DECLARATION OF ORIGINAL AND OWNERSHIP

ARWOODBASE: IDENTIFYING CHARACTERISTICS / PROPERTIESOF SELECTED MALAYSIA WOOD THROUGH DATABASE

1. We are **student of Wood-Based Technology Diploma program at Politeknik Sultan Salahuddin Abdul Aziz Shah,** located at Persiaran Usahawan, Seksyen U1, 40150 Shah Alam, Selangor. (Referred to as 'the Politeknik').

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Made and genuinely acknowledged by the said:

Signature :

Name : Muhammad Hafiy Jauhar Bin Jamalullail (08DBK22F1023)

Date :

Signature :

Name : Nasuha Hani Binti Md Nizam (08DBK22F1027)

Date :

Signature :

Name : Awang Nor Huzairi Bin Awang Zakaria (08DBK22F1029)

Date :

Signature :

Name : Muhamad Danish Haikal Bin Sabaruddin (08DBK22F1051)

Date :

APPROVAL PAGE

Reviewed by;-

Supervisor : Muhamad Fairuzzairi Bin Abdul Hamid

Signature :

Date :

Verified by;-

Project Coordinator : Zullhyzrifee Ishraf Bin Zulkifly

Signature :

Date :

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Lastly, we hope that the results of this project will benefit all relevant parties and serveas an inspiration for greater efforts in the future. May all the knowledge and experiences gained be utilized and further developed for even greater success.

ABSTRACT

This study explores the integration of Augmented Reality (AR) technology with the fieldof dendrology and databases to develop a more interactive and visual learning methodfor identifying the characteristics and properties of trees and wood. By combining 3D AR technology with an informative database, this study enables the construction of 3D tree models that can be interactively displayed. Through AR, users can view the physical structure of wood and gain a deeper understanding of tree characteristics, including physical features, composition, and the uses of each type of wood. The database developed in this study stores detailed information on various tree species, their characteristics, and wood properties, allowing users to access this information more systematically.

This approach aims to enhance users' understanding of physical properties through a more engaging and easily comprehensible visual medium. The results of this study are expected to contribute to students by providing adequate, easily accessible, and easily understood information. With this AR-based approach, users have the opportunity to benefit from clearer and more detailed visualizations, enriching their learning experience and appreciation of dendrology knowledge.

Keywords: 3D AR, Database, Wood Physical Structure

ABSTRAK

Kajian ini meneroka integrasi teknologi Augmented Reality (AR) dengan bidang dendrologi, dan pangkalan data untuk membangunkan satu kaedah pembelajaran yang lebih interaktif dan visual dalam mengenalpasti ciri-ciri serta sifat sesuatu pokok dan kayu. Dengan menggabungkan teknologi AR 3D dan pangkalan data berinformasi, kajian ini membolehkan pembinaan model 3D pokok yang boleh dipaparkan secara interaktif. Melalui AR, pengguna dapat melihat struktur fizikal kayudan memahami ciri-ciri pokok dengan lebih mendalam, termasuk ciri-ciri fizikal, komposisi, dan kegunaan setiap jenis kayu. Pangkalan data yang dibangunkan dalam kajian ini menyimpan maklumat terperinci mengenai pelbagai jenis pokok, ciri-ciri, dansifat kayu, memudahkan pengguna untuk mengakses maklumat tersebut dengan lebih sistematik.

Pendekatan ini bertujuan untuk meningkatkan kefahaman pengguna terhadap sifat fizikal dan melalui medium visual yang lebih menarik dan mudah difahami. Hasil kajian ini diharap dapat menyumbang kepada pelajar dengan menyediakan maklumat yang mencukupi, lebih mudah diakses, dan mudah difahami. Dengan adanya pendekatan berasaskan AR ini, pengguna berpeluang memanfaatkan visualisasi yang lebih jelas dan terperinci, sekali gus memperkayakan pengalaman pembelajaran dan penghayatan terhadap ilmu dendrologi.

Kata kunci : AR 3D, Pangkalan Data, Struktur Fizikal Kayu

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CHAPTER 1
INTRODUCTION

1.1 INTRODUCTION

This project aims to integrate 3D Augmented Reality (AR) technology with dendrology,a field of study that focuses on aspects such as classification, physical characteristics,and general information about various types of trees. With the assistance of AR, user can view 3D models of trees in a more interactive and realistic manner using deviceslike smartphones or tablets. This enables them to explore the physical features of trees, such as shape, height, and external structure, within a real-world environment.

Through this approach, users can not only visualize the actual appearance of trees but also access detailed information about each species, including their scientific names, native habitats, uses, and other physical characteristics. The application of AR in this project offers an immersive experience where users can select specific tree models and instantly display rich information about their dendrological characteristicson their screens. This makes learning about trees more visual and easier to understand compared to conventional methods, which often rely on text or static images.

Additionally, the project includes the development of a comprehensive database that stores detailed information about various types of trees. This database allows users to quickly and accurately access and search for tree information. Whenever users select a 3D tree model through the AR application, supplementary information from the database is displayed, providing more complete and in-depth insights. The database not only facilitates easy reference but also supports updates, enabling the addition or revision of the latest data on tree species or their physical characteristics as needed.

Overall, this approach offers a more interactive and effective learning method by leveraging AR technology to deliver information in a more engaging and relevant way for users. This project is expected to become a valuable tool for students, researchers, and anyone interested in gaining a deeper understanding of the world of trees and wood. It aligns with technological advancements in education and botanical research.

1.2 PROJECT BACKGROUND

In this modern technological era, the use of AR is becoming increasingly widespread across various fields of education and research, including environmental science and biology. However, the application of AR in the field of dendrology remains limited. This study seeks to introduce AR as a tool that can enhance understanding of tree structures and characteristics. The use of a digital database enables informationabout trees and wood to be accessed more easily and effectively compared to physical references, which require significant time and space.

1.3 PROBLEM STATEMENTS

Information about trees is difficult to understand in the form of text and static images and is scattered across various sources. This hinders effective learning and referencing processes. The use of Augmented Reality (AR) for 3D tree models, along with an interactive database, is expected to simplify understanding and increase users' interest in the field of dendrology.

1.4 OBJECTIVES

1. To integrate Augmented Reality (AR) technology to display 3D models of trees and wood, allowing users to interact directly with visual information.

2. To develop a database that stores comprehensive information about the characteristics or properties of wood, including dendrological information such as leaf types.

1.5 RESEARCH QUESTION

- How can AR technology help in understanding the anatomy of trees and wood?

- To what extent can a digital database improve the efficiency of management and access to information about various types of trees?

1.6 PROJECT SCOPE

This project involves the development of a database that stores information about types of wood and tree characteristics. It also focuses on the use of AR to display3D structures of wood and trees to facilitate user understanding. The scope of this project is limited to providing basic information and 3D visuals of the most used trees and wood in industry and education.

1.7 PROJECT SIGNIFICANCE

This project facilitates learning about trees through interactive 3D visuals, making the information easier to understand and more engaging. A comprehensive database allows quick access to tree information for students and researchers.

1.8 DEFINITION OF TERMS / OPERATIONAL DEFINITIONS

- **Augmented Reality (AR):** A technology that allows digital objects, such as 3D model, to be integrated into the real-world environment through devices like smartphones or tablets.

- **Dendrology:** A branch of botany that studies trees, including their types and characteristics.

- **Database:** A system that organizes and stores information so it can be easily accessed and used by users.

CHAPTER 2
LITERATURE REVIEW

2.1 INTRODUCTION

This field study is conducted to gather the necessary data on various types of trees and their characteristics, which will be included in the project's database. In this context, the study also involves an analysis of the potential of Augmented Reality (AR) technology to display tree information and 3D structures interactively. This step is important to ensure that the developed application can provide a more effective and easily understandable learning experience for users.

2.1.1 DENDROLOGY

Dendrology is a branch of botany that focuses on the study of trees, particularly concerning their structure, characteristics, and species classification. It involves studying how trees grow, the types of trees that exist, and their roles in the ecosystem.Additionally, dendrology also includes the analysis of wood properties, tree resistance to diseases the potential uses of trees in various industries, such as construction and furniture making.

In the context of education and research, dendrology is important because it helps us understand the diversity of flora and the functions of ecosystems influenced by these trees. Knowledge of dendrology also contributes to conservation efforts and the management of natural resources, which is vital in addressing climate change and environmental pollution. Therefore, dendrological studies are not only beneficial in academic fields but also in other sectors such as agriculture, forestry management, and environmental conservation.

Traditionally, dendrology has relied heavily on direct observation of tree morphological features, such as leaf shape, flowers, and stem structure. However, with advancements in technology, particularly Augmented Reality (AR) and digital databases, dendrological studies can now be expanded in a deeper and more interactive manner. Technologies like AR allow students and researchers to view treesin clearer, interactive 3D visual forms, providing a better understanding of trees without solely relying on field studies. This opens opportunities to enhance how we learn and understand dendrology through a more dynamic and contemporary approach.

2.2 PREVIOUS STUDIES

Previous studies on the application of Augmented Reality (AR) in education anddendrology show that this technology has great potential in enhancing the learning process and understanding biological concepts, including the study of trees and dendrology. Below are some previous studies relevant to the use of AR in this field.

Table 2.1: Previous studies relevant to the use of AR

NO.	NAME	PREVIOUS
1.	**Bacca et al. (2014)**	This study highlights the benefits of AR in science education, particularly for understanding complex biological concepts. Bacca et al. found that AR enhances student motivation and comprehension compared to traditional methods. By interacting with 3D models, students can better grasp concepts like morphology and anatomy. The study recommends broader use of AR in teaching science subjects, including dendrology, to help students visualize tree structures more effectively.
2.	**Chu et al. (2015)**	Chu et al. (2015) explored using AR to enhance dendrology education by developing an application that displays 3D tree models based on key morphological features. The AR system provides real-time information through mobile devices, improving the visual representation of tree structures and aiding the understanding of specific features in natural settings. This study aligns well with Arwoodbase, which also uses AR to present interactive tree visuals to users.

3.	**González et al. (2018)**	In this study, González et al. discuss the use of databases in the field of dendrology and demonstrate how digital systems can assist in the management and classification of tree species. This database allows researchers and educators to store and access information about tree characteristics, tree types, and their uses more efficiently.
4.	**Nasir et al. (2019)**	Nasir et al. (2019) developed an AR application featuring 3D models of trees from Malaysia's tropical forests, providing details on their habitats, ecological traits, and industrial uses. This study highlights how AR can enhance understanding beyond physical structures, offering insights into trees' ecological and economic contexts. This approach can enrich Arwoodbase by adding ecosystem-related information and practical applications.

