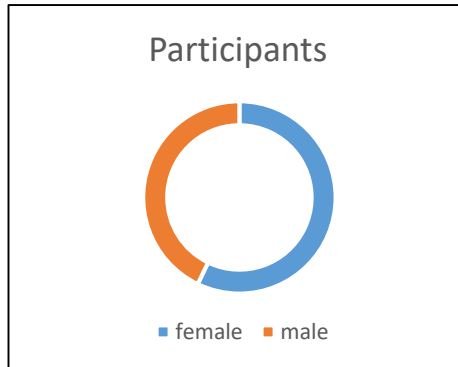
The review phase is the last stage in the Agile development cycle. After completing all previous processes, displaying the application to the user, who will then review it. This phase is used to maintain track of the freshly launched app and any user feedback. Also, the application must have had a flaw that went unreported when it was initially deployed. User feedback is vital to improving key features of the software and keeping it updated.



#### 4. Results and Discussion

##### 4.1 Data analysis on Preliminary Study

This section explains the preliminary analysis conducted at the early phase of the application development. An online survey was conducted to investigate the needs and opinions of potential users of the application.



**Figure 2: Gender and age distribution of participants (students)**

Total number of 35 students from Tadika Khalifah Junior UTHM participated in the online survey, while most of them are female student. Figure 2 depicts the gender and age distribution of participants (students).

The results in Table 6 represent the student’s perspectives on the use of technology in learning, particularly in Dentistry. Most of the students responded positively about applying technology in learning Dentistry to attract students and enhance their enjoyment. Utilizing technology in the learning process offers an attraction for students to engage in the learning content compared to textbook references.

**Table 6: Student’s perspective on the use of technology in learning**

| Questions  | Yes(%) | No (%) |       |        |
|--|--------|--------|-------|--------|
| Have your teacher ever used an educational application that helps you learn in a scientific subject?                 | 24.5   | 75.5   |       |        |
| Questions  | SA (%) | A (%)  | D (%) | SD (%) |
| Are existing ways of teaching scientific topics in schools sufficient for you to master the content?                 | 43     | 29     | 14    | 9      |
| You spend a large amount of time using technology.   | 57     | 20     | 14    | 9      |
| You support the idea of creating an educational application that helps in teaching students the scientific material. | 71     | 17     | 9     | 3      |
| Electronic educational applications are better than educational book in the learning process for you.                | 60     | 20     | 9     | 11     |

##### 4.2 Black Box Testing

Black box testing, also known as Behavioral Testing, is a software testing method in which the internal structure/design/implementation of the item being tested is not known to the tester. These tests can be functional or non-functional, though usually functional. Table 7 shows the summary of black-box test results for the navigation button.

**Table 7: Black-box result**

| Testing (Buttons) | Expected Result                | Actual Results | Corrective action |
|-------------------|--------------------------------|----------------|-------------------|
| Start Button      | Display mainpage               | Success        | None              |
| Setting Button    | Navigate to setting interface  | Success        | None              |
| Unmute Button     | Background music will play     | Success        | None              |
| Mute Button       | Background music will stop     | Success        | None              |
| Info Button       | Navigate to info interface     | Success        | None              |
| Back Button       | Navigate to previous interface | Success        | None              |
| Next Button       | Navigate to next interface     | Success        | None              |
| Play Button       | Play the animation             | Success        | None              |
| Pause Button      | Pause the animation            | Success        | None              |
| Home button       | Navigate to main page          | Success        | None              |

### 4.3 User Acceptance Testing

To make sure this application works well, testing and evaluation has been done. This test was done using Google Form and some questions were asked in the questionnaire. Testing and evaluation is done by involving the target users after the application is completed. In addition, this testing is done to ensure that the application has met the requirement and needs of users. Table 8 shows the results of the respondent’s feedback.

**Table 8: Respondent’s feedback**

| Feedback   | Yes (%) | No (%) |
|--|---------|--------|
| This application is very useful for you              | 80      | 20     |
| The mission in this app so hard to play              | 10      | 90     |
| The learning in module is so difficult to understand | 30      | 70     |

Figure 3: Respondent’s feedback

Based on the percentage table, it can be concluded that the highest frequency in the graph of Statement 1 (This application is very useful for you) the average respondent stated in Statement 1 is yes with percentage of 80%. While in statements 2 (The mission in this app is so hard to play), the average respondent stated in the statement is yes with a percentage of 10%, and for statement 3 (The questions in the learning in module is so difficult to understand) people (30%) think yes for that statement.

Based on the tester’s feedback, it is proven that ‘TeeCare’ can help them to learn dentistry in a different atmosphere than usual, learning in the classroom. Therefore, the function of gamification in very necessary for learning in the century of modernization to attract users to learn and gamification should be inserted in very learning application so that the application is not boring for the young user.

## 5. Conclusion

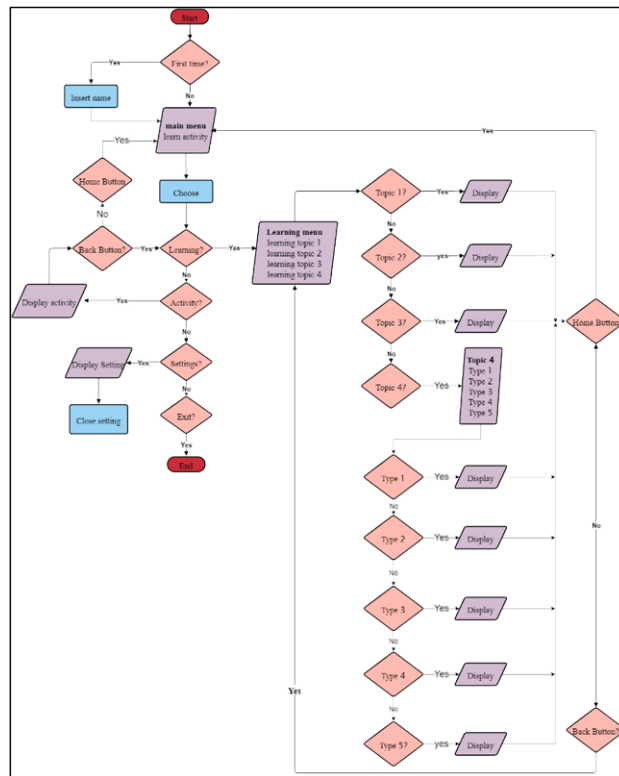
This report has six chapters that explain the whole development effort. The first chapter introduces the project broadly. This part covers the issue description, the main objective of the project, the scope of the project coverage, the expectations for the end product that may be produced later in the project, and the relevance of project development. Literature Review is the following stage, and it examines the findings of journals, books, published papers, and other resources related to the project. Chapter 3 describes the methodologies used in the creation and design of this application. Finally, Chapter 4 will contain the study’s results as well as their analysis. The last chapter will discuss the interface design for applications. The suggested apps have the potential to offer greater ease and interest for target users in helping youngsters learn to identify the shape of teeth and brush correctly, therefore

preventing tooth decay at a young age. Moreover, the suggested application uses augmented reality technology, which may enhance the user experience and make learning more fun.

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**Appendix A**



**Figure 2: Flowchart**

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