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PetalsPalette: Blossoming Knowledge by Bridging Technology and Nature through Augmented Reality Learning Application for Flower Identification

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ABSTRACT

This study focuses on learning different types of flowers using augmented reality (AR), which overlays digital content onto the physical environment. Studies regarding flowers or botanical species are complicated by a lack of adequate resources and tools, which puts barriers in place for educators and students who want to engage with the learning content. Current conventional methods of learning are not enough since some of the content may need further visualization of the real species or characteristics. Even though technological tools might be available, without necessary features and resources, particularly for visualization, the use will only be more distracting than helpful. Furthermore, providing an engaging user experience is crucial to ensure that learners effectively absorb the material. Our preliminary investigation has successfully validated the problem statement concerning lack of information and knowledge about flowers, which involves students in UiTM and educators. Thus, PetalsPalette, an AR application, was developed to provide opportunities for learners to learn about flowers through an AR which has been proven effective for learning. Five phases of methodology have been used, namely requirement analysis, design, implementation, testing, and maintenance. In the conducted testing, 33 respondents found that the PetalsPalette application is highly attractive, simple to understand, efficient, dependable, stimulating, and novel. PetalsPalette successfully enhanced flower identification for UiTM students through an AR-based mobile application. Future work aims to improve device compatibility and advance AR capabilities to create more inclusive and adaptable applications.

1. INTRODUCTION

Flowers have a profound ability to bring the enjoyment to those who are interested in them. This enjoyment often extends beyond the aesthetic beauty of the flowers that carry the hidden meaning and symbolism that

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can enhance the experience for enthusiasts (Kim et al., 2020). The study of flowering phenology and the anti-inflammatory properties of ornamental flowers adds to the understanding of the genuine interest individuals have in flowers (Łysiak, 2022). Moreover, the role of flower colour in angiosperm evolution drwas attention to the evolutionary value of flowers and their visual characteristics (Narbona et al., 2021). These aspects collectively contribute to the widespread interest in flowers and the enjoyment derived from engaging with them.

However, learning about plants and flowers faces ongoing issues like the difficulty of identifying them, limited access to live examples, and challenges in seeing their features and traits (Łysiak, 2022; Chamidah et al., 2019; Narbona et al., 2021). Textbooks and still photograph are traditional ways of teaching that do not always show how the plants' or flowers' characteristics. This makes it challenging for learners to really grasp the appropriate information what they want to know and learn about the flower (Chamidah et al., 2019). Furthermore, since STEM (Science, Technology, Engineering and Mathematics) educations are critical and have been set to the highest consideration for a developing country to progress, such as Malaysia, it is crucial to maintain the interest to learn the knowledge. At the very least, to make individuals love the nature's flora and fauna more and save the environment. To maintain this, learners need more fun and engaging ways to learn. The lack of interactive and attractive tools might affect the interest of the individuals (Parsons et al., 2020), as they struggle to find information without any aid tool for the process. It also puts barriers in front of educators and students who want to engage with botany but lack the necessary tools and resources to effectively teach and learn about its species (Chamidah et al., 2019). The traditional methods, which involved manual techniques, are known to have limitations due to the lack of up-to-date and comprehensive information (Tonmoy & Islam, 2023).

Flowers are not only visually appealing but also possess intricate structures and features that have been the subject of extensive study. The morphological and anatomical study of flower structures has also been a subject of interest, shedding light on the diversity and characteristics of different flower morphs (Wulansari et al., 2022). Technology can be very important in improving understanding of and impressions of flowers. Studying and viewing flowers can be much more interesting and educational with the use of augmented reality (AR) technology. AR is a technology that integrates computer-generated content with the real world, allowing for the overlay of digital information onto the physical environment. This technology differs from virtual reality (VR) as it does not replace the real world but enhances it with digital elements. AR content can encompass various forms such as two-dimensional (2D) images, three-dimensional (3D) models, text, and real-time information, offering a novel and interactive experience (Vidak et al., 2022). AR has been found to have significant potential in various fields, including education, training, and industrial applications (Lam et al., 2021; Moesl et al., 2022; Wong et al., 2022).

The identification of flowers using AR involves the real-time recognition of flower species based on their physical and biological characteristics, integrating the real world with electronic information. This innovative approach offers significant advantages to researchers, particularly in the field of botany, by enabling the seamless combination of physical and digital realities for accurate flower identification (Setiyaningsih et al., 2021). The utilization of AR technology for flower identification has the potential to revolutionize botanical research and speed up species identification, offering a novel and efficient method for researchers to analyse and classify various flower species based on their unique characteristics (Marchenko & Kuzovkina, 2021; Rajesh Kumar & Subhashini, 2023; Setiyaningsih et al., 2021). A study by Wilujeng et al. (2019) looks closely at how AR technology can be used to create multimedia learning materials about plant structure, especially for the Wijaya Kusuma flower, aimed at college students. The findings demonstrated the successful creation of a prototype of the Wijaya Kusuma flower as a virtual object inserted into the real environment in real-time. However, the study also highlighted the need for further development to improve the application by integrating AR with mobile applications.

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2. METHODOLOGY

Waterfall methodology has been used in this study. The waterfall methodology is a sequential software development process that consists of five distinct phases: requirements, design, implementation, testing, and maintenance, with each phase building upon the deliverables of the previous phase. The first phase, requirements, involves gathering and documenting the requirements. The second phase, design, focuses on creating the architectural and detailed design of the system based on the gathered requirements. The third phase, implementation, involves the actual coding and unit testing of the software. Finally, the maintenance phase involves making modifications, correcting defects, and enhancing the system based on user feedback and changing requirements. Fig. 1 shows the research activity diagram for waterfall methodology that involves five phases with activities, tools, or techniques and the deliverables.

