

## Building an Augmented Reality Application for Oral Health Care

Gilang Raihansyah<sup>[1]</sup>, Sri Chusri Haryanti<sup>[2]</sup>, Dr. Anita Rosa Delima<sup>[3]</sup>, Dr. Nur H. N. Prastiyani<sup>[4]</sup>, Shreya Mudgal<sup>[5]</sup>, Sowmya H<sup>[6]</sup>,  
Syeda Muskan Fathima<sup>[7]</sup>,  
Umme Afshan<sup>[8]</sup> Mrs. Sowmya S R<sup>[9]</sup>

<sup>1 2 3 4</sup> Universitas YARSI, Jl. Letjen Suprpto, Cempaka Putih, Jakarta, Indonesia <sup>5 6 7 8</sup> Information Science Engineering, Student, DSATM, Bangalore-88, Karnataka <sup>9</sup> Information Science Engineering, Faculty, DSATM Bangalore-88, Karnataka

### Abstract

*The general health and quality of life depend on teeth. Healthy oral and dental hygiene entails being free from ailments such as gum disease, tooth decay, tooth loss, and cancer of the throat. Dental caries is one of the conditions that affect teeth. The International Caries Detection and Assessment System is one of the categories for the dental caries disease (ICDAS). A solid medical learning strategy will improve one's comprehension of medical students. The purpose of this study is to develop an augmented reality learning media application for dental caries utilizing the ICDAS classification. Unity 3D software was used to create a markerless augmented reality application for Android. Using this programme to manipulate object rotation and object zoom provides benefits. However, there are still issues with this application's precise object design and when the user scans the surroundings. SUS testing yields a value of 83, indicating that the application is both acceptable and practicable for user usage. Because augmented reality can be utilized as a learning tool, especially in the field of dentistry, the development of applications for learning dental caries according to the ICDAS categorization is quite beneficial.*

**Keywords:** Augmented Reality, Tooth, Markerless.

### I. INTRODUCTION

There are numerous applications for oral health in general as technology advances, but do not go into detail on the use of two-dimensional images for classification and applications related to dental health in general presents a difficulty to researchers trying to develop augmented reality (AR). Teaching dental students about dental illness as well as dental caries is crucial for their education. Dental caries or cavities are categorized using systems like the International Caries Detection and Assessment System (ICDAS), GV Black, and Mount. ICDAS, a popular scoring system for dental caries based on knowledge gleaned from a survey of the literature on clinical caries detection systems, is one of the categories of dental caries.

For overall health & quality of life, dental health is essential. The absence of gum disease, tooth decay, tooth loss, infections, and other diseases is a sign of good dental health. Teeth that are not in good health make it difficult to bite, chew, smile, communicate, and maintain one's psychosocial well-being. Dental caries, often known as cavities, are among society's most prevalent dental health issues (Widayati, 2014). Food particles stuck to the teeth produce calcification, which leads to the development of dental caries lesions or cavities (Widayati, 2014). In general, dental health is important, especially throughout childhood when children eat items that promote tooth caries.

A poly illness known as dental caries lesion disease primarily affects youngsters between the ages of 6 and 9. Upon reaching the age of six, the permanent. The age of nine years is known as the mixed dentition period, during which the number of permanent teeth and primary teeth in the oral cavity is almost equal, namely 14 permanent teeth and 10 primary teeth (Listriah, R., & Levi, 2018). As molars have begun to grow, they are more susceptible to caries. Humans need to learn how to treat and prevent these illnesses in order to avoid them. A requirement for fulfilling the goals of human growth is learning. Dentistry only includes online teaching tools and visuals for learning about dental caries, therefore dental knowledge cannot be expanded. Further understanding of the ICDAS categorization is rated as insufficient because it is difficult to visualize what dental caries or cavities look like. The researcher developed an augmented reality (AR) application called TeethRies based on the aforementioned factors. The application will display a dental object that the researcher created using the data that was gathered and which discusses the ICDAS categorization. The application uses the markerless technique and scans the environment instead of using a marker.