5.	**Serna et al. (2020)**	The study highlighted the importance of AR in dendrology education by combining 3D visualization with a digital database. Their AR system lets students interact with 3D tree models and access detailed species information, aligning with Arwoodbase's goal to integrate AR and a database for comprehensive insights into tree characteristics, species, and their uses.
6.	**Zhang et al. (2021)**	Zhang et al. (2021) explored AR for managing forest biodiversity knowledge by displaying 3D tree structures, helping users learn species characteristics like height, leaf shape, and stem type. This interactive approach aligns with Arwoodbase's goal of providing clear visual information about tree structures and species.
7.	**Fischer et al. (2022)**	Fischer et al. (2022) showed that AR enhances public access to dendrological information by offering multi-perspective views and detailed species data. Their AR project helped park visitors and explorers identify trees while learning about their uses and history, supporting Arwoodbase's goal to introduce tree features through AR technology.

Table 2.2: Continuation of previous studies

2.3 SUMMARY

Previous studies highlight the significant potential of using AR in the field of dendrology, particularly in providing users with visual and interactive experiences to understand tree characteristics, identify species, and learn about the ecological roles of trees in nature. AR systems integrated with databases offer easy access to well- organized information, enabling users to comprehend trees in a broader context. The Arwoodbase project, with a similar approach, has the potential to enhance education and research in dendrology using this innovative technology.

Table 2.3: Citations and References List

NO.	Citations and Reference List Source: Books
1.	According to studies in the field of augmented reality (AR) and science education, AR-based applications have the potential to enhance students' understanding through interactive and immersive visualization (Azuma, 1997; Billinghurst & Dünser, 2012). These studies support the use of technologies such as Unity and tools like ARCore, ARKit, and Vuforia in developing AR applicationsfor education. Additionally, the use of 3D visualization for tree morphology can help students better and more deeply recognize the biological characteristics of trees.

2.	Wu, Lee, Chang, and Liang [2013] emphasize that AR can provide a more realistic learning context, allowing students to explore tree structures in greater depth and visually understand dendrological components. The use of AR applications like this is highly suitable for courses such as Wood Based Technology, which require an in-depth understanding of plant and wood structures.
3.	Research by Falk & Dierking (2000) indicates that contextual information, such as tree habitats and scientific names, can enhance students' ecological understanding. Further studies by Huang, Chen, & Chou (2016) found that additional information in educational AR applications enriches the learning experience by increasing students' interest in the ecosystems being studied. Additionally, Chen, Chi, & Lin (2015) emphasized that self-paced interactive learning applications using AR allow students to master topics more deeply and at their own learning pace.
4.	According to Yuen, Yaoyuneyong, and Johnson [2011], augmented reality (AR) applications in education provide immersive learning experiences by integrating digital elements into real-world environments. This technology is highly effective in enhancing the understanding of complex concepts such as the internal structure of trees and growth processes [Bacca et al., 2014]. These studies demonstrate that integrating AR into subjects like dendrology helps students better understand the connection between theory and practical application.

Table 2.4: Continuation of citations and references list

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

At the initial stage of the Arwoodbase project study, we need to examine the design and concept of our product to ensure it provides suitable learning tools for first-semester students studying Dendrology in the Wood-Based Technology course. Our goal is to ensure that the Augmented Reality (AR) technology used can offer a deeper understanding of trees and dendrology species in an interactive and visual way. For students who are just starting their studies in the Wood-Based Technology course, understanding dendrology is crucial as it provides a foundation for comprehending the characteristics of trees, their uses in the wood industry, and the relationship between trees and the natural environment. Therefore, the Arwoodbase application is developed to support students' learning by providing easily accessible information about different tree species, their structures, and their applications in the wood industry.

We conducted research on how AR can be applied to display tree structures more interactively, enabling students to see and understand tree characteristics more clearly rather than relying solely on images or text. The application also includes a database that stores basic information about various tree species relevant to the dendrology subject studied by first-semester students.

3.2 FLOWCHART

This flowchart illustrates the step-by-step process of creating Arwoodbase the initial idea to the final product.

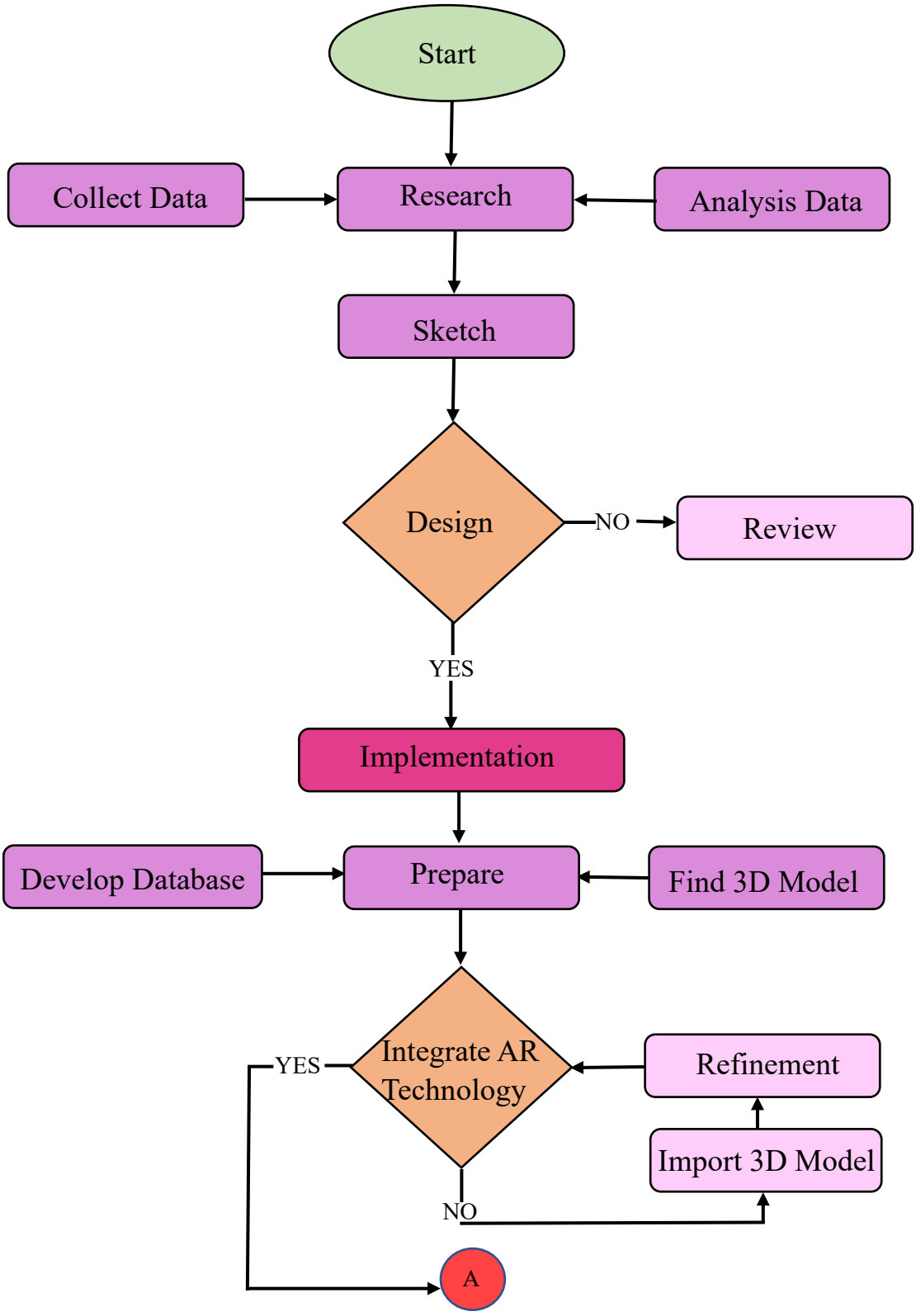

Diagram 3.1: Flowchart of process for the making Arwoodbase

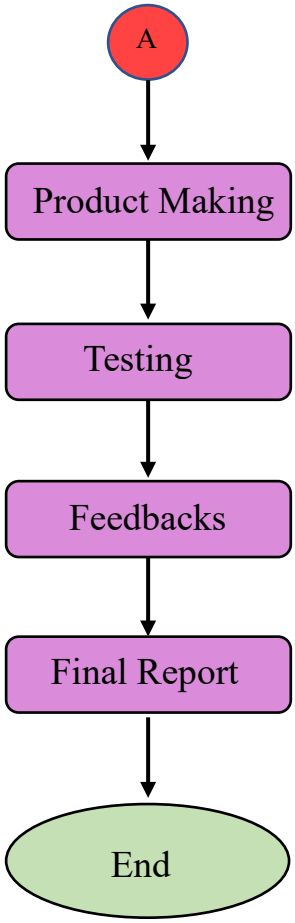

Diagram 3.1: Continuation of flowchart of process for the making Arwoodbase

3.3 PROJECT DESIGN

This project combines two main components, which are the database and Augmented Reality (AR), to enable users to access interactive visual information about trees. The system consists of two main parts:

- **Database:** Stores detailed information about tree species, such as name, habitat, physical characteristics, and uses of the tree.

- **AR System:** Uses mobile devices to display interactive 3D models of trees, allowing users to view the tree structure and information about the tree in a visual format.

3.4 METHOD / PROCEDURES / TECHNIQUES FOR PROJECT DEVELOPMENT

In this section, the methods, procedures, and techniques used for the development of the project will be outlined. These include the approach taken to design, implement, and test the system, as well as the specific technologies and tools utilized to ensure the successful completion of the project. The following steps highlight the key stages involved in the development process, including planning, system design, and the selection of relevant materials and resources.

