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DEVELOPMENT OF *MECHYAR* APPS FOR LEARNING MECHANICAL DESIGN

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ABSTRACT - The development of the *MechyAR* application is a new way of learning that is aimed at improving current learning. This application was created to make it easier for students to learn mechanical components by utilizing current technology. The primary objective of this study is to identify appropriate multimedia elements for use in the application development, to develop the application, and to test the functionality of the *MechyAR* application as a new virtual learning method that employs virtual technology. Questionnaires were distributed to Design and Technology subject teachers to identify appropriate multimedia elements to be used in application development. The data were analyzed using SPSS 25.0 which are then used as a guide for the researcher to develop *MechyAR* application. The Prototype Development Model was used as a guide in developing and implementing the *MechyAR* application. This application was evaluated by experts based on their teaching experiences in the field of multimedia technology. From the findings, multimedia elements namely graphics, animation, video, and audio are important elements that need to be applied in the newly developed *MechyAR* application. Furthermore, experts agreed and supported the development of this application to be used as a new method of student learning for the Design and Technology subject, particularly the Mechanical Design topic. Overall, the application of mechanical learning characterized by Augmented Reality can be concluded to be functional and suitable for use as an initial exposure for student learning in academic secondary school.

Keywords: design and technology, mechanical design, multimedia elements

1. INTRODUCTION

Many countries' administrative systems, organization, and efficiency have improved because of technological advancements. Technological advancements have simplified the navigation of administration, management, broadcasting and media, telecommunications and communications, and education, among other fields. As such, our country's educational system is undergoing rapid transformation. Advances in technology can also be seen in the field of education, where computer-assisted teaching and learning methods were introduced and

enhanced to be at par with the current level of technological development and to produce a holistic generation that is well-versed not only in academics but also in technological knowledge [1]. Educators have introduced and used a variety of new methods and techniques to improve the effectiveness and efficiency of the teaching process. In this era of rapid globalization, it is expected every student to have a set of skills that includes basic academic skills, critical thinking, problem-solving abilities, the ability to work in groups, the ability to use technology, and the ability to communicate effectively [2]. Educators must be capable of effectively teaching and learning for students to be born capable of contributing to the nation's and country's development.

Therefore, the chalk and talk method is no longer compatible with the 21st Century Teaching and Learning concept, which promotes student-centred learning rather than teacher-centred learning. Learning will be more engaging and effective if teachers are able to incorporate a variety of appropriate methods and techniques, depending on the lesson's objectives. According to many studies [3,4,5] competence refers to an educator's capacity to comprehend, behave, evaluate, make decisions, and act in the course of their duties. To conduct student-centred learning, today's education requires teachers to act as facilitators. This is to ensure that students can work in groups and apply their inquisitiveness to their learning. Student-centred learning can provide a fun new learning experience for students [6] and encourage them to self-explore the topics being studied [7]. Additionally, previous research has highlighted how student-centred learning and student learning outcomes can be improved through the use of Augmented Reality applications, an exciting new technology that enables users to examine virtual objects learned in class [8, 9].

Augmented Reality (AR) is a new technology that not only helps increase the perception of teaching dynamics but can also incorporate sensory modalities such as touch, sight, and hearing [10,11]. Specific to adding a variety of sensory modalities, there are many researchers revealing potential benefits of using AR in formal education such as improving student academic achievement [12], knowledge retention [11] and engagement [13] to achieve critical learning outcomes during the teaching -learning process. Previous research suggests that educators should use cutting-edge and advanced technology applications, such as Augmented Reality. Furthermore, it was reported that AR has a lot of potential to change educational settings such as improving progressive pedagogy, teaching strategies, classroom arrangement, and content delivery [14]. The use of augmented reality applications is expected to improve students' cognition and interaction, resulting in more effective learning [15].

In one study, traditional 2D and 2D simulation systems were compared to see if such systems resulted in better learning among university students. AR simulations, according to the researchers, play a more supportive role in students' collaborative learning than traditional learning [16]. In a comparative media study, the researchers investigated how different forms of technological mediation (computers vs. robots) might impact kindergarten students 'perceptions of AR-infused teaching and learning. The results show that regardless of the type of media, younger children tend to have higher satisfaction with AR-infused learning content [17]. A study by [18] compared the teaching effectiveness of location -based AR navigation tools with Google maps and print -based materials among students diagnosed with intellectual disabilities or autism spectrum disorders. The researchers discovered that when students used location-based augmented reality navigation tools, their performance improved significantly compared to when they used traditional learning materials [18].

1.1 Statement of Problem

In 2017, the Secondary School Standard Curriculum (KSSM) was implemented in stages to replace the Integrated Secondary School Curriculum (KBSM) as a transformation process in the field of education. As a result, a new subject, the Design and Technology has been added to the new curriculum to replace the Living Skills subject. The Design and Technology teachers were found to be unprepared in terms of planning, implementing, and assessing RBT-based learning in secondary schools. This is due to the teacher's constraint, as their teacher-training background and teaching experience is limited to the Living Skills area [19,20,21]. According to previous studies [22,23], changes in curriculum may cause a slew of issues for teachers. Teachers are required to attend time-consuming meetings and workshops, which interfere with their ability to focus during the teaching process, jeopardizing the effectiveness of their classroom instruction.