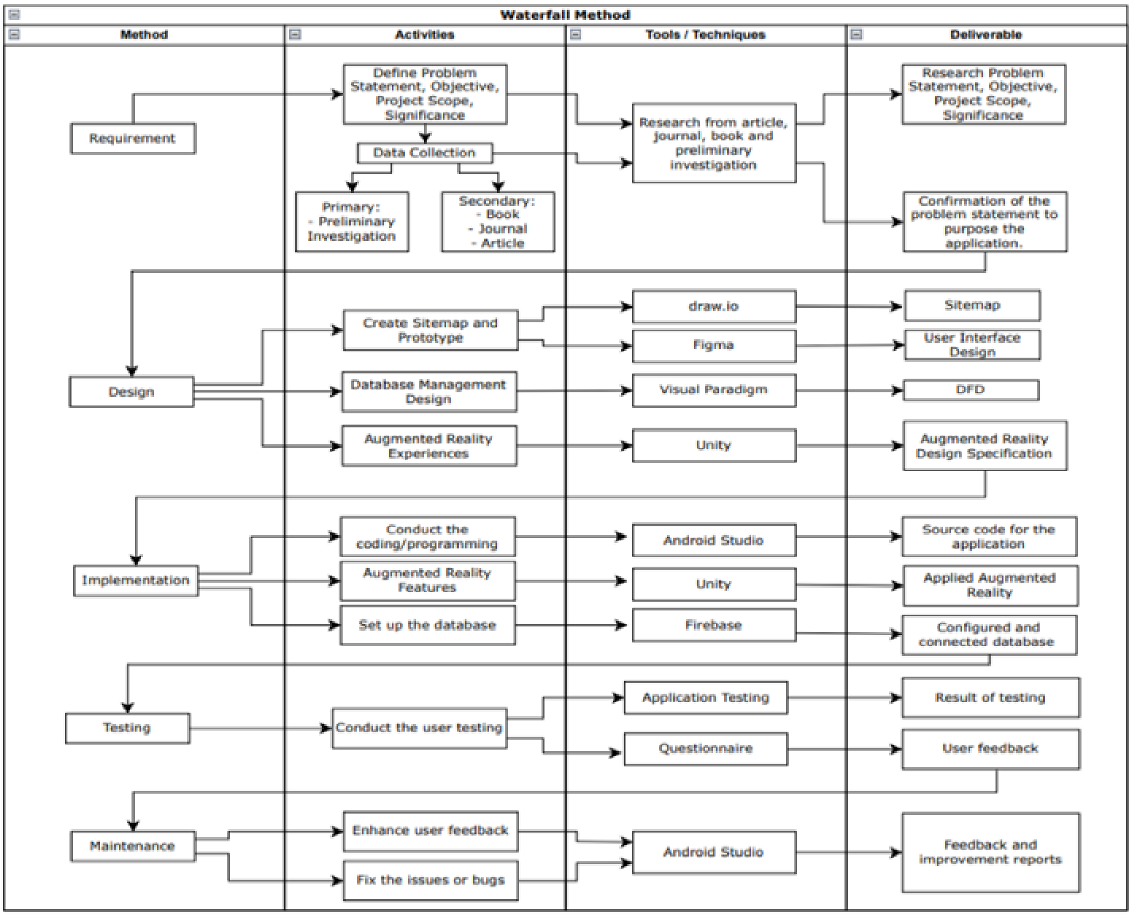

Fig. 1. Methodology, activities, tools, and deliverables of the study

A preliminary investigation has been conducted to understand the initial requirement and need for flower information and AR application use, particularly among students. This information serves as a foundation for further analysis and potential enhancements in flower learning and understanding. The respondents include students in UiTM who are interested in flowers, as well as educators and students involved in planting degree. Out of 107 respondents, 83% showed interest in getting information and knowledge or learning about flowers; 10% had no interest, and 7% had no interest in the process. The respondents were also asked to rate their ability to identify flower species on a scale from 1 to 5, with 1

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indicating the least ability and 5 signifying a high ability. The distribution of responses reveals that 21% chose the lowest scale of 1, indicating a limited proficiency in identifying flower species. Most respondents, 37% each, chose scales 2 and 3, suggesting a moderate level of ability. A smaller group of respondents, 3% in total, expressed a relatively high ability by selecting scale 4. Only 2% respondents claimed the highest level of ability, scale 5, in identifying flower species. These findings showed the lack of flowers' information even though the respondents indicated high interest in learning about the flowers. Conventional ways of learning are always limited, which limits their learners in learning (Chamidah et al., 2019).

When asked about the respondents' familiarity with the meaning of flowers and their interest in acquiring information and the knowledge; 32% of respondents indicated that they are familiar with the meaning of flowers. On the other hand, 44% of respondents stated that they are not familiar with the meaning of flowers. Additionally, 24% of respondents expressed uncertainty regarding their familiarity with flower meanings or their interest in obtaining information and knowledge. For question regarding the impact of knowledge on boosting their interest in flowers.The majority of 86% of respondents affirmed that knowledge has a positive influence in increasing their interest in flowers. Conversely, a small minority of 3% respondents indicated that knowledge does not have such an impact, while 11% of respondents expressed uncertainty on this matter.

On the other hand, the investigation also found that 77% of the respondents agreed that technological advancement application, such as AR, can enhance peoples' interest in using for flower learning. 18% were unsure and 5% stated that the technology would not help in the learning. Since AR is still in its infancy in certain country and rural regions that are currently starting to consider the AR use (Avila-Garzon et al., 2021), the question regarding the technology gave clear opportunities of its application in the field. Generally, the findings show the interest in learning about flowers as well as the applications of AR as the information-gathering method. In the design and development phase, Figma, Unity, Android Studio, Visual Code Studio, and Firebase are the main software used to develop the PetalsPalette. Fig. 2 shows the Sitemap for the application. The sitemap created to show and navigate the pages available in the application. The goal of this sitemap is to indicate the flow of the application pages. The sitemap illustrates the application flow for both admin and user, highlighting the differences in navigation and access level between the admin and user applications. The Admin has the access to manage the flower graphics and information that are stored in the database, while the user can utilize the application to view the selected content, including its graphic.

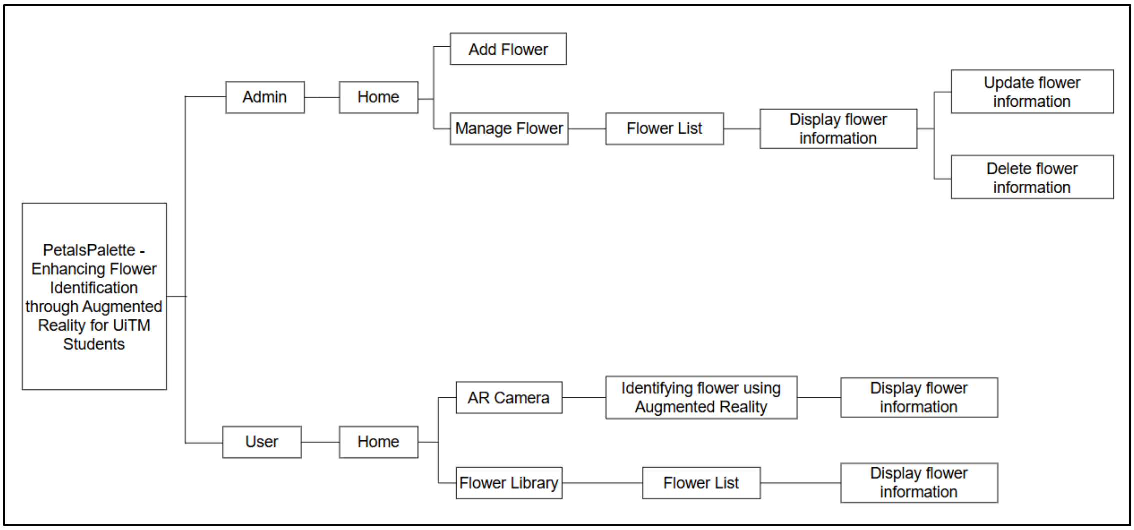

Fig. 2. PetalsPalette sitemap

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Fig. 3 shows the flow for DFD of PetalsPalette. Admin sends new flower information to the Adding Flower Data process. Then, the new flower data is stored in the Flower Database. The Flower Database displays flower information to the Admin. After that, the Admin can view the flower information from Flower Database and can manage or update the flower information. Then, Admin sends updated flower information to the Updating Flower Data process and stored it in the Flower Database.