3.4.1 PROJECT DEVELOPMENT PROCESS

- **Product Sketches**

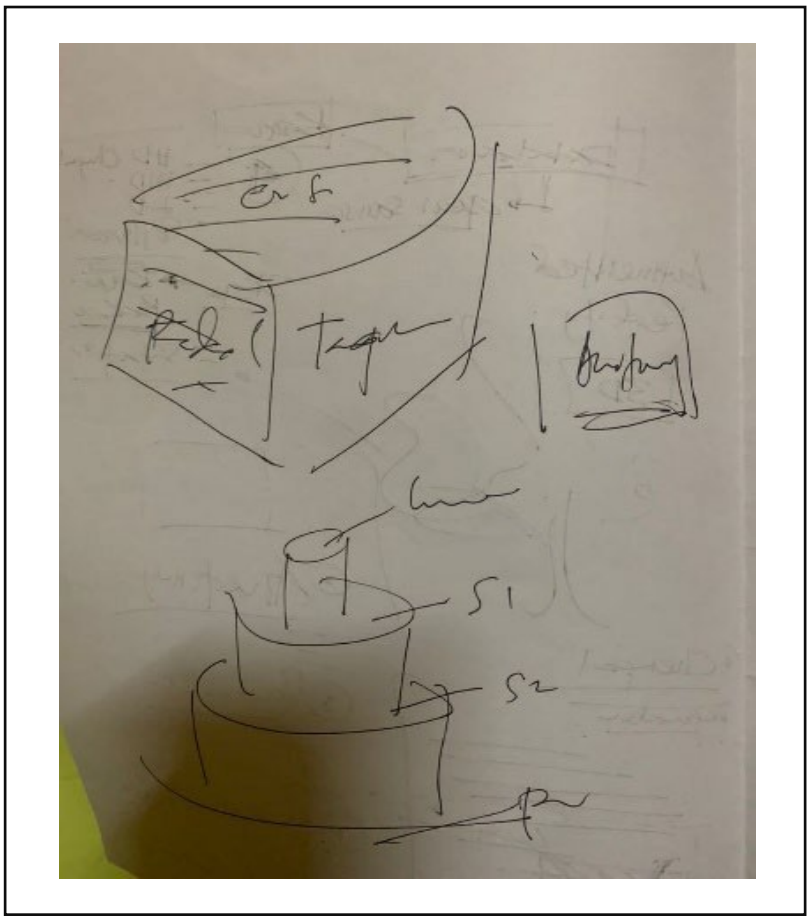

Figure 3.1: Product Sketches

We have created initial sketches as a guide for displaying the 3D models in the Arwoodbase application. These sketches are intended to ensure the development process runs smoothly and results in accurate and visually appealing tree models.

- **3D Models**

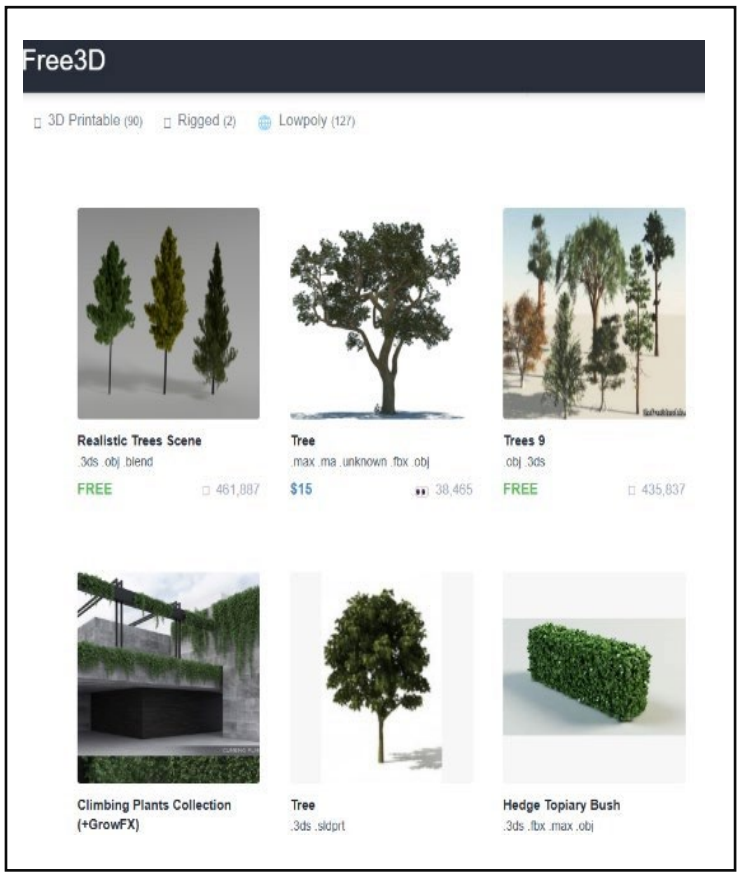

Figure 3.2: Website

We are currently in the process of searching for high-quality 3D models to be included in the Arwoodbase application. Among the tree species we have selected for this project, we are focusing on incorporating detailed models of the durian tree and the jelutong tree. These models will enrich the learning process by providing more realistic visual representations for students studying dendrology.

- **Information Collection Process**

Figure 3.3: Malaysia Tree In Colour

Figure 3.4: Malaysia Plant Red List

We have selected the Malaysian Timber Industry Board (MTIB) and the CHERAS site as the primary locations for data collection, focusing on the chosen 3D tree species as well as several other additional tree species to ensure a comprehensive dataset for our project.

- **Application Design Selection**

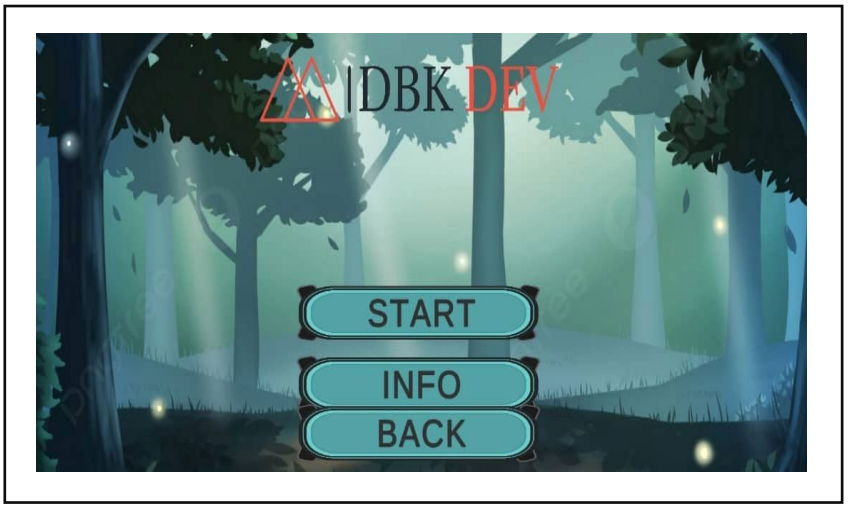

Figure 3.5: Design 1

Figure 3.6: Design 2

We have designed two different layouts for the application. After conducting a thorough evaluation, we decided to select the second design because it provides easier access for users. This layout is more user-friendly, simplifies navigation, and allows important information to be accessed more quickly and efficiently compared to the first design.

- **Process of Script Creation**

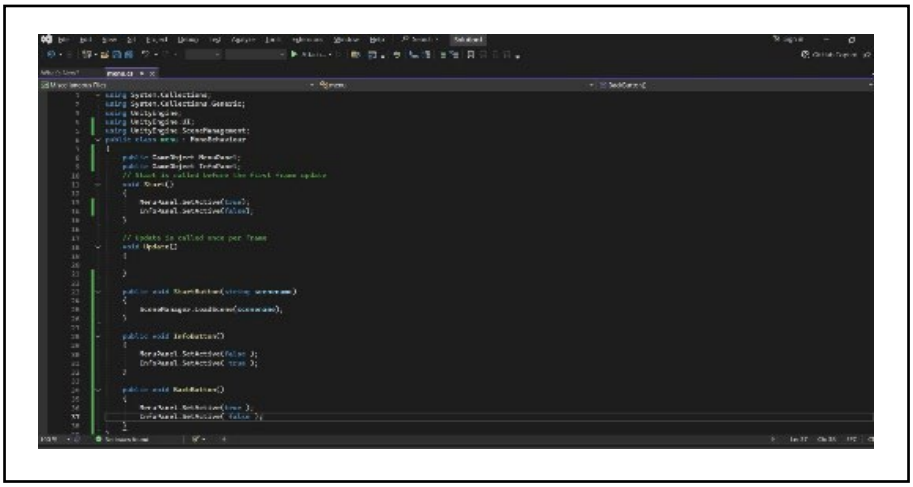

Figure 3.7: Script

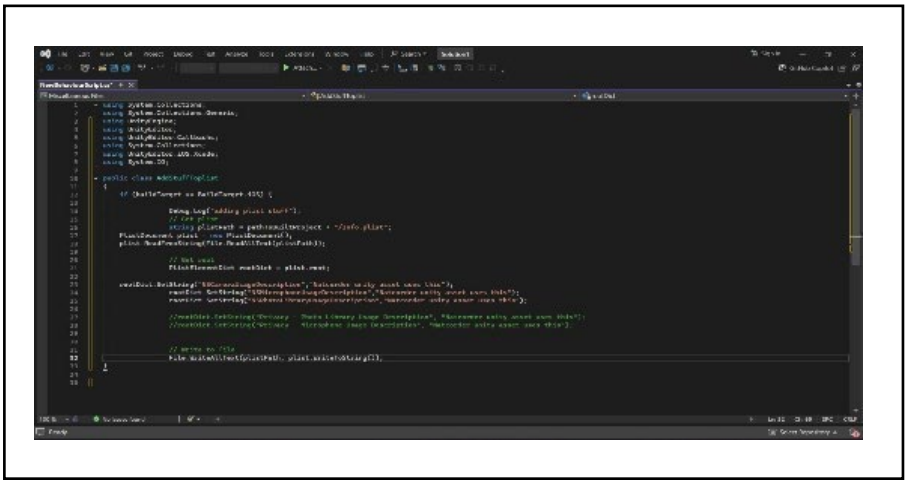

Figure 3.8: Script

The development of the initial script for Arwoodbase was carried out with the primary objective of facilitating smoother and more seamless transitions between scenes within the application. This script plays a crucial role in enhancing user experience by ensuring that navigation flows effortlessly, reducing loading times, and maintaining continuity as users move from one scene to another.