Based on the way the markers are used, there are two options: markers that use cards and markers that use the environment in this application, or markerless markers possessing the benefit of not utilizing a card.

## I. LITERATURE REVIEW

The community at large is the intended audience for the application that earlier researchers created, hence the information presented is not detailed and there is a chance that it won't hold up. The prior application likewise used the same technique, which involves scanning the current marker with the target image. Since dental students are the intended audience for this study, it was created using a markerless method or by scanning the environment in real time. It is hoped that the application's detailed information will aid in the learning process because using augmented reality, students won't have to imagine dental objects using the ICDAS classification.

### Dental caries:

Enamel, dentine, and cementum of the teeth are affected by the condition known as caries, which is brought on by the activity of bacteria in fermentable carbohydrate pulp and infection spreading to the periapical tissues, both of which can be painful. This disease can be stopped very early on thanks to the potential for remineralization (Silviana, 2018). Dental caries can be categorized in a number of ways, including GV Black, ICDAS, and GJ Mount. In 2002, a team of cariologists and epidemiologists created the ICDAS system. Following a study by an international conference on clinical trials on the detection of carious dental lesions with significant variations integrating experience between modern criterion systems, such as the ICDAS criteria, and criteria employed in a number of prior studies The six categories of the ICDAS are as follows:

- D1 - When the teeth are white and dry on the outside of the teeth, lesions can be seen.
- D2 - When the teeth are wet, white lesions can be seen on their surface.
- D3 - The enamel surface of the tooth has a small lesion.
- D4 - Deeper enamel lesions emerge as black dentin shadows or have passed the DEJ (Dentine Enamel Junction).
- D5 - The dentin has been affected by the lesion.
- D6 - The pulp is affected by the lesion.

### Augmented Technology reality

When two- or three-dimensional virtual items are combined with a real environment, they are projected into reality in real time. With augmented reality applied to all senses, including touch, smell, and hearing. Along with being used in industries including industry, education, and the military. Using technology, virtual reality. This may insert information into the virtual world and display it in the physical world via a webcam, computer, Android phone, or special glasses.

### Use of Markers

AR features two types of markers: markers and markers without markers. To bring up a 3D item, markers in AR require a marker

or card. Nonetheless, Markerless in AR is a flawed technology because it doesn't require a particular context to display 3D content at a particular location. According to Muhammad, Sukmo Wardhono, and Afirianto (2018), markerless AR systems must recognise without the usage of special information by using coordinate position, orientation, and movement devices.

### Blackbox Testing

Testing the purpose of the application To inspect is a programme walk with should or is there an issue that must be fixed on programme until make quality programme improved significantly. Through Blackbox testing, a system that recognises input is tested so that researchers may locate the error. Blackbox testing is employed to ensure that applications have acceptable internal quality (Ningrum et al., 2019). A system was tested using Blackbox so that the developer would be aware of the location error system.

### System Usability Scale (SUS)

The System Usability Scale is a useful questionnaire. In order to obtain findings from testing the usability of a system, information, and counselling corner view for each individual user. The survey's five response options are "strongly disagree (STS)", "disagree (TS)", "neutral (N)", "agree (S)", and "strongly agree (ST)".

## I. RESEARCH METHODOLOGY

Study Research and development, sometimes known as R&D, is the used methodology. There is a method for producing research that involves certain existing items. Then, its efficacy was evaluated (2015) Widyaiswara. This was picked because it has the goal of creating a brand-new product for research. It is an application that uses augmented reality powered by Android to teach users how to classify tooth decay using the ICDAS system. For this research, the researcher used the Multimedia Development Life Cycle (MDLC) development model since it was developed to meet the needs of the study and build a product or application for learning how to prevent tooth decay. The MDLC model divides the progress application into various components.

### Objective

The MDLC paradigm is one in which applications are employed as a medium for applications, such as manufacturing applications. This application uses MDLC as a learning tool.