When a user scans a flower marker, the Scanning Marker of Flower process retrieves the flower information from the database in the AR system. Also, the User can view the flower information from the Flower Database. This DFD illustrates the complete cycle of flower data is managed by the Admin and accessible to the User. The Flower Database plays a role in storing, updating, and retrieving the flower data, ensuring both the Admin and the User gets the same flower data.

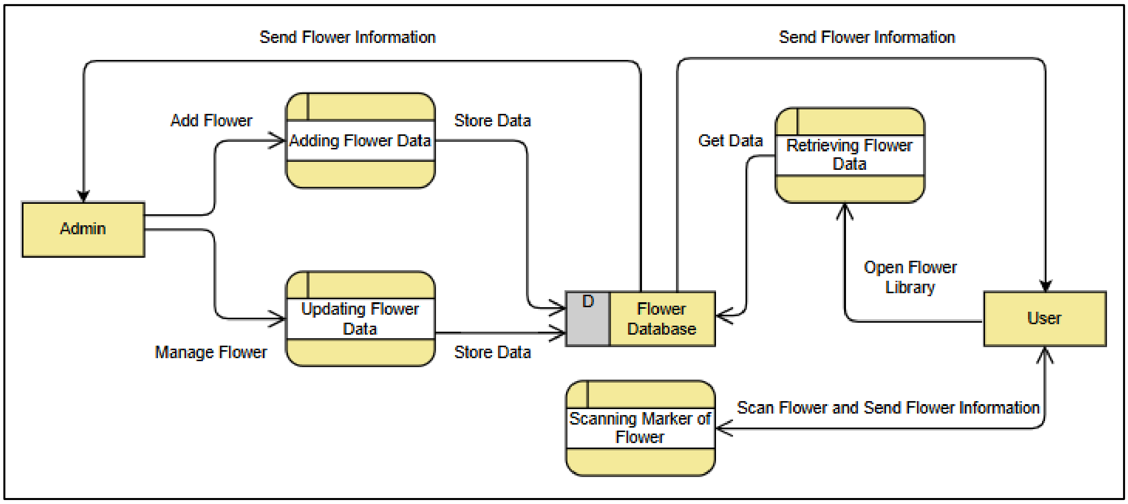

Fig. 3. PetalsPalette data flow diagram

User interface design plays a pivotal role in facilitating visual interaction between users and the application, as demonstrated by the prototypes illustrated. Fig. 4 shows the design sketch and user interface for the admin application, highlighting the functionalities for administrators. The Add Flower page allows the admin to input new flower information into the system. On this page, the admin can upload a flower image, enter the flower's name, and provide a detailed description. The Flower List page provides a comprehensive view of all flowers currently in the system. From this page, the admin can select flowers to update information, modifying the existing details such as the flower image, name, or description. Fig. 5 shows the design sketch and user interface in the user application. There are two buttons for AR Camera and Flower Library. The AR Camera is to enhance the user experience through AR by scanning a marker-based flower image, and it will provide real-time text information about the flower. In Flower Library, the user can view the details about the flower information.

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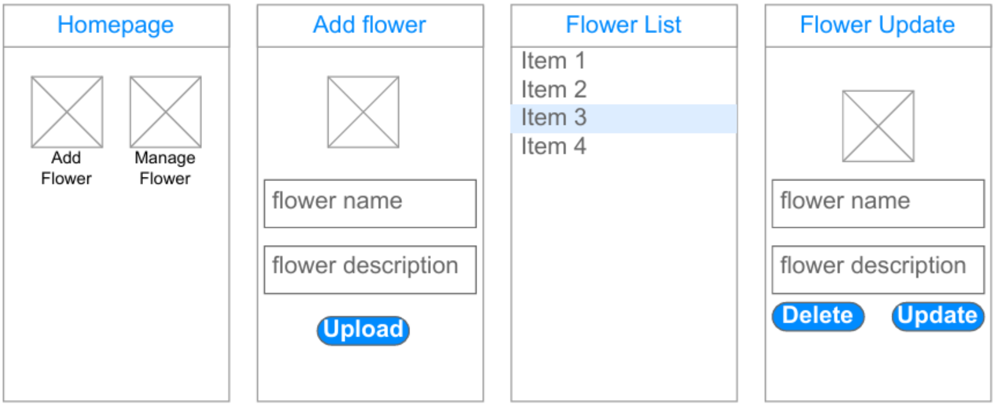

Fig. 4. Admin design sketch

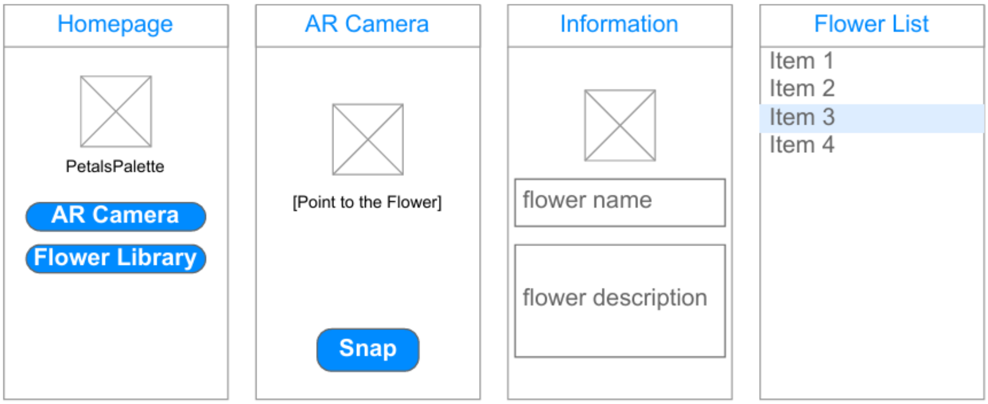

Fig. 5. User design sketch

Firebase was used to store and manage the flower data. Firebase is integrated with Android Studio and Unity, ensuring the data is displayed accurately across both applications. Fig. 6 shows the process of adding flower data within Android Studio through the admin application. The system generates a Flower ID automatically, also known as a unique key. The Flower ID facilitates the insertion of data into Firebase Realtime Database. In Fig. 7, the FlowerDataFetcher.cs is represented within Unity to retrieve data to the Flower Library within the user application. This functionality enables access to flower data stored within application's database, enhancing the user experience by providing timely and accurate information about various flowers that have been added in the database. Realtime Database is used to store the flower data, as shown in Fig. 8.