- **3D Model Process**

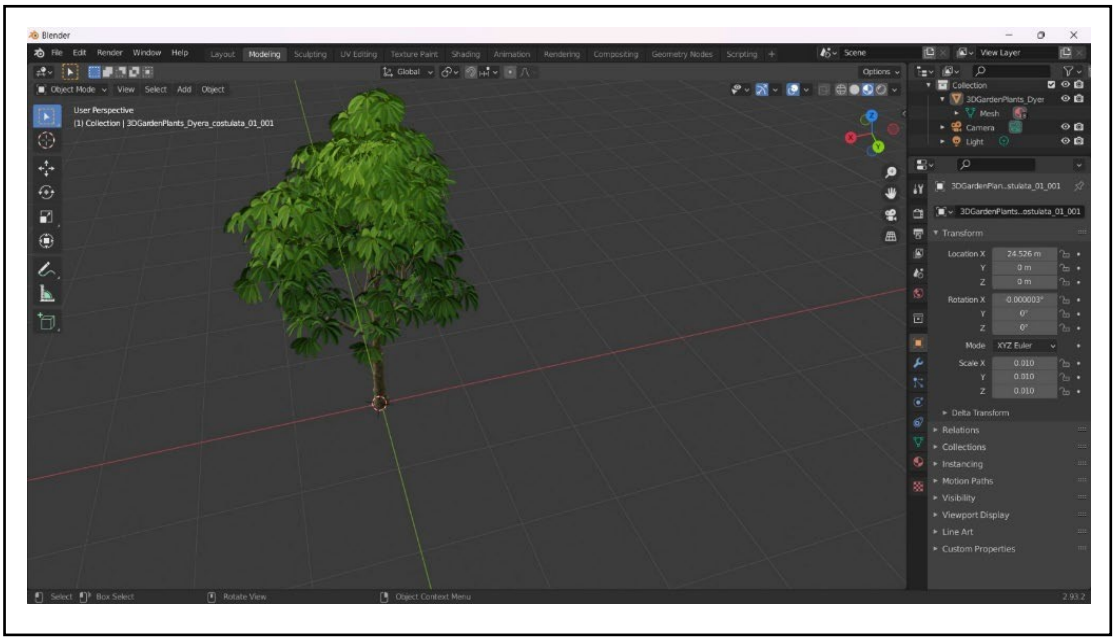

Figure 3.9: 3D Model

The 3D model has been integrated into the application, and its position has been carefully adjusted to ensure it is displayed in a vertical orientation. This adjustment was made to provide a clearer view of the model, enhancing the visual experience for users, especially when interacting with the model from different angles.

- **Materials Process**

Figure 3.10: Materials

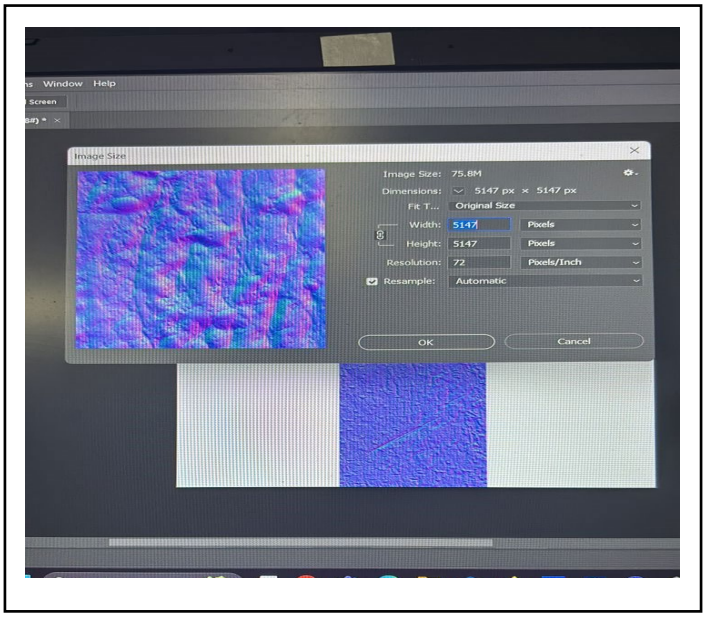

Figure 3.11: Materials

The 3D model that has been inserted needs to have materials added to areas that lack textures or materials. This addition is necessary to complete the overall appearance of the model, making it more realistic and aesthetically pleasing. By applying appropriate materials to all areas, the model will appear more refined, enhancing the visual quality and providing a better user experience.

- **Process of Adding Notes**

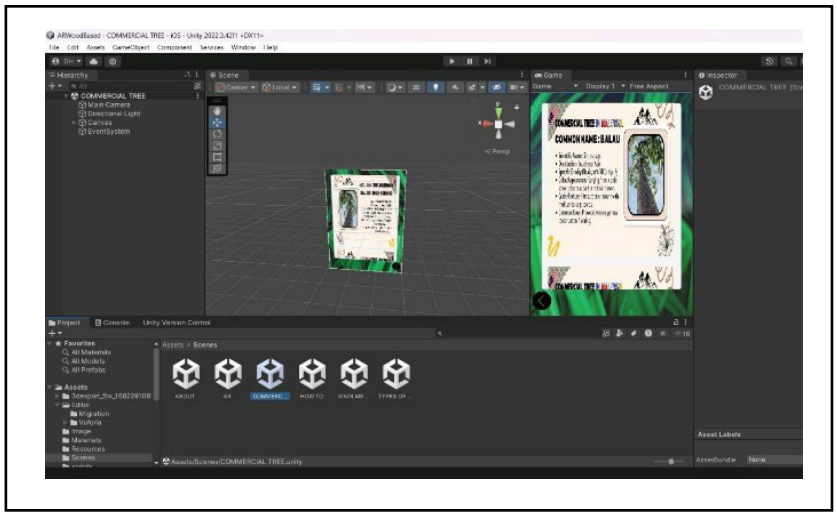

Figure 3.12: Tree Notes

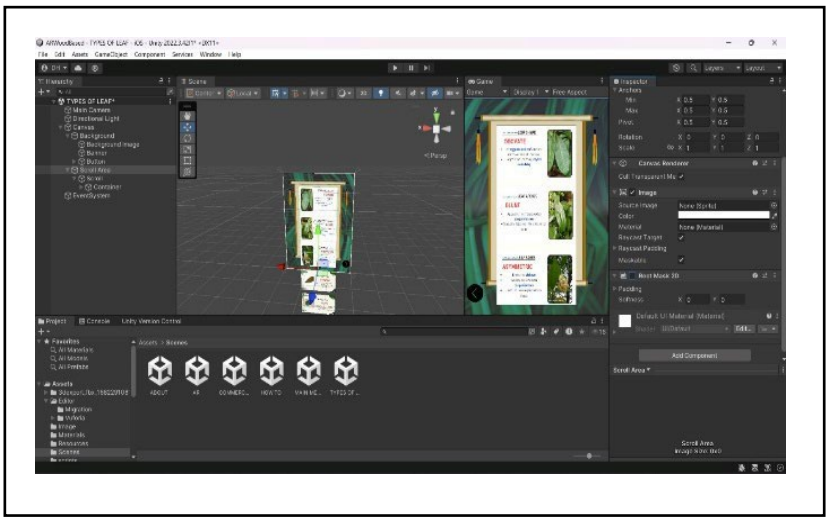

Figure 3.13: Leaf Notes

The leaf and tree notes created in the Canva application are imported into the Arwoodbase application to be used as visual references and informational resources. This import process allows these notes to be integrated into the Arwoodbase software, providing users with access to more interactive and engaging learning materials.

- **Image Target Process**

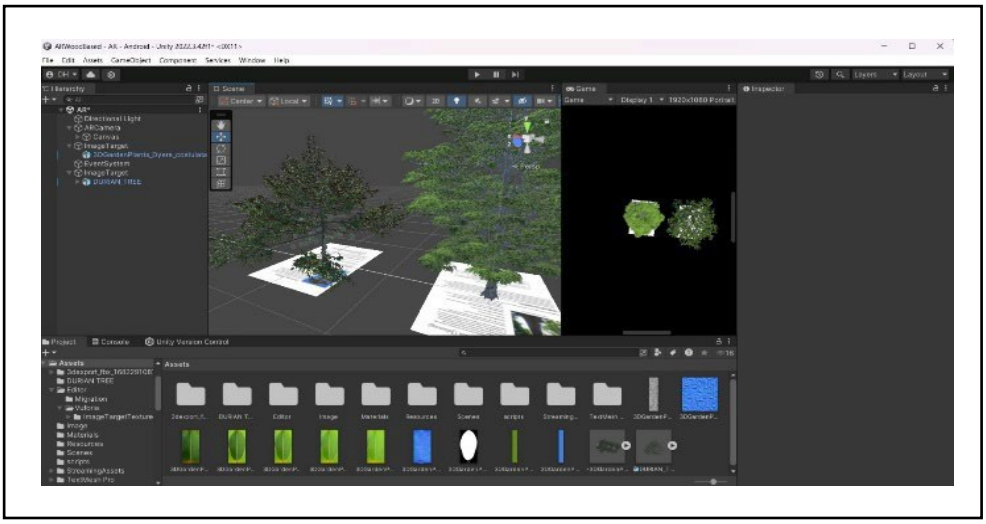

Figure 3.14: Durian Tree

Figure 3.15: Jelutong Tree

Placing the 3D model on the image target, which is the ebook cover, involves determining the model's position based on the specified size, ensuring it is accurately aligned with the designated area on the image. This process requires the system to first recognize the image target, followed by calculating the appropriate size and orientation for the 3D model to be displayed correctly according to the set specifications.

- **Software Process**

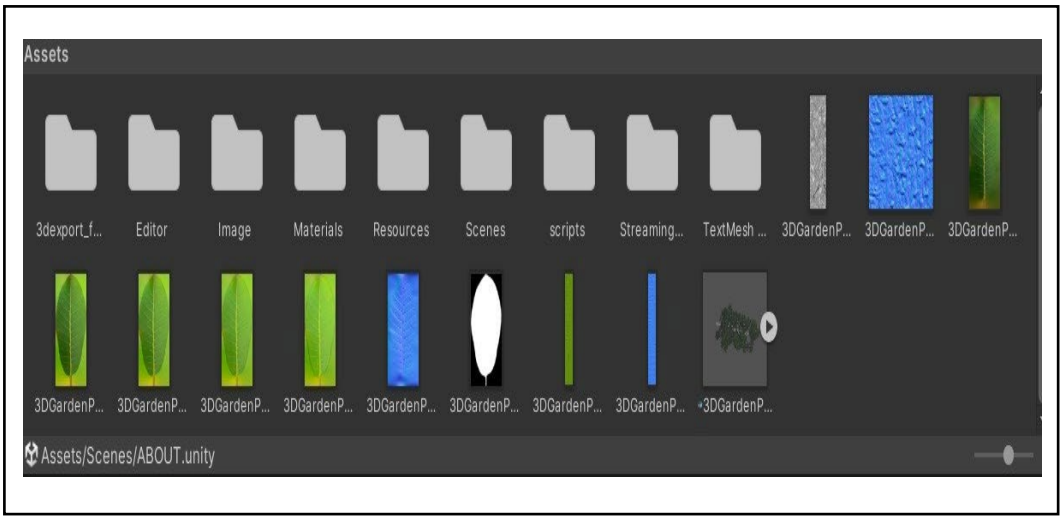

Figure 3.16: Software

Using the software to combine all the imported assets, including 3D models, images, and other elements, to ensure perfect alignment and seamless integration between each component. This process involves organizing and adjusting each asset according to the project's requirements, ensuring that all elements function well within a single virtual environment, considering factors such as size, scale, and interaction between them.