### Process

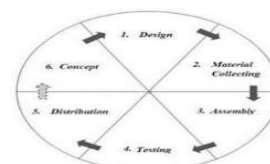


Figure 1 MDLC Process

Processes in the MDLC model are shown in the image above and are described as follows:

**a. Draft**

In this stage, this researcher is doing analysis and needs sources / specialists who are dentists with understanding of teeth and sources obtained from the medical YARSI dentistry university.

**b. Design**

Based on data analysis already \_ researchers do, continue to stage design. At this level, the planning product will look like an application for use. Use a web-based application for process planning or design, such as Figma.

**c. Gathering Information**

For Need-Making Applications, Object Which Needed is Tooth 3D Object Already Happen Caries with ICDAS categorization with format FilmBox (fbx) and Information Related Object.

**d. Making**

Once the necessary items have been gathered, the process will go on to the application stage. Unity 3D and use Language C# programming.

**e. Testing**

This researcher will combine the entire system live on stage. Following the completion of the process integration, the system was thoroughly inspected and tested to detect any potential points of failure and error. Additionally, he conducted analysis and discussion of test results that were already completed in order to hunt for connections between problems and application stability for media learning. On research This uses blackbox And beta tester using method questionnaire open Which typically used For classifying is responder encounter problem or no, the application will be validated by the source person and/or user. 31 students who have dental health as part of their coursework will receive an online System Usability Scale (SUS) evaluation of the application.

**f. Distribution**

Application developed (build) in the form of Application Package Files (apk) and uploaded to Google Drive after it declared "Ready to use." Having downloaded and paired the application on any Android phone (install).

**Place Study and Timetable**

Creation of system applications From January 2022 to August 2022, a period of eight months, was completed; nonetheless, there was not enough time. Time is used by the author's actions to perform. Study conducted in various locations, including the author's home, a few cafes, and a co-worker's home. And for gathering data the author conducts source interviews.

**II. RESULTS AND DISCUSSION**

At this point, the researcher conducted interviews and built a form for the application that uses augmented reality. The truth that will be constructed by the writer. The form asks respondents to recommend features that the TeethRies application should have

in order to function properly. It contains information about the application that will be developed.

**Examination of User Needs**

In addition to the needs analysis, the interview table also includes two categories of requirements: functional requirements and non-functional requirements.

**a. Functional Prerequisites**

The Augmented Reality Application for Dental Caries Lesion Learning Based on the International Caries Detection and Assessment System (ICDAS) implements certain functional requirements based on an analysis of resource people, including:

1. The program can show the user interface  
The exit, scan, about, definition of dental caries, instructional, and definition of ICDAS options are included in the main menu.
2. The program can show the user interface  
The major component of the tutorial feature is a description of how to utilize the application. If the user is familiar with how to use this application, it has a "I understand" feature.
3. The program can show the user interface.  
The key feature of the scan feature is the presentation of 3D objects with zoom and rotate features followed by the "home" button. Additionally shows the gear's type and provides a feature to access the gear's details.
4. The program can show the user interface.  
offers a definition of dental caries that, according on the user's selection, will explain dental caries in accordance with ICDAS. There are also 3D dental items with a rotate feature and two buttons labelled "scan" and "home."
5. The program can show the user interface.  
includes an explanation of the ICDAS, a definition of the ICDAS, and the buttons "home" and "scan."
6. The program can show the user interface.  
A of the dental caries selection of things " that, if used, will pin the user back to the scan that the object had previously undergone.
7. The program can show the user interface.  
The "about" section, which includes information about the researcher and offers a button to go back "home."

**a. Non-Functional Requirements**

1. The Augmented Reality Dental Caries Lesion Learning App Based on the International Caries Detection and Assessment System (ICDAS), the application is meant to be user-friendly so that users can utilize it with ease.
2. An application for augmented reality. A version of the Android operating system of at least 7.0 (Nougat) and higher is required to execute the dental carries lesion learning program based on the

## International Dental Caries Detection and Assessment System (ICDAS).

### Use-Case Diagram

The application TeethRies effect capability is shown in the Use - Case diagram (Figure 2), which also shows how users can access related applications.