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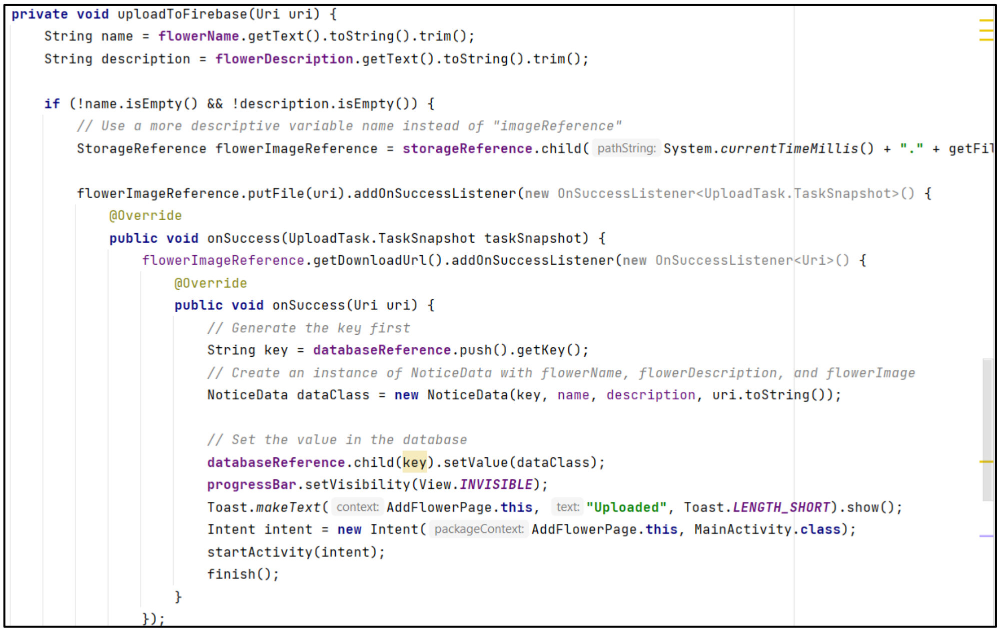


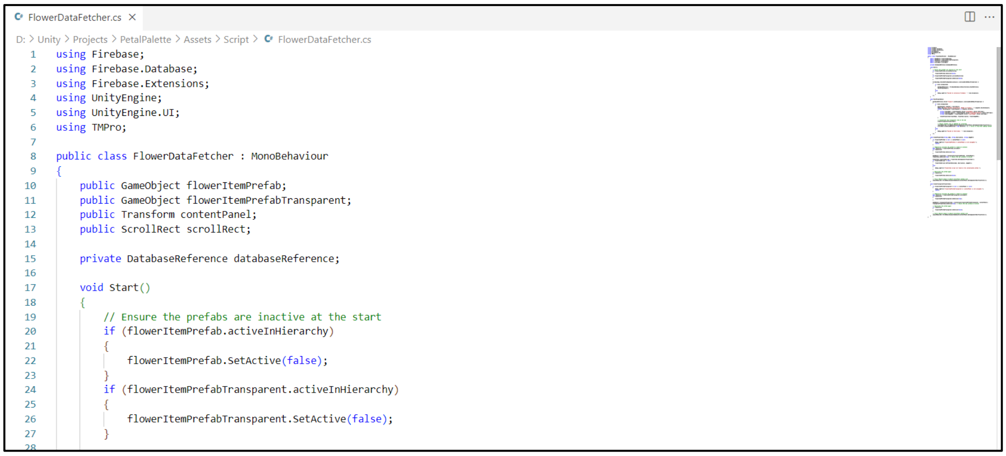
```java
private void uploadToFirebase(Uri uri) {
    String name = flowerName.getText().toString().trim();
    String description = flowerDescription.getText().toString().trim();

    if (!name.isEmpty() && !description.isEmpty()) {
        // Use a more descriptive variable name instead of "imageReference"
        StorageReference flowerImageReference = storageReference.child( pathString: System.currentTimeMillis() + "." + getFil

        flowerImageReference.putFile(uri).addOnSuccessListener(new OnSuccessListener<UploadTask.TaskSnapshot>() {
            @Override
            public void onSuccess(UploadTask.TaskSnapshot taskSnapshot) {
                flowerImageReference.getDownloadUrl().addOnSuccessListener(new OnSuccessListener<Uri>() {
                    @Override
                    public void onSuccess(Uri uri) {
                        // Generate the key first
                        String key = databaseReference.push().getKey();
                        // Create an instance of NoticeData with flowerName, flowerDescription, and flowerImage
                        NoticeData dataClass = new NoticeData(key, name, description, uri.toString());

                        // Set the value in the database
                        databaseReference.child(key).setValue(dataClass);
                        progressBar.setVisibility(View.INVISIBLE);
                        Toast.makeText( context: AddFlowerPage.this,  text: "Uploaded", Toast.LENGTH_SHORT).show();
                        Intent intent = new Intent( packageContext: AddFlowerPage.this, MainActivity.class);
                        startActivity(intent);
                        finish();
                    }
                });
```

Fig. 6. Add Flower code



FlowerDataFetcher.cs
D: > Unity > Projects > PetalPalette > Assets > Script > FlowerDataFetcher.cs

```csharp
using Firebase;
using Firebase.Database;
using Firebase.Extensions;
using UnityEngine;
using UnityEngine.UI;
using TMPro;

public class FlowerDataFetcher : MonoBehaviour
{
    public GameObject flowerItemPrefab;
    public GameObject flowerItemPrefabTransparent;
    public Transform contentPanel;
    public ScrollRect scrollRect;

    private DatabaseReference databaseReference;

    void Start()
    {
        // Ensure the prefabs are inactive at the start
        if (flowerItemPrefab.activeInHierarchy)
        {
            flowerItemPrefab.SetActive(false);
        }
        if (flowerItemPrefabTransparent.activeInHierarchy)
        {
            flowerItemPrefabTransparent.SetActive(false);
        }
```