3.4.2 MATERIAL AND EQUIPMENT

- **Unity**

Figure 3.17: Unity

Unity is a popular and versatile game engine, often used to develop video games as well as interactive applications such as Augmented Reality (AR) and VirtualReality (VR). One of the main advantages of Unity is its ability to support developmentin both 3D and 2D formats, making it suitable for complex visual applications, includinggames and educational apps. Unity uses the C# programming language for scripting, allowing developers to control elements of the application such as animations, movement, and interaction more flexibly.

We use Unity to provide various features that facilitate the creation of AugmentedReality (AR) applications. With support for high-quality 3D and 2D graphics, Unity enables the development of interactive and realistic tree models for this project.

- **Microsoft Visual Studio**

Figure 3.18: Microsoft Visual

Microsoft Visual Studio is an Integrated Development Environment (IDE) developed by Microsoft to assist developers in creating various types of applications such as desktop, web, and mobile apps. With Visual Studio, developers can code, debug, and manage code within a comprehensive platform. This IDE offers features such as an intelligent code editor, collaboration tools, and integration with cloud services like Microsoft Azure. Its ability to support both large and small-scale projectsmakes it a popular choice among professional developers and development teams worldwide.

We use this application in the development of Arwoodbase to create interactive AR visuals, allowing users to easily interact with 3D tree models and dendrological information. Additionally, Visual Studio supports coding, making Arwoodbase more responsive and easier to update.

- **Blender**

Figure 3.19: Blender

Blender is a free, open-source software for 3D modeling, animation, rendering, and simulation. It is widely used in the graphics and gaming industries due to its comprehensive features, such as detailed modeling, 2D and 3D animation, photorealistic rendering, and physics simulation. With strong community support, Blender is suitable for both beginners and professionals in various creative fields.

We use Blender because it is free, easy to use, and provides a complete set of 3D modeling tools to accurately create tree visuals.

- Canva

Figure 3.20: Canva

Canva is an online graphic design platform that allows users to easily and quickly create and produce various types of designs. It offers a wide range of customizable templates for various uses, such as posters, infographics, presentation slides, logos, social media graphics, and more. With a user-friendly interface and easy-to-use tools. Canva contains various design elements such as images, icons, fonts, and editing tools to enhance the final output.

We use Canva to make the information collected more visually appealing for inclusion in Arwoodbase.

3.5 DATA ANALYSIS METHOD

The data collected in the Arwoodbase project has been processed and analyzed using descriptive statistics and Pearson's moment product correlation analysis (r). Descriptive statistics were used to describe the response patterns of the respondents, while correlation analysis was conducted to determine the relationships between variables such as the effectiveness of the 3D model, the ease of understanding the wood database, and the level of improvement in understanding dendrology. The analysis process was carried out using the latestversion of SPSS software.

Results of some data analysis:

1. Descriptive Statistics:

a) Most respondents gave positive evaluations of the effectiveness of the 3D model, indicating the effectiveness of interactive visuals in understanding wood and tree structure.

b) Most respondents found the information in the commercial wood database to be "easy to understand," with only a few stating it was "very easy."

c) Most respondents also reported that the project had a high or very high impact on their understanding of dendrology .

3.6 SUMMARY

This project focuses on the collection of data related to tree species and the development of an application using the Unity platform. The visualizations created in this project aim to help students better understand the subject of dendrology through the presentation of engaging and easily understandable information.

Although this project did not involve user surveys, the development of the application still followed appropriate methods to ensure that the outcomes could achieve the set objectives. Overall, this project provides a foundation for a more creative and interactive learning approach to the subject of dendrology.

CHAPTER 4
RESEARCH FINDINGS AND DISCUSSION

4.1 INTRODUCTION

This section discusses the research findings and data analysis obtained throughout the development of the Arwoodbase project. These findings cover the effectiveness of Augmented Reality (AR) technology in presenting tree information interactively, the content of the database provided, as well as user feedback on the developed application. The focus of this section is to evaluate how well the Arwoodbase application meets the project objectives in supporting first-semester students learning in the subject of Dendrology.

The study also focuses on the extent to which AR technology can enhance students' understanding of tree's characteristics visually and interactively, compared to conventional learning methods such as text and static images. These findings not only provide an assessment of the application's effectiveness but also contribute to the development of digital learning tools in the fields of wood technology and dendrology education.

Additionally, this section evaluates the application's impact on user motivation and experience, particularly students who use Arwoodbase as a learning tool. The analysis conducted in this section helps identify key aspects for future improvements, with the goal of making the application more comprehensive and beneficial for educational and research purposes.

4.2 RESEARCH FINDING / TESTING

The research findings were made to obtain student information regarding the use of AR for learning methods about wood and trees. These are the research findings from our project:

Tempat Pengajian

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Politeknik Kota Kinabalu	24	42.1	42.1	42.1
	Politeknik Sultan Salahuddin Abdul Aziz Shah	33	57.9	57.9	100.0
	Total	57	100.0	100.0	

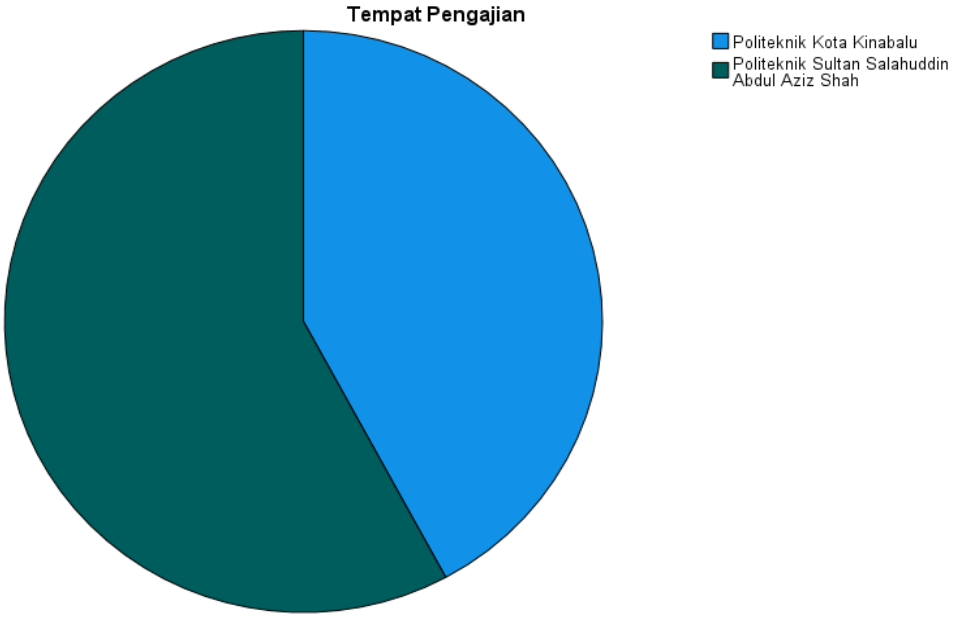

Figure 4.1: Education Institution

In Figure 4.1, 57.9% of the respondents are from Sultan Salahuddin Abdul Aziz Shah Polytechnic, while 42.1% are from Kota Kinabalu Polytechnic.

Tahun pengajian

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Tahun 1	53	93.0	93.0	93.0
	Tahun 3	4	7.0	7.0	100.0
	Total	57	100.0	100.0	

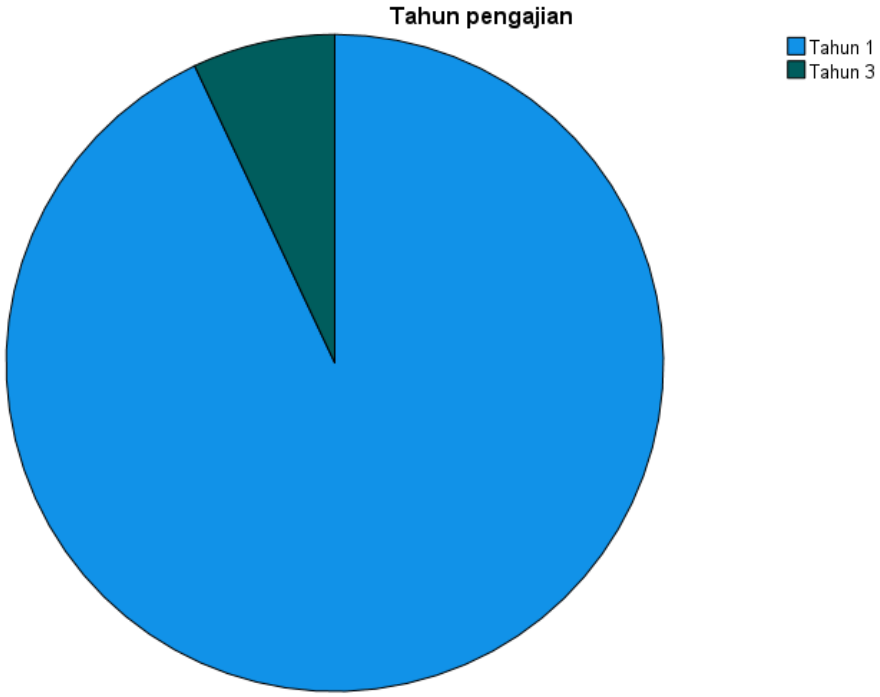

Figure 4.2: Academic Year

In Figure 4.2, the majority of respondents (93.0%) are in their first year, while 7.0% are in their third year.

Tahap pengajian

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	diploma	13	22.8	22.8	22.8
	Diploma	43	75.4	75.4	98.2
	sem 1 diploma	1	1.8	1.8	100.0
	Total	57	100.0	100.0	

Figure 4.3: Education Level

In Figure 4.3, a total of 75.4% of respondents are at the Diploma level, followed by 22.8% who mentioned "diploma," and 1.8% who are in semester 1 of a diploma program.