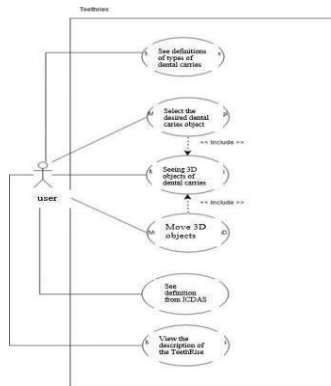




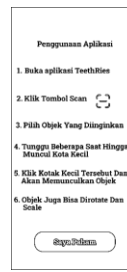




Figure 2 Use Case Diagram.

### Storyboards

The scene that will be made is outlined in the storyboard. Table 3 provides an explanation of the situation in the storyboard.

Scene	Scene Name	Information
	Scene 1 Main Menu	The programme shows a menu to launch the AR scene, ICDAS definition, ICDAS type definition, about, tutorial, and then it closes.
	Scene 2 ICDAS Definition Menu	The programme features two home buttons, an AR scene, and the description of ICDAS shown to help users comprehend what is meant by ICDAS in this perspective.

	Scene 3 Definition Menu ICDAS type	For a better understanding of the kinds in ICDAS, the programme provides ICDAS type definitions. This view includes an AR scene and two home buttons
	Scene 4 Menu About	The app features a back button in the view wherethe about menu with information about the creation of the app is displayed.
	Scene 5 Tutorial Menu	The programme shows an instructional menu to help users learn how to use it, and the display has just one home button.
	Scene 6 Calculus grading scene	To get to this scene, the user has to select one out of the 5 calculus grading options present on the screen. Upon clicking an option a 3D model of that grading will be projected.
	Scene 7 Menu Scan	In the applications scan menu, the object that was chosen in the previous view will be displayed. There is a home and detail button present.

### UI Design



Figure 3 Menu UI Design



Figure 3 depicts the TeethRies application's main menu interface, which includes buttons for the scan, about, tutorial, and ICDAS features, definition, and ICDAS gear type definition on the menu button serves to close the program, while Scan is running, and the interface is showing the selected object. Then, when you select the tooth type, it will take you to the definition interface for that type, while when you click the ICDAS definition button, it will explain what ICDAS is. The tutorial interface will then appear after you click the tutorial button, and it will walk you through using the program.

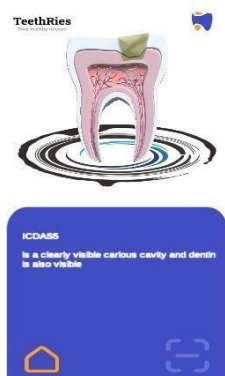


Figure 4 UI Design Tooth Type Definition

Figure 4 shows a tooth interface specification. where the home button and scan are two features. When the home button is clicked, the main menu interface is displayed. If selected, a 3D version of the desired object will be displayed. Information of the chosen and present type tooth is displayed on interface defining type tooth, where the tooth decay developed.

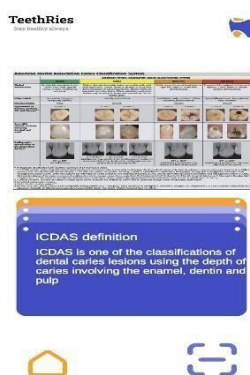


Figure 5 UI Design ICDAS Definition

Figure 5 is an ICDAS definition interface that, like Figure 9, has two buttons labelled "home" and "Scan," which act similarly to the other interfaces and display the ICDAS definitions.



Figure 6 UI Design About Applications

Figure 6 shows the applications about interface, which has a button back to return to the main menu.