Fig. 7. FlowerDataFetcher code

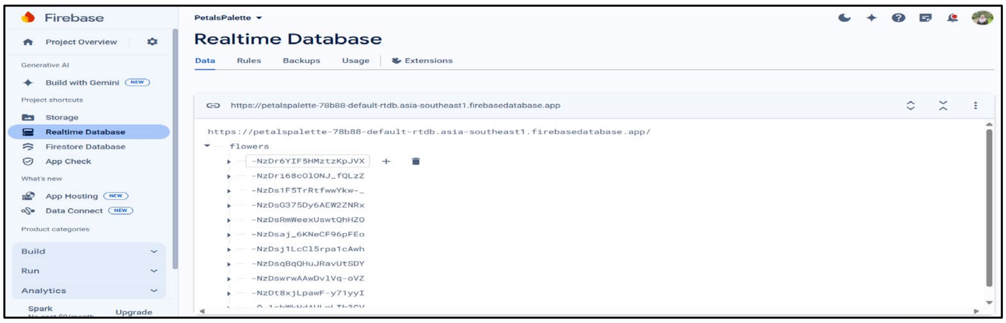


Fig. 8. Realtime database

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Vuforia was used to create the image marker for the target image to develop AR features in the PetalsPalette user application. The target image was added into the Vuforia database, it generates the marker features as shown in Fig. 9. The image will display the type of the target, status, target ID, rating of augmentability, and information about when the image was added and modified. After that, all the target images will be downloaded into a database to be exported to Unity. The marker features act to detect the image for AR. Vuforia uses an image marker-based system. The image database is first downloaded as a Unity package. While in Unity, this database is imported into the project. After the import, the image target can be set up by selecting the database from Vuforia for the image target.

Next, as depicted in Fig. 10, the Asset folder within Unity is used to store images of the flower that contain the marker. After setting the image target in Unity, the next step shows in Fig. 11, is to create a canvas that will display the flower name and description when the image marker is detected. This involves designing a user interface (UI) within Unity that includes text fields or panels where the flower name and description will appear. This step ensures that whenever the image marker is recognized by the Vuforia engine, the corresponding information about the flower is presented to the user in a clear and visually appealing manner. This setup enhances the interactive experience by providing relevant details about the flower directly on the screen.

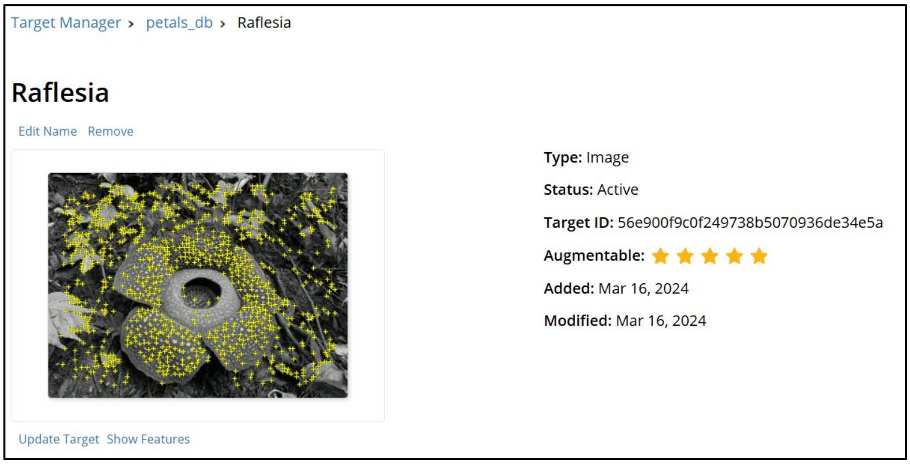

Fig. 9. Flower image marker

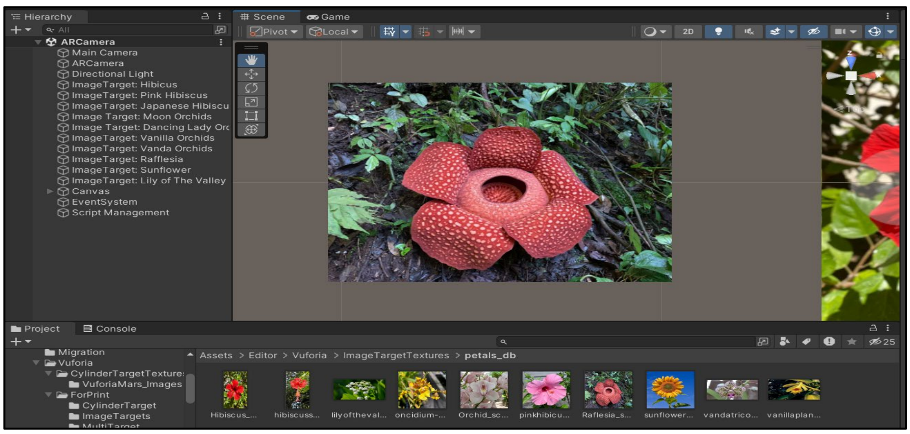

Fig. 10. Image target in Unity

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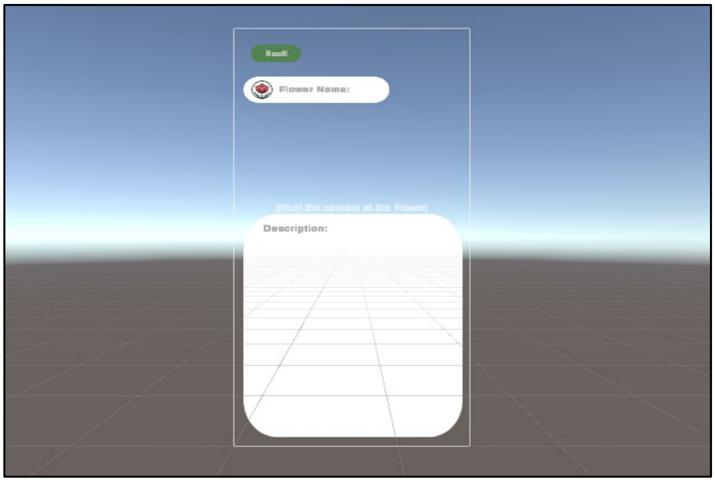

Fig. 11. Image target setting in Unity

Once the flower name and description are set up, they are tracked within the UI, as shown in Fig. 12. The description for each detected flower is attached to the AR trackable element of the image marker. With this setup, when the image marker is detected, the corresponding data that has been inserted for each flower is retrieved and displayed. This ensures that users receive the accurate name and description of the flower in real-time as the AR system recognizes the image markers. Fig. 13 and Fig. 14 show the AR applications of PetalsPalette for admins and users. Fig. 13 enables the admin to add flower information, including its graphics and their characteristics or contents. The added or updated content of the flowers will be saved in the database. Meanwhile, as in Fig. 14, the user is enabled to select and view the content of the flowers. The marker can be scanned, and the content of the selected flowers will be appeared. The user can navigate the content to further understand the flower species.