Adakah anda merasakan penggunaan teknologi Augmented Reality (AR) membantu anda memahami anatomi kayu dengan lebih jelas?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Membantu	24	42.1	42.1	42.1
	Neutral	7	12.3	12.3	54.4
	Sangat membantu	26	45.6	45.6	100.0
	Total	57	100.0	100.0	

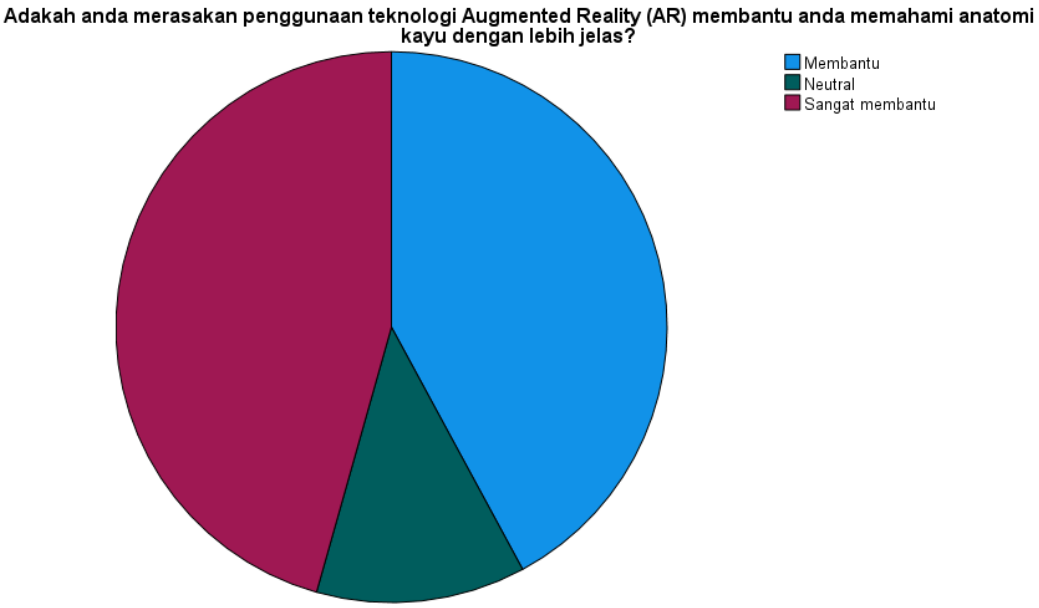

Figure 4.4: Use of Ar

In Figure 4.4, the AR technology is considered very helpful by 45.6% of respondents, helpful by 42.1%, and neutral by 12.3%.

Adakah aplikasi ARwoodbase ini menarik?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Menarik	41	71.9	71.9	71.9
	Neutral	16	28.1	28.1	100.0
	Total	57	100.0	100.0	

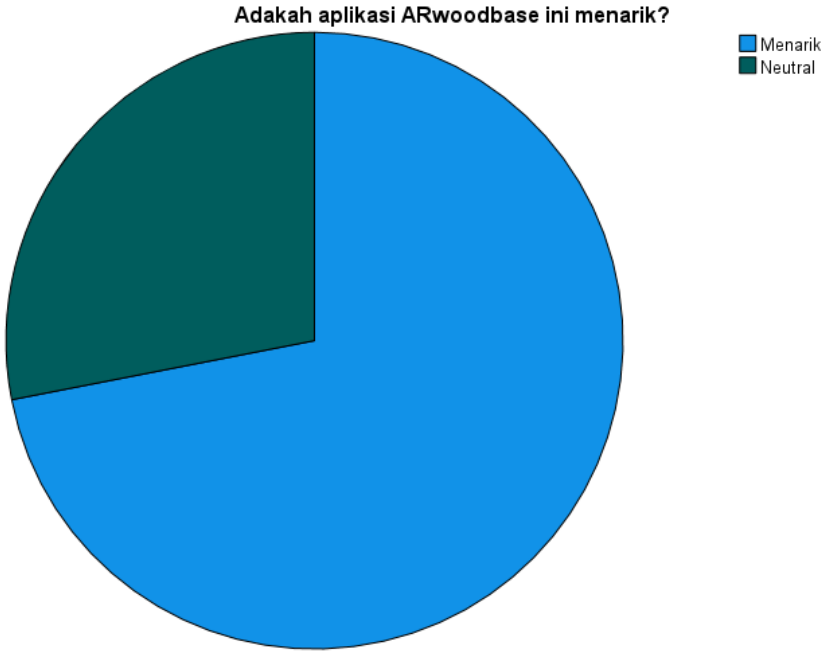

Figure 4.5: Arwoodbase Application

In Figure 4.5, a total of 71.9% of respondents find the application interesting, while 28.1% provided a neutral response.

Bagaimana keberkesanan model 3D dalam memvisualisasikan struktur kayu dan pokok secara interaktif?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Berkesan	28	49.1	49.1	49.1
	Neutral	7	12.3	12.3	61.4
	Sangat berkesan	20	35.1	35.1	96.5
	Tidak berkesan	2	3.5	3.5	100.0
	Total	57	100.0	100.0	

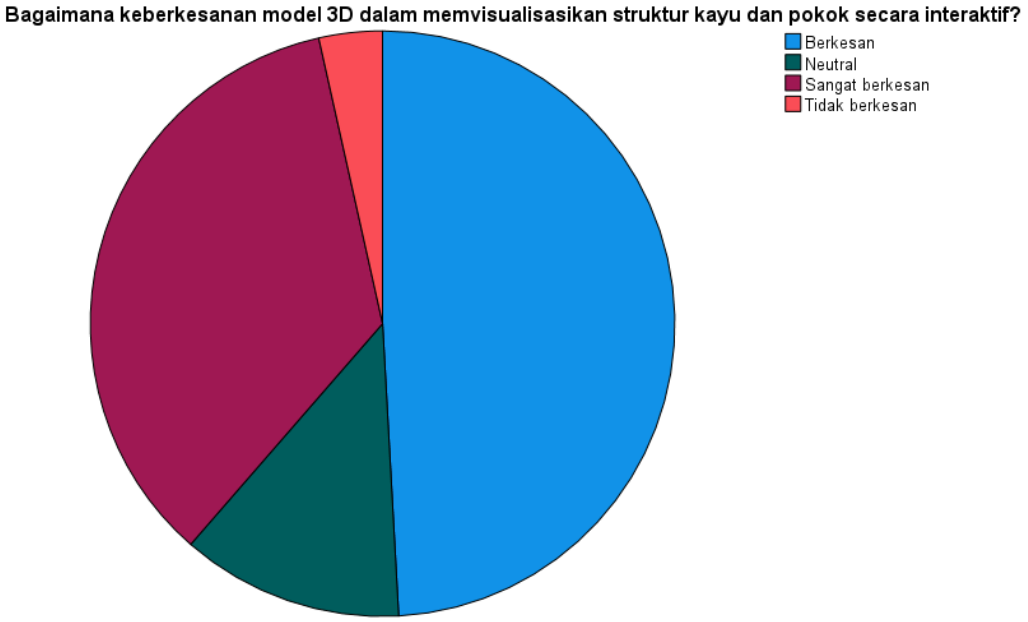

Figure 4.6: Effectiveness of 3D Model

In Figure 4.6, a total of 49.1% of respondents find the 3D models effective, 35.1% find them very effective, 12.3% are neutral, and 3.5% find them ineffective.

Adakah maklumat yang disediakan dalam pangkalan data mengenai jenis kayu komersial di Malaysia mudah difahami dan diakses?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Mudah	27	47.4	47.4	47.4
	Neutral	11	19.3	19.3	66.7
	Sangat mudah	19	33.3	33.3	100.0
	Total	57	100.0	100.0	

Figure 4.7: Ease of Information

In Figure 4.7, have 47.4% of respondents find the information easy to understand, 33.3% find it very easy to understand, and 19.3% are neutral.

Sejauh mana projek ini membantu anda meningkatkan pemahaman terhadap topik dendrologi dan anatomi kayu?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Neutral	13	22.8	22.8	22.8
	Sangat tinggi	14	24.6	24.6	47.4
	Tinggi	30	52.6	52.6	100.0
	Total	57	100.0	100.0	

Figure 4.8: Understanding Dendrology

A total of 52.6% of respondents stated that this project greatly improved their understanding, 24.6% reported very high improvement, and 22.8% were neutral.

Adakah anda berpuas hati dengan kombinasi visual AR dan teks sebagai bahan pembelajaran?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Neutral	26	45.6	45.6	45.6
	Sangat puas hati	31	54.4	54.4	100.0
	Total	57	100.0	100.0	

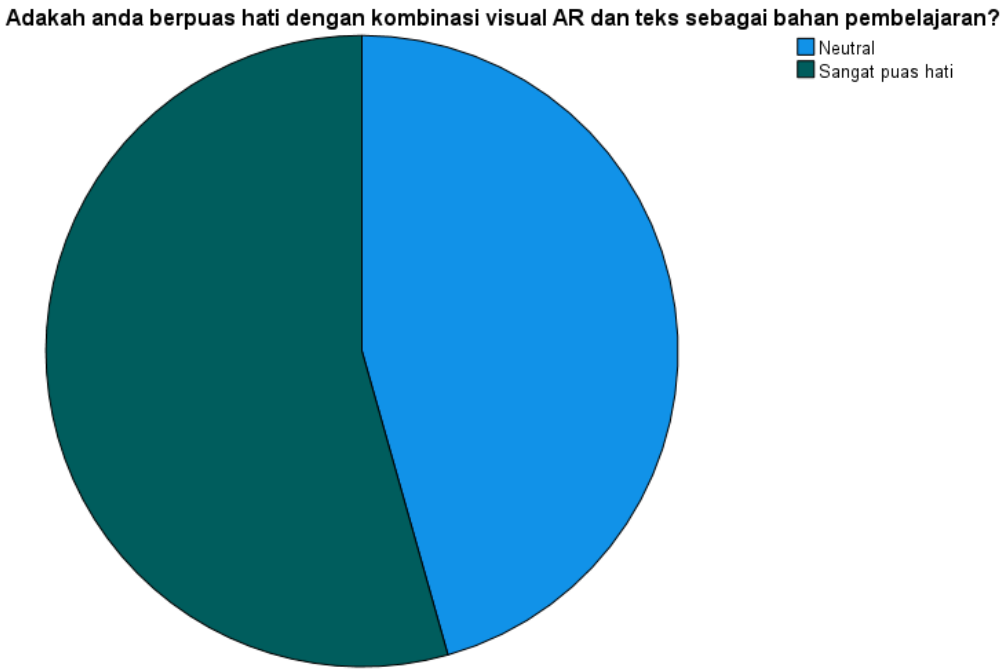

Figure 4.9: Combination of Ar and Text

The combination of AR visuals and text was very well received by 54.4% of respondents, while 45.6% were neutral.