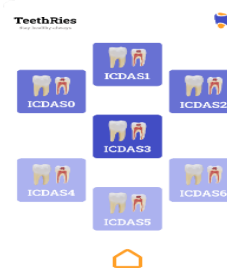


Figure 7 UI Design Select Scan Object

The interface for choosing the kind of object you want to display in 3D is shown in Figure 7. When a type is clicked, the scan interface, where the 3D item would appear, is displayed. Only the home button is displayed on the interface for election types. to access the main menu.

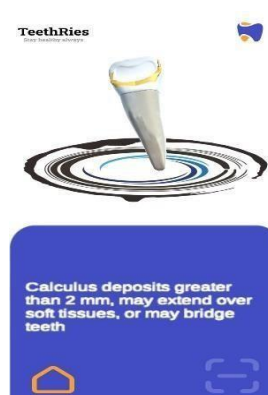


Figure 8 UI Scan Object Design

The Scan interface in Figure 8 displays 3D objects using Vuforia in accordance with the objects

chosen in the select object interface. There are 5 calculus grading option to choose. Upon selection of either option, a 3D model of that tooth with that grading will be projected. Along with model and description of the model is present at the bottom half.



Figure 9 Design UI Application Tutorials

Figure 9 shows an instructional interface with instructions for using the application and a button to return to "home" if the user is familiar with how to use it.

### 3D Object Design

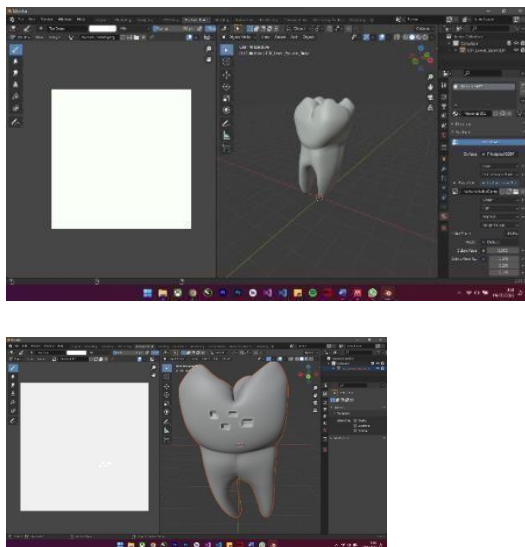


Figure 10 Types of ICDAS0 and ICDAS1

Figure 10 illustrates how the shape of teeth that are still healthy and fall under the ICDAS categorization of type ICDAS0 have not been impacted by dental caries. As opposed to Figure 15, where it is also visible that the front teeth have ICDAS1-type yellowing. The tooth enamel has changed, and it is obvious that the yellow area is a dry tooth.

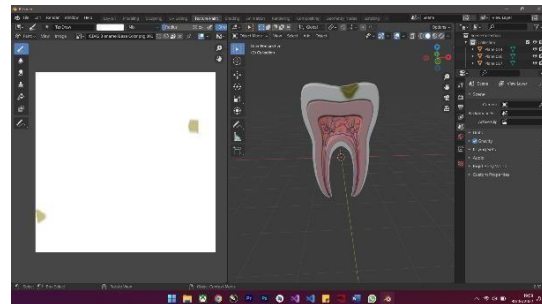
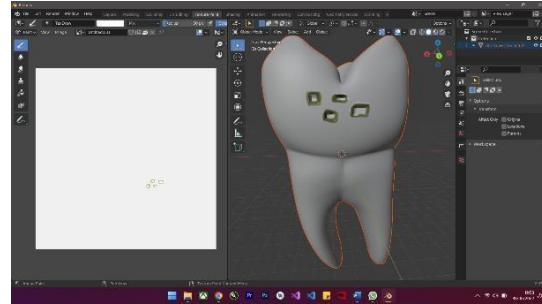


Figure 11 Types of ICDAS2 and ICDAS3

Figure 11 shows ICDAS2 type changes that are now occurring on emails and are visible even though the teeth are currently moist, whereas ICDAS3 type email caries is already in progress on the opposite side without any visible dentine damage.