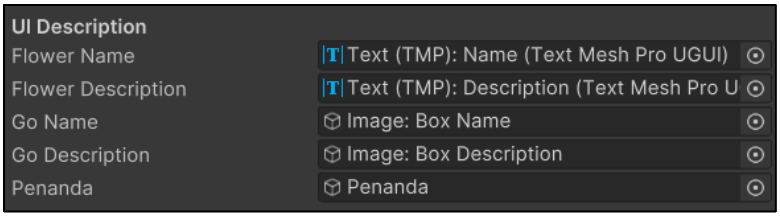

Fig. 12. UI description

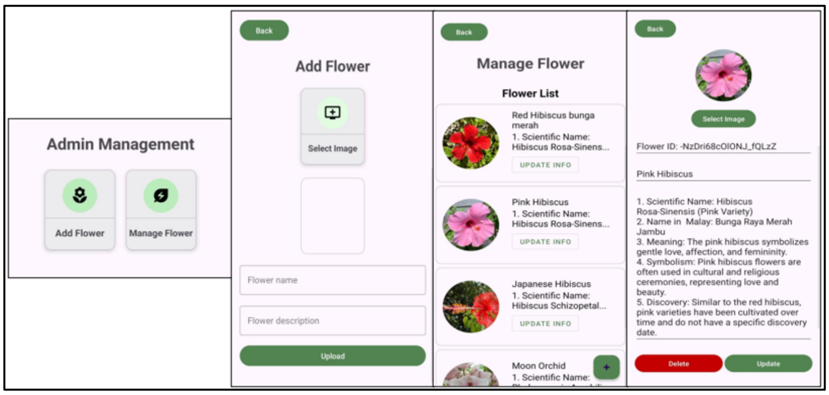

Fig. 13. The developed PetalsPalette (admin)

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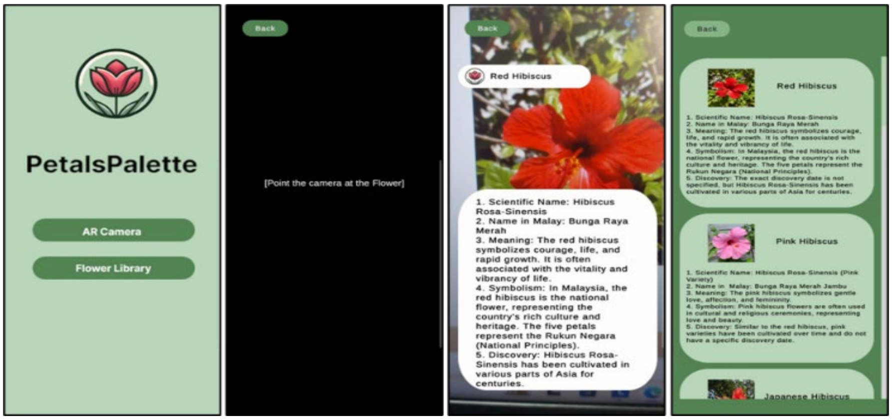

Fig. 14. The developed PetalsPalette (user)

3. PETALSPALETTE TESTING

The Post-Study System Usability Questionnaire (PSSUQ) and User Experience Questionnaire (UEQ) has been used to gather usability and experience perceptions from the respondents. This testing aims to evaluate the usability and user experience of the developed system in identifying the flowers using AR. The testing occurred at an open space in UiTM Arau, Perlis. The goal was to assess if the application could successfully scan the image marker under various lighting conditions.

A guide for users to download the PetalsPalette user application was provided. During the testing, the user received the step-by-step instructions on how to use the application. For the admin application, explanations were given on how the admin could manage the application, with data updates occurring automatically after any changes made by the admin. Users received a Google Form containing PSSUQ and UEQ questionnaires after the testing to provide feedback on the application's usability and functionality. The questionnaires were written in English, included 16 questions from the PSSUQ and 8 questions about the UEQ. A total of 33 UiTM students participated in the user testing, providing valuable responses.

3.1 PSSUQ results

Fig. 15 shows the analysis of usability and experience test results for PSSUQ among UiTM students. In this figure, you can view the mean scores for system usefulness (SYSUSE), information quality (INFOQUAL), and interface quality (INTERQUAL) for the 33 respondents. At the bottom of the figure, the average scores for the mean score, SYSUSE, INFOQUAL, and INTERQUAL are calculated. The average score for the 16 questions from the PSSUQ is under 1.60. This indicates that the respondents generally have a strong agreement with the positive statements about the system's usability, as lower scores on the PSSUQ reflect higher levels of satisfaction and agreement (Mohamad Jamil et al., 2022). Therefore, the users found the PetalsPalette application to be highly useful, with high information and interface quality.

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	Questions																Scores on PSSUQ			
Participant	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	MEAN SCORE	SYSUSE	INFOQUAL	INTERQUAL
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1.00	1.00	1.00	1.00
2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1.00	1.00	1.00	1.00
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1.00	1.00	1.00	1.00
4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1.00	1.00	1.00	1.00
5	1	2	1	1	2	2	1	2	1	1	2	2	2	2	2	2	1.63	1.50	1.50	2.00
6	1	3	2	2	1	3	2	2	1	2	3	1	1	1	1	1	1.69	2.00	1.83	1.00
7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1.00	1.00	1.00	1.00
8	1	1	1	1	1	1	3	2	1	1	1	1	1	1	1	1	1.19	1.00	1.50	1.00
9	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1.00	1.00	1.00	1.00
10	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1.00	1.00	1.00	1.00
11	1	1	1	1	1	2	2	2	1	1	2	2	1	2	2	1	1.44	1.17	1.67	1.67
12	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1.00	1.00	1.00	1.00
13	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1.00	1.00	1.00	1.00
14	1	1	2	2	2	2	2	2	2	2	2	1	2	1	2	1	1.69	1.67	1.83	1.67
15	1	1	1	1	1	2	7	7	2	2	2	2	2	2	2	1	2.25	1.17	3.67	2.00
16	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1.00	1.00	1.00	1.00
17	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1.00	1.00	1.00	1.00
18	1	1	1	1	1	1	5	1	2	1	1	2	2	2	1	1	1.50	1.00	2.00	1.67
19	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1.00	1.00	1.00	1.00
20	1	1	1	1	1	2	2	2	2	1	2	2	1	1	1	2	1.44	1.17	1.83	1.00
21	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1.00	1.00	1.00	1.00
22	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1.94	1.83	2.00	2.00
23	1	1	2	2	2	2	4	2	3	1	1	2	1	2	3	1	1.88	1.67	2.17	2.00
24	1	1	1	1	1	2	2	3	2	2	1	1	2	2	1	1	1.50	1.17	1.83	1.67
25	1	1	1	2	2	1	2	2	3	3	2	3	3	3	4	2	2.19	1.33	2.50	3.33
26	1	2	2	2	2	2	2	1	2	1	1	1	3	2	1	1	1.63	1.83	1.33	2.00
27	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1.06	1.00	1.17	1.00
28	1	1	1	1	1	1	5	5	3	3	1	1	1	1	2	1	1.81	1.00	3.00	1.33
29	1	2	1	2	2	2	1	2	1	1	2	2	2	2	2	2	1.69	1.67	1.50	2.00
30	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1.94	1.83	2.00	2.00
31	1	2	1	2	2	3	1	2	2	1	2	1	2	2	2	1	1.69	1.83	1.50	2.00
32	1	2	2	2	2	2	2	2	2	1	2	1	1	1	2	1	1.63	1.83	1.67	1.33
33	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1.00	1.00	1.00	1.00
Average Score																	1.39	1.26	1.53	1.41