Adakah anda menghadapi sebarang masalah teknikal semasa menggunakan aplikasi AR ini?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Tidak	43	75.4	75.4	75.4
	Ya	14	24.6	24.6	100.0
	Total	57	100.0	100.0	

Figure 4.10: Technical Issue

A large majority of respondents (75.4%) did not face any technical issues, but 24.6% reported experiencing problems.

Adakah anda merasakan penggunaan AR dalam projek ini boleh diaplikasikan untuk topik lain dalam program Teknologi Berasaskan Kayu?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Neutral	5	8.8	8.8	8.8
	Sangat sesuai	26	45.6	45.6	54.4
	Sesuai	26	45.6	45.6	100.0
	Total	57	100.0	100.0	

Figure 4.11: Other Topics

In Figure 4.11, a total of 45.6% of respondents think AR technology is suitable for other topics, while an equal percentage stated it is highly suitable, and 8.8% were neutral.

Cadangan penambahbaikan untuk projek ini

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid		1	1.8	1.8	1.8
	-Tiada-	1	1.8	1.8	3.5
	.	1	1.8	1.8	5.3
	bagi penerangan lebih lanjut secara bersemuka	1	1.8	1.8	7.0
	bagi realistik supaya dpt tarik perhatian pelajar	1	1.8	1.8	8.8
	Baik	1	1.8	1.8	10.5
	baik saja	1	1.8	1.8	12.3
	Buat gambar bagi boleh zoom	1	1.8	1.8	14.0
	buat lebih menarik lagi	1	1.8	1.8	15.8
	Letak lagu	1	1.8	1.8	17.5
	melancarkan lagi apps tersebut mungkin kepada 60 fps	1	1.8	1.8	19.3
	Membekalkan video tutorial	1	1.8	1.8	21.1
	Menggunakan kualiti yg tinggi	1	1.8	1.8	22.8
	Menggunakannya app AR tanpa internet.	1	1.8	1.8	24.6
	No comment	1	1.8	1.8	26.3
	ok itu sahaja	1	1.8	1.8	28.1

	sangat ok	1	1.8	1.8	29.8
	sudah baik	1	1.8	1.8	31.6
	Sudah sempurna tak perlu penambahbaikan	1	1.8	1.8	33.3
	takde ape yang perlu diubah	1	1.8	1.8	35.1
	takde semua dh okay sngt	1	1.8	1.8	36.8
	Tambah bunyi	1	1.8	1.8	38.6
	tambah muziq	1	1.8	1.8	40.4
	Tambah topik yang sesuai	1	1.8	1.8	42.1
	Tambahkan muzik bagi lebih menarik	1	1.8	1.8	43.9
	Teknologi	1	1.8	1.8	45.6
	tiada	14	24.6	24.6	70.2
	Tiada	10	17.5	17.5	87.7
	Tiada apa-apa penambahbaikkan	1	1.8	1.8	89.5
	Tiada penambahbaikan yang perlu dilakukan.	2	3.5	3.5	93.0
	Tiada sebarang penambahan cadangan.. penggunaan AR sesuai untuk pelajar baharu untuk mengenali dan memahami subjek dendrologi dan wood anatomy	1	1.8	1.8	94.7
	Tiara	1	1.8	1.8	96.5
	vr kena ade sound	1	1.8	1.8	98.2

	xde	1	1.8	1.8	100.0
	Total	57	100.0	100.0	

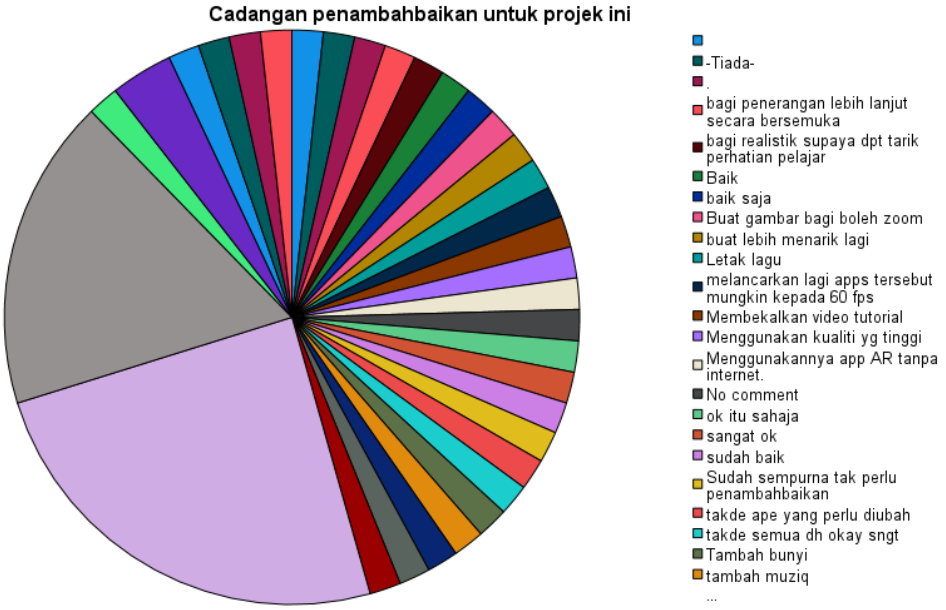

Figure 4.12: Suggested

4.3 DISCUSSION

The Arwoodbase project has demonstrated the effectiveness of using Augmented Reality (AR) technology to enhance students' understanding of dendrology in an interactive and visual manner. Research findings show that the application successfully provides detailed visualizations, including features such as leaf shapes, bark textures, and branch arrangements, which are difficult to convey through text or static images. First-semester students reported that this approach made it easier and more engaging for them to grasp the basic concepts of dendrology.

The primary strength of this project lies in its combination of AR technology and a comprehensive database, enabling users to easily access information such as scientific names, habitats, and wood uses. This aligns with the project's objective to provide a suitable learning tool for students in Wood-Based Technology studies.

However, some limitations were identified. The accuracy of the 3D models for certain tree species needs improvement to better reflect their actual structures, while the application also requires devices with specific specifications to function optimally, potentially limiting its accessibility.

These findings highlight the significant potential of AR technology in education, especially in fields that require complex visualizations like dendrology. For future improvements, the project could be expanded by adding more tree species, refining the 3D models, and ensuring the application is compatible with a wider range of devices. Overall, Arwoodbase has successfully achieved its objectives and has the potential to become an innovative learning tool in wood technology education.

4.4 SUMMARY

Overall, the Arwoodbase project has successfully achieved its main objective of introducing Augmented Reality (AR) technology into dendrology learning. This application provides a more interactive and engaging learning approach, helping first-semester students understand tree features such as leaf shapes, bark textures, and physical structures more clearly. With the integration of a comprehensive database, students can easily and quickly access essential information such as scientific names, native habitats, and wood uses, making this application an effective learning tool.

However, this study also identified several limitations that need to be addressed. These include the accuracy of the 3D models, which require improvements to better resemble actual tree structures. Additionally, the need for devices with specific specifications to run the application optimally limits its accessibility for some users. These limitations present opportunities for future improvements, particularly in making the application more user-friendly and compatible with a wider range of devices.

The findings from this project not only meet the needs of students in the subject of Dendrology but also contribute significantly to the advancement of educational technology in the field of Wood-Based Technology. With continuous improvements, such as adding more tree species, refining 3D models, and ensuring wider accessibility, Arwoodbase has the potential to become a more comprehensive and impactful learning platform.

Thus, this project not only meets its predetermined goals but also opens opportunities for future developments. Arwoodbase demonstrates that combining innovative technologies like AR with education can create positive changes in how students understand complex concepts such as dendrology. This makes the project a solid foundation for the development of more advanced learning technologies in the future.

CHAPTER 5
CONCLUSION AND RECOMMENDATIONS

5.1 INTRODUCTION

In this chapter, we will summarize the key findings from our project on integrating Augmented Reality (AR) into dendrology education. The main goal of our research was to explore how AR technology could enhance the learning experience for students studying tree characteristics and properties. By combining interactive 3D models with a comprehensive database, we aimed to provide a more engaging and effective educational tool.

We will also discuss the conclusions drawn from our findings, offer recommendations for future work, highlight the limitations of our project, and summarize the overall impact of our study. By reflecting on these aspects, we hope to contribute valuable insights that can guide further developments in the use of AR technology in educational settings, particularly in the field of wood-based technology and dendrology.

5.2 CONCLUSION

Our project clearly showed how Augmented Reality (AR) can improve learning in dendrology. By creating interactive 3D models of trees, we allowed users to see tree structures in a lively and engaging way. This method was much more effective than traditional learning tools like textbooks or static images. With AR, users could rotate and zoom in on the 3D models, exploring details that would be hard to show in regular educational materials. This hands-on experience not only grabbed users' attention but also encouraged them to take an active role in their learning.

Feedback from users emphasized how AR made complicated ideas in dendrology easier to understand. Many participants said that the interactive visuals helped them grasp the physical features and properties of different tree species more clearly. For example, students found that seeing 3D images of tree bark, leaves, and overall shapes helped them appreciate the variety among species in a way that flat images could not. This positive response highlights the benefits of using AR technology in education, which helps students connect what they learn in theory with real-life applications. Being able to see trees in their actual environments also added context to their learning.

In conclusion, we believe that combining AR with a well-organized database represents a big step forward in teaching dendrology. This new approach not only makes learning more enjoyable for students but also fits well with today’s teaching methods that focus on interactivity and engagement. The database supports the AR models by offering detailed information about each tree species, such as scientific names, habitats, and uses, which users can easily access. By using technology in this way, we encourage a deeper understanding of nature and its complexities, especially in the field of wood-based technology. This project sets a strong base for future AR developments that could further enhance educational methods and inspire new learners interested in trees and environmental science.

5.3 RECOMMENDATIONS

Based on what we learned from our project, we have several suggestions to improve the use of Augmented Reality (AR) in teaching about trees and to make the overall experience better for users.

First, we recommend expanding the database to include more types of trees and extra information about their roles in the environment, how they are used, and their conservation status. This would give users a richer learning resource that shows the variety of trees and their importance in different ecosystems. Including details about rare or endangered species could also help raise awareness about conservation and the need to protect the environment, making the learning experience not just educational but also meaningful.