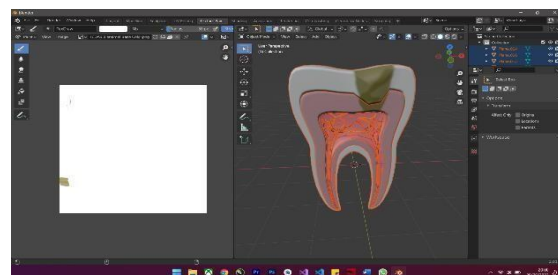
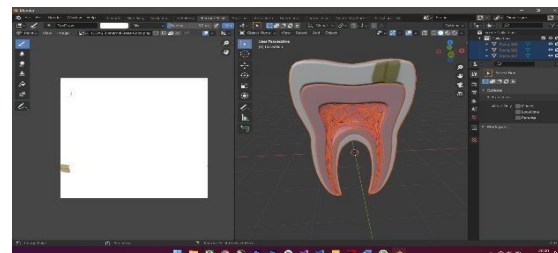


Figure 12 Types of ICDAS4 and ICDAS5

Dentin shadow is present on the cavity in Figure 12 showing ICDAS4 type, although caries has not yet reached fresh dentin till the dentine-molar junction. Dentin enamel junction refers to the area where the dentin and the gum meet on the crown of the tooth. However, the image next to it (Figure 12) shows type ICDAS5, where dental caries has already affected the dentin area.

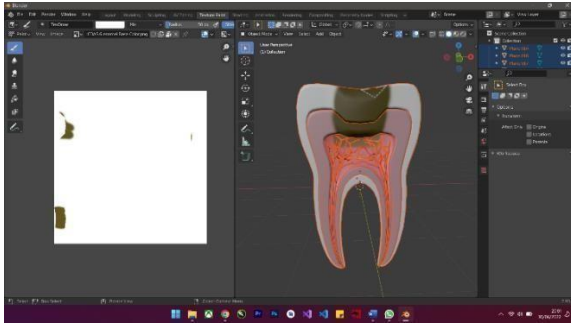


Figure 13 Type ICDAS6

Figure 13 is type ICDAS6 where carries the Already reach pulp. Pulp Alone is network tie Which consists of on cell, substance basic, and fibre.

## Making License Key on Vuforia

Making License Key on Vuforia Application TeethRies use Vuforia libraries as supporters for make an AR. On manufacture the Vuforia app comes into play as setting manager targets with use ground plane where is the target is environment around \_ without exists the following target images is channel additionlicense key on Vuforia. • The first step that must be taken is to create a license that has been provided by Vuforia. This license serves to make applications with augmented technology reality in the Unity 3D editor.



Figure 15 Additional License key to unity

Figure 15 demonstrates how the licence key that was entered into the app licence key in Unity is beneficial for augmented reality (AR) usage.

## ARCamera and Ground Plane Stage Integration in Unity

Writer adds a few components like ARCamera and Ground plane stages to in hierarchy inside \_ after adding a licence key to Unity.

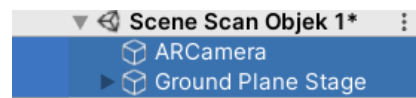


Figure 16 A Unity 3D scene.

Figure 1 Integration of ARCamera and Ground plane

## Unity's integration of 3D objects

At this point, the author imports 3D objects from the OBJ and FBX file formats into Unity 3D, after which the 3D objects are collected into a storage space called Assets (Figure 17). After 3D items were already there, the writer added 3D objects at the proper phases in each ground plane.