Fig. 15. PSSUQ calculation and results

3.2 UEQ results

Fig. 16 shows the results of the UEQ. It displays the mean scores based on the questions answered by the participants. The mean score for UEQ questions is about 4.5. This value indicates that the respondents generally have a strong positive agreement with the statements about their user experience while using the PetalsPalette application. Since the UEQ score ranges from 1 to 5, with 5 indicating strong agreement, the users found the application provides a fantastic user experience.

	Questions							
Participant	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
1	5	5	5	5	4	3	4	4
2	5	5	5	5	5	4	5	5
3	5	5	5	5	5	5	5	5
4	5	5	5	5	5	5	5	5
5	5	5	4	5	5	5	5	4
6	5	5	5	5	5	5	5	5
7	5	5	5	5	5	5	5	5
8	5	5	5	5	5	5	5	5
9	5	5	5	5	5	5	5	5
10	5	5	5	5	5	5	5	5
11	5	5	5	5	4	5	4	5
12	5	5	5	5	5	5	5	5
13	5	5	5	5	5	5	5	5
14	5	5	5	5	5	5	5	5
15	5	5	5	5	5	5	5	5
16	5	5	5	5	5	5	5	5
17	5	5	5	5	5	5	5	5
18	5	5	5	5	5	4	5	5
19	5	5	5	5	5	5	5	5
20	5	5	5	5	5	5	5	5
21	5	4	5	5	5	5	5	5
22	5	4	4	4	4	4	4	4
23	5	5	4	5	4	4	5	5
24	5	5	5	5	4	4	5	4
25	5	5	4	5	4	4	5	5
26	5	5	5	5	5	4	5	4
27	5	5	5	5	5	4	5	5
28	5	5	5	5	3	4	4	4
29	5	4	4	5	4	4	4	4
30	5	4	4	4	4	4	4	4
31	5	3	4	5	4	4	4	4
32	5	4	4	5	4	5	5	5
33	5	5	4	5	5	5	4	5
Mean Score	5	4.79	4.73	4.94	4.64	4.58	4.76	4.73

Fig. 16. UEQ calculation and results

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4. DISCUSSION

The overall findings for PSSUQ and UEQ collected the positive responses from the respondents, indicating that the PetalsPalette application effectively enhances flower identification through AR. Table 1 shows the overall PSSUQ results: Overall Satisfaction has a mean score of 1.39, SYSUSE (System Usefulness) has a mean score of 1.26, INFOQUAL (Information Quality) has a mean score of 1.53, and INTERQUAL (Interface Quality) has a mean score of 1.41. These low scores indicate that the respondents were highly satisfied with the application's usability, usefulness, information quality, and interface quality. Previous studies in AR for learning also showed that the PSSUQ score indicates that the AR application is well-received, with the score for each dimension are approaching 1 (1 indicates a strong agreement), but opportunities for enhancing the user experience persist (Kheng, 2023).

Table 2 shows the overall UEQ results for the 8 questions. The first question, which assesses attractiveness, received a score of 5. The second and third questions, which evaluate perspicuity, both received a score of 4.76. The fourth question, related to efficiency, scored 4.94. The fifth question, which measures dependability, scored 4.64. The sixth and seventh questions, which pertain to stimulation, both scored 4.67. The final question, the eighth, which assesses novelty, received a score of 4.73. The average user experience (UX) result is 3.59. These results indicate that respondents found the PetalsPalette application to be highly attractive, easy to understand (perspicuity), efficient, dependable, stimulating, and novel. The overall positive scores across different user experience dimensions demonstrate that the application provides a favorable user experience. in terms of the feelings and impressions made while interacting with the developed application. This aligns with the study by Derisma and Hersyah (2021), which reported positive findings regarding the evaluation of AR usage in learning. The utilization of AR provides significant feelings of learning, impressions, and positive attitudes towards the learning content. In their study, Ramli et al. (2023) also show positive findings of UEQ in the utilization AR and game elements in STEM content. Studying STEM subjects in an online medium, as well as conventional methods, might be hard and challenging, with technical vocabulary, intricate images, and complex explanations. With AR, the learning experience can be more engaging and benefit the learners.

As for AR marker detection from various lighting, the testing showed that lighting did affect the marker detection. The lighting made the content disappear or fail to appear in the session. However, finding suitable lighting in the testing location solved the problem easily.

Table 1. PSSUQ results

Scores on PSSUQ	Mean Score; Range 1–7
Overall Satisfaction	1.39
System Usefulness (SYSUSE)	1.26
Information Quality (INFOQUAL)	1.53
Interface Quality (INTERQUAL)	1.41

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Table 2. PSSUQ results

Questions	Aspect	Average Answer Result
Q1	Attractiveness	5
Q2 Q3	Perspicuity	4.76
Q4	Efficiency	4.94
Q5	Dependability	4.64
Q6 Q7	Stimulation	4.67
Q8	Novelty	4.73
	UX Average Result:	3.59

5. CONCLUSION

This paper offers an in-depth primer on a study called PetalsPalette, which highlights flower learning through AR for students. The study concludes that the users have successfully embraced the PetalsPalette mobile application due to its robust usability and experience. Despite these achievements, limitations were acknowledged, including the exclusive focus on UiTM students and constraints in AR technology, such as static text updates. Suggestions for future work include reaching out to a wider range of users beyond UiTM, testing the app on different devices and operating systems, and improving AR technology to make the application more flexible and user-friendly for everyone. Broader participation ensures the generalization of the findings and can show the acceptability of the proposed application. These improvements aim to advance AR technology in flower identification and enhance overall usability across diverse user groups and technological environments.