Second, creating training materials or workshops would be helpful for users who are not familiar with AR technology. These resources could include easy-to-follow guides, user manuals, and video tutorials that show how to use the AR application. By offering clear instructions and support, we can help users get the most out of technology and improve their learning. Additionally, holding workshops in schools and universities could encourage students to explore AR together, promoting teamwork and discussions.

We also suggest setting up a regular schedule to update both the AR models and the database. This would make sure that users have access to the latest information and research about trees. Keeping the content current is important, especially as new findings come out. Seasonal updates could show how trees change throughout the year, providing a lively learning experience that reflects nature.

Furthermore, using this AR application in various educational places, such as schools, universities, and nature reserves, could increase its reach. By including the AR tool in different learning programs, we can help more people understand trees and their significance. Partnering with nature reserves or botanical gardens to create guided tours using AR could also offer visitors a more engaging experience, making learning about trees more interactive and informative.

Lastly, having a feedback system in the application is essential. This would allow users to share their thoughts and suggestions for improvements and new features. Involving users in the development process helps us adapt the application to better meet their needs and interests. Regularly checking user feedback can guide future updates and ensure that the AR tool stays useful and effective for teaching about trees.

In summary, these recommendations aim to build on the strengths of our project while addressing areas for improvement. By expanding the database, providing user support, keeping the content updated, exploring different educational settings, and encouraging user feedback, we can significantly enhance the learning experience and make the AR tool an even more valuable resource in teaching about trees and the environment.

5.4 PROJECT LIMITATION

While our project has shown good results in using Augmented Reality (AR) for teaching about trees, there are several limitations that we need to recognize. Understanding these limitations is important for improving the project in the future and for setting realistic expectations for users and educators.

One major limitation was the technical problems some users faced while using the AR application. These issues can include software bugs or compatibility problems with different devices. For example, users with older smartphones or tablets may have had trouble running the AR application smoothly. This could lead to frustration and negatively affect the learning experience. To fix this, future developments should focus on making the application more stable and ensuring it works well with a wider range of devices. Regular testing and updates will be essential to minimize these technical issues and provide a better user experience.

Another limitation was the small number of participants in our study. The group of users who tested the AR application was relatively limited, which may not fully represent the experiences and challenges of a larger audience. A small sample size can lead to biased feedback and may not reflect the opinions of different age groups or levels of comfort with technology. For future studies, it will be important to include more participants to gather a broader range of insights and ensure the application meets the needs of all potential users.

Additionally, our project mainly focused on tree species found in Malaysia, which may limit its relevance for users in other regions. While studying local species is valuable, it may not be helpful for individuals interested in trees from different climates or ecosystems. Expanding the project to include more tree species from various parts of the world would increase its usefulness and provide a global perspective on dendrology. This could involve working with institutions or researchers from different regions to gather and share information about trees that are important in their local areas.

Furthermore, relying on AR technology may not suit everyone's learning style. Some users may prefer traditional learning methods, like reading books or attending lectures, rather than interacting with digital content. While AR offers an engaging way to learn, it may not work well for those who are used to conventional educational approaches. To address this, future versions of the project could include multiple ways to learn, giving users different options to engage with the material. This might involve providing printed guides or video lectures along with the AR experience.

Lastly, the time and resources we had for this project were limited, which may have affected how deeply we could research and develop the AR application. With more time and funding, we could have explored additional features, like adding sound effects, animations, or even virtual reality (VR) elements to make the experience even more immersive. Future projects should aim for a more thorough development process that allows for these improvements.

In conclusion, recognizing the limitations of our project is important for its future success. By addressing technical issues, increasing the diversity of participants, expanding the range of species studied, accommodating different learning styles, and securing more resources for development, we can enhance the AR application and make it a more effective educational tool for learning about trees. By learning from these limitations, we can create a better and more inclusive learning experience for users in the future.

5.5 SUMMARY

In summary, our project successfully used Augmented Reality (AR) to improve learning about trees in dendrology. By creating 3D models of various tree species, we gave users a unique way to see and explore tree features those traditional methods, like textbooks, can't provide. This new approach not only captured users' attention but also helped them understand complex information about trees and their biology more easily.

Users provided very positive feedback, indicating that AR makes learning more fun and accessible. Many participants said that interacting with the 3D models made it easier to learn about different types of trees. This shows that AR can be a valuable tool in modern education, especially in subjects that require visual understanding, like dendrology. By combining technology with learning, we can create more engaging and meaningful experiences for students.

However, we also identified some limitations in our project. Technical issues, a small number of participants, and a focus mainly on local tree species were challenges that could impact the project's overall effectiveness. These limitations point to areas for improvement, such as expanding the database, involving a more diverse group of participants, and ensuring the content is relevant to different regions and learning styles. Addressing these challenges will be important for making future versions of the project more successful.

Looking ahead, we believe that using AR in education has great potential. By continuing to develop this technology, we can create a richer learning experience that meets the needs of all kinds of learners. This project serves as a starting point for future research into using AR as a teaching tool, not just in dendrology but in other subjects as well. Ultimately, we hope to inspire a greater appreciation for nature and encourage students to engage with environmental science in exciting new ways.

In conclusion, our study shows that Augmented Reality can greatly enhance how we learn about trees. With further development, AR has the potential to change education by making complex topics easier to understand. By building on what we've learned from this project, we can help ensure that technology and education work together to promote a better understanding of the environment and its importance.

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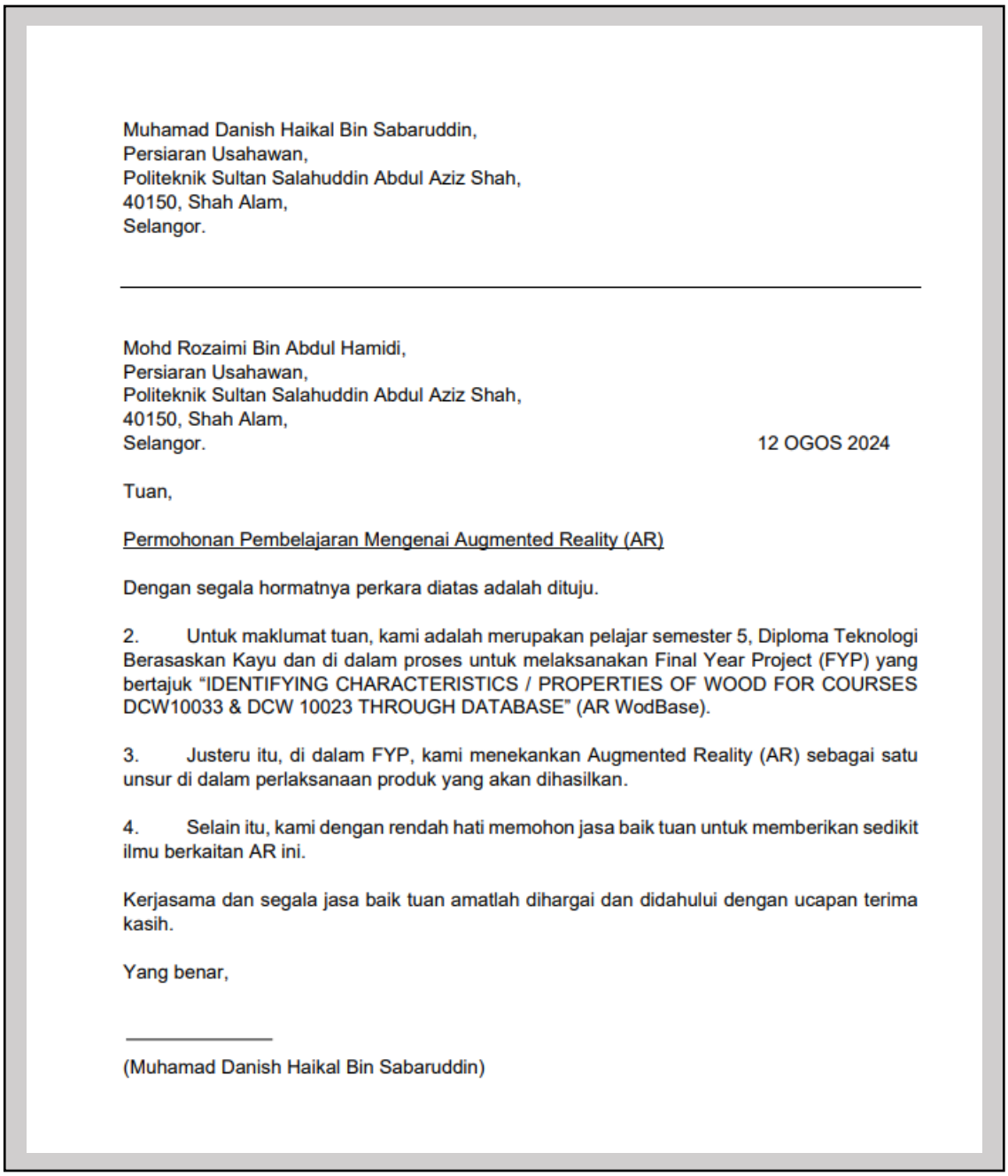
APPENDIXES

a) Appendixes A

- Application form for using external services



Muhamad Danish Haikal Bin Sabaruddin,
Persiaran Usahawan,
Politeknik Sultan Salahuddin Abdul Aziz Shah,
40150, Shah Alam,
Selangor.

Mohd Rozaimi Bin Abdul Hamidi,
Persiaran Usahawan,
Politeknik Sultan Salahuddin Abdul Aziz Shah,
40150, Shah Alam,
Selangor.

12 OGOS 2024

Tuan,

Permohonan Pembelajaran Mengenai Augmented Reality (AR)

Dengan segala hormatnya perkara diatas adalah dituju.

2. Untuk maklumat tuan, kami adalah merupakan pelajar semester 5, Diploma Teknologi Berasaskan Kayu dan di dalam proses untuk melaksanakan Final Year Project (FYP) yang bertajuk "IDENTIFYING CHARACTERISTICS / PROPERTIES OF WOOD FOR COURSES DCW10033 & DCW 10023 THROUGH DATABASE" (AR WodBase).

3. Justeru itu, di dalam FYP, kami menekankan Augmented Reality (AR) sebagai satu unsur di dalam perlaksanaan produk yang akan dihasilkan.

4. Selain itu, kami dengan rendah hati memohon jasa baik tuan untuk memberikan sedikit ilmu berkaitan AR ini.

Kerjasama dan segala jasa baik tuan amatlah dihargai dan didahului dengan ucapan terima kasih.

Yang benar,

(Muhamad Danish Haikal Bin Sabaruddin)

b) Appendixes B

- **Gantt Chart**