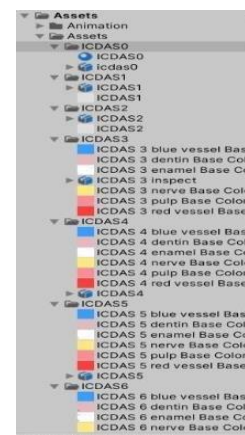


Figure 17 Adding Objects

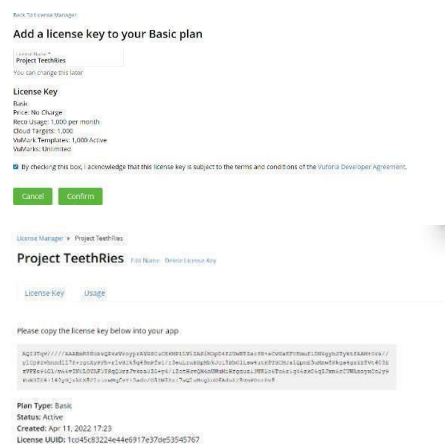


Figure 14 License Key

A licence display key received from the previous licence creation is shown in Figure 14. License To establish a connection between Unity 3D and the target manager on the Vuforia libraries, the obtained key must be entered at the time of each augmented application creation. The licence key must then be entered into Unity 3D suitable for use in AR.

## Black Box Analysis

After testing Blackbox testing for known system functions \_ based on the scenarios tested is legitimate and has been carried out in line with each of the following functions.

**Table 3 Blackbox Markerless Feature**

Scenario Testing	Expected results	Conclusion
The user clicks on the button after it has already been filled.	Users can select the item they want to display	completed
The object to be displayed is chosen by the user.	After environment, the thing on the chosen tooth will appear.	

Scenario Testing	Expected Results	Conclusion
<ul style="list-style-type: none"> <li>Users may access the ICDAS definition menu</li> <li>Users can comprehend the information presented in the ICDAS definition menu.</li> </ul>	Users successfully enter the menu for ICDAS definition. Users can comprehend the details that are offered.	Already Completed

**Table 4 Blackbox feature**

Scenario Testing	Expected Results	Conclusion
The user selects the Scan menu's button for details	Users can view item details	Already Completed
Users rotate existing objects, and they zoom in and out on objects.	Users can rotate object with one finger Objects can be zoomed with two fingers.	Already Completed Already Completed

**Table 7 Blackbox Features**

Scenario Testing	Expected Results	Conclusion
The user reads the contents of the "about" menu after clicking the "about" button.	Users successfully navigate to the applications menu and read	Already Completed

**Table 5 Blackbox Object Definition feature**

Scenario Testing	Expected Results	Conclusion
<ul style="list-style-type: none"> <li>Users can choose from the available cards on the slides.</li> <li>Users can access the object definition menu to obtain object details.</li> </ul>	Users successfully press the accessible slides knobs. Users can comprehend the contents explanation and details.	Already completed Already completed

**Table 8 Blackbox Feature Tutorial**

Scenario Testing	Expected Results	Conclusion
The user by clicking the tutorials icon in the home menu	User is aware of how to use the tutorials mentioned application.	Already Completed
Reads the tutorials instructions on how to use the application; users clicking the "I understand" button located in the tutorial.		

Can be summarised in several of the tables above (Tables 5 through 10), which use on Blackbox previously completed and tested in backbox the include researchers, resource persons, and advice.

**Table 6 Blackbox ICDAS Definition Features**



## Beta Testers

In the survey, 31 respondents said they would want to try out the application and complete a questionnaire. The questionnaire is divided into two types: open and closed. On research This study makes use of an open-ended questionnaire that is widely used to categorise whether a respondent has a problem (Salmaa, 2021). In contrast, SUS testing was done using a method of method computation that involved giving a questionnaire in the form of a Google form to more than 31 respondents. Respondents to surveys must pay to download and use the application. 10 statements and 2 questions with a 5-point Likert scale were included in the questionnaire, with the screening statement appearing in Table 11 and the question to be filed in Table 12.

**Table 9 Screening Statement**

No	Statement Screening
1	I'm eager to learn about dental caries lesions utilising an augmented reality learning tool and the ICDAS classification.