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7. CONFLICT OF INTEREST STATEMENT

The authors agree that this research was conducted in the absence of any self-benefits, commercial or financial conflicts.

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8. AUTHORS' CONTRIBUTIONS

Nur Azmatun Farwizah carried out, analysed, and wrote the research report; **Nurtihah Mohamed Noor** supervised, guided, and provided solutions throughout the research duration; **Mohd. Fitri Yusoff** offered ideas and solutions, organized, and edited this article.

9. REFERENCES

Avila-Garzon, C., Bacca-Acosta, J., Duarte, J., & Betancourt, J. (2021). Augmented reality in education: An overview of twenty-five years of research. *Contemporary Educational Technology*, *13*(3), ep302. https://doi.org/10.30935/cedtech/10865

Chamidah, D., Kristianto, S., Sunaryo, Fajarianto, O., Ahmad, A., Ani Setyo Dewi, Y., Sambodja, E., Ambarumi Munawaroh, D., Fitriah, N., & Indriawati, P. (2019). Feasibility of based augmented reality devices discovery learning on students learning outcomes in morphology of Wijaya Kusuma flower epiphyllum anguliger. *Journal of Physics: Conference Series*, *1175*, 012261. https://doi.org/10.1088/1742-6596/1175/1/012261

Derisma, D., & Hersyah, M. (2021). User experience measurement using augmented reality application in learning 4.0. In *ICED-QA 2019: Proceedings of the 2nd International Conference on Educational Development and Quality Assurance* (pp. 230-240). European Alliance for Innovation.

Kheng, T. K. (2023). *Interactive augmented reality aided software for Physics education using exploratory approach*. http://eprints.utar.edu.my/6102/

Kim, I., Park, J.-S., & Choi, K.-O. (2020). Analysis of designation and symbolic meanings of floral emblems in South Korea as elements of garden tourism and design. *Journal of People, Plants, and Environment*, *23*(1), 87–99. https://doi.org/10.11628/ksppe.2020.23.1.87

Lam, K. Y., Lee, L. H., & Hui, P. (2021). A2W: Context-aware recommendation system for mobile augmented reality web browser. In *Proceedings of the 29th ACM International Conference on Multimedia* (pp.2447–2455). ACM. https://doi.org/10.1145/3474085.3475413

Łysiak, G. (2022). Ornamental flowers grown in human surroundings as a source of anthocyanins with high anti-inflammatory properties. *Foods*, *11*(7), 948. https://doi.org/10.3390/foods11070948

Marchenko, A. M., & Kuzovkina, Y. A. (2021). Calculation of the ovule number in the genus salix: A method for taxa differentiation. *Applications in Plant Sciences*, *9*(11–12). https://doi.org/10.1002/aps3.11450

Moesl, B., Schaffernak, H., Vorraber, W., Holy, M., Herrele, T., Braunstingl, R., & Koglbauer, I. V. (2022). Towards a more socially sustainable advanced pilot training by integrating wearable augmented reality devices. *Sustainability*, *14*(4), 2220. https://doi.org/10.3390/su14042220

Mohamad Jamil, P. A. S., Karuppiah, K., Mohammad Yusof, N. A. D., Mohd Suadi Nata, D. H., Abdul Aziz, N., How, V., Mohd Tamrin, S. B., & Naeni, H. S. (2022). Usability testing of a wireless individual indicator system application: monitoring exposure to outdoor air pollution among Malaysian traffic police. *Digital Health*, 8, 205520762211033. https://doi.org/10.1177/20552076221103336

Narbona, E., Arista, M., Whittall, J. B., Camargo, M. G. G., & Shrestha, M. (2021). Editorial: The role of flower color in angiosperm evolution. *Frontiers in Plant Science*, *12*. https://doi.org/10.3389/fpls.2021.736998

Parsons, T. D., Gaggioli, A., & Riva, G. (2020). Extended reality for the clinical, affective, and social

https://doi.org/10.24191/jcrinn.v10i2.524

neurosciences. *Brain Sciences*, *10*(12), 922. https://doi.org/10.3390/brainsci10120922

Rajesh Kumar, K., & Subhashini, S. J. (2023). Visualizing medical flowers details by using deep neural network. *Recent Developments in Electronics and Communication Systems*, 208-215. https://doi.org/10.3233/ATDE221259

Ramli, R. Z., Sahari Ashaari, N., Mat Noor, S. F., Noor, M. M., Yadegaridehkordi, E., Abd Majid, N. A., ... & Abdul Wahab, A. N. (2024). Designing a mobile learning application model by integrating augmented reality and game elements to improve student learning experience. *Education and Information Technologies*, *29*(2), 1981-2008. https://doi.org/10.1007/s10639-023-11874-7

Setiyaningsih, Y., Dijaya, R., & Suprianto, S. (2021). Ethnosciences based augmented reality on botanical garden. *JUITA: Jurnal Informatika*, *9*(2), 173. https://doi.org/10.30595/juita.v9i2.10602

Tonmoy, T. K., & Islam, Md. A. (2023). Do students look for information differently? Information-seeking behavior during the Covid-19 pandemic. *Digital Library Perspectives*, *39*(2), 166–180. https://doi.org/10.1108/DLP-09-2022-0073

Vidak, A., Movre Šapić, I., & Mešić, V. (2022). Augmented reality in teaching about Physics: First findings from a systematic review. *Journal of Physics: Conference Series*, *2415*(1), 012008. https://doi.org/10.1088/1742-6596/2415/1/012008

Wilujeng, S., Chamidah, D., & Wahyuningtyas, E. (2019). The use of augmented reality to introduce Wijaya Kusuma flower. In *Proceedings of the 6th International Conference on Community Development*. https://doi.org/10.2991/iccd-19.2019.135

Wong, J., Bayoumy, S., Freke, A., & Cabo, A. (2022). Augmented reality for learning Mathematics: A pilot study with WebXR as an accessible tool. In *Towards a New Future in Engineering Education, New Scenarios That European Alliances of Tech Universities Open Up* (pp. 1805–1814). https://doi.org/10.5821/conference-9788412322262.1216

Wulansari, T. Y. I., Senjaya, S. K., & Astuti, I. P. (2022). Flower structures of averrhoa dolichocarpa *Rugayah & Sunarti. Journal of Tropical Biodiversity and Biotechnology*, *7*(3), 74585. https://doi.org/10.22146/jtbb.74585