**Table 10 Questions and statements in the questionnaire**

No	Questions Asked
1	I think I will use this system again
2	I find this system complicated to use
3	I find this system easy to use
4	I need help from other people or technicians in using this system
5	I feel the features of this system work as they should
6	I feel there is a lot of inconsistency (incompatible with this system)
7	I have a feeling that others will understand how to use the system quickly
8	I find this system confusing
9	I feel there are no obstacles in using this system
10	I need to familiarize myself first before using this system
11	Is it easy to operate the scaling module (zoom in / zoom out) on objects?

12	Is it easy to operate the rotation module on objects?
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Each question on the Likert scale contains five possible responses, ranging from really detest to really like.

The findings are computed to get a final score for the SUS test, which ranges from 1 (one) to 100 (one hundred). The respondents' SUS test responses are presented in (Appendix 1). The SUS testing formula is used to recalculate the data that has been added together based on the respondents' responses. by 2.5 (two and five), which is the product of the sum. in order to achieve the result shown in (Appendix 2).

A score of 83 is achieved once the SUS method has been calculated and divided by the total number of respondents. With the score received, it is concluded that the application that has been prepared and tested is an application that corresponds to a value of 83 as indicated in Figure 31 regarding the SUS calculation.

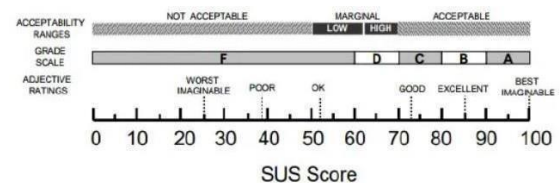


Figure 18 calculation of SUS

## Distribution

The application can be built once the scene has been created. There are some modifications made to the Build Settings settings for Android as seen in Figure 19 before the application is produced. By choosing Add Open Scenes, the newly constructed scene is entered.

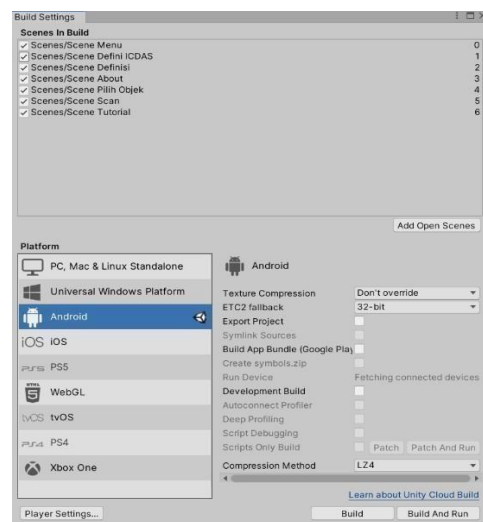


Figure 19 Build setting

Before the application is constructed, there are a few settings under the Player Settings area. The screen display is configured to either portrait or horizontal orientation for screen orientation options. The Resolution and Presentation section of the Player menu contains this parameter. Return to Build Settings and choose Build to start building the app. If the Android phone is linked to a PC or laptop, you can also choose Build and Run, in which case the app will install on its own. The developed app is then uploaded to Google Drive. Users can download the application while it is in beta testing to give it a try right away.

### III. CONCLUSIONS AND SUGGESTIONS

It is possible to draw the following conclusions from the research that has been done and the descriptions that have been presented in the earlier chapters:

1. Based on the findings of this study, dental students can use the Application for Learning Dental Caries Lesion with ICDAS Classification Based on Augmented Reality.
2. The results of tests conducted on responders reveal benefits in learning, object manipulation (rotation, The scanning environment is where there are problems since respondents do not fully understand the optimal scanning environment. This programme employs two strategies, namely:

- a. Blackbox  
In this Blackbox test, we're checking that the application's functionality functions flawlessly and that the results we get are functionally sound.
- b. Beta Tester  
During the beta testing phase, respondents filled out a survey to test the application, and the results were used to determine the assessment using the SUS formula. The findings are scored at 83, and according to the SUS calculation, the results are considered user feasible.

### Suggestion

The author hopes that it can be improved with a few features or techniques, such as:

1. A quiz element was included for dental students to review.
2. Improving the visual appeal and readability of the design for dental students.

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