The teaching content of Design and Technology for Form 2 consists of two main topics, namely Inventive Problem Solving (Topic 1) and Technology Application (Topic 2). The current study focuses on Topic 2 which is the Technology Applications and is further focused on the subtopic of Mechanical Design. The objective in the Mechanical Design subtopic is to expose students to mechanical components, component functions, 3D sketches of project or gadget design, component suitability on gadgets, weaknesses, and strengths of components on gadget systems, building functional mechanical gadgets and improvements that can be made to the gadget system. Students are assessed through project assignments where they are required to develop gadgets based on what is learned in this Mechanical Design subtopic.

As a result, the use of textbooks solely as reference material in teaching and learning is inadequate to help students gain a better understanding of mechanical components, component functions, and how to apply those components in the development of their gadgets, as Mechanical Design is a new learning topic for them. Teachers should therefore employ a variety of approaches, methods, and techniques to assist students in learning the concept of Mechanical Design. However, the Design and Technology teachers face challenges due to a lack of tools and facilities [24, 25]. According to [26, 27], multimedia software with elements such as graphics, animation, video, and audio can stimulate and attract students while also assisting in the delivery of lesson content. The incorporation of technological software or multimedia elements into the teaching and learning process can assist students in acquiring knowledge in a more realistic and visual manner. This can also help students understand real-world systems like mechanical systems, which are covered in the subtopic of Mechanical Design topic in Design and Technology subject for Form 2 students in academic secondary schools.

Thus, research on the development of augmented reality applications as well as multimedia elements suitable for use in augmented reality applications is critical to assisting in the development of interactive teaching aids that can be used in complex topics such as Mechanical Components in the Design and Technology subject in academic secondary schools. The development of this augmented reality application demonstrates that the application of teaching techniques is appropriate and consistent with the governing concept of 21st Century Teaching and Learning.

1.2 Study Objective

In general, the purpose of this study is to investigate the appropriate multimedia elements deemed important to be included in the development of the *MechyAR* application. The development of this application aimed at assisting Design and Technology teachers in carrying out a more effective and efficient teaching and learning process, which may engage more active students' participation in the classroom process. The specific objectives of this study are:

i. Identify the appropriate multimedia elements in the development of *MechyAR* application for the Mechanical Design topic in Design and Technology subject
ii. Designing the *MechyAR* application featuring Augmented Reality
iii. Identify expert views on the usability of *MechyAR* application

2. MATERIALS AND METHODS

The primary objective of this study is to create a learning media for the Design and Technology subject, with a particular emphasis on the Mechanical Design topic, by incorporating a prototyping development model with augmented reality. The Analysis, Design, Development, Implementation, and Evaluation (ADDIE) model was utilized in this study. The ADDIE model's development procedures are divided into five stages: analysis, design, development, implementation, and evaluation [28, 29]. Figure 1 depicts the stages of the ADDIE model.

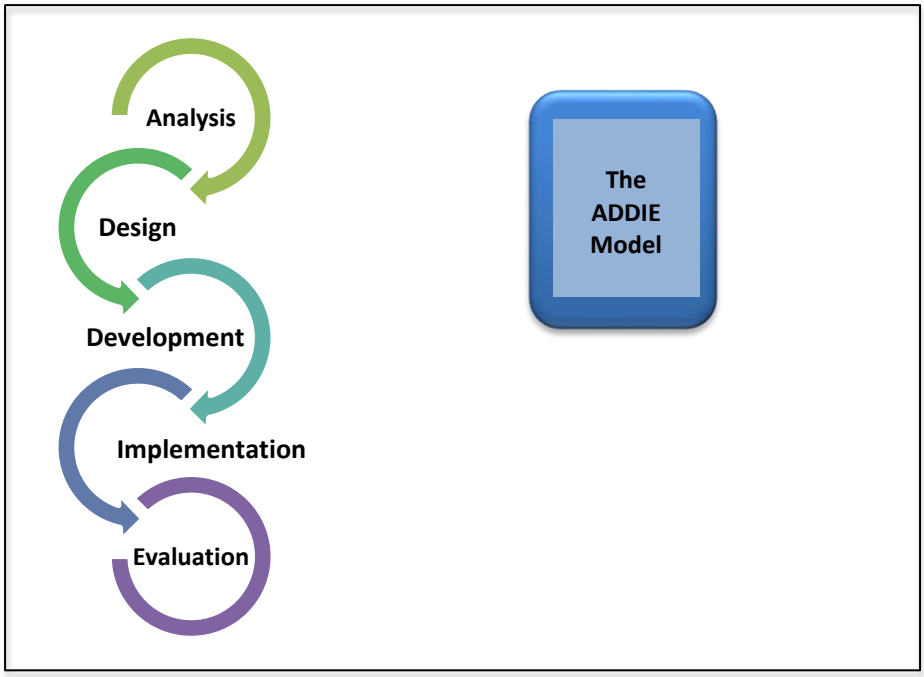


Figure 1. Stages of the ADDIE model

Further, Figure 2 depicts the functional flow chart to outline the development process of *MechyAR*, an augmented reality learning application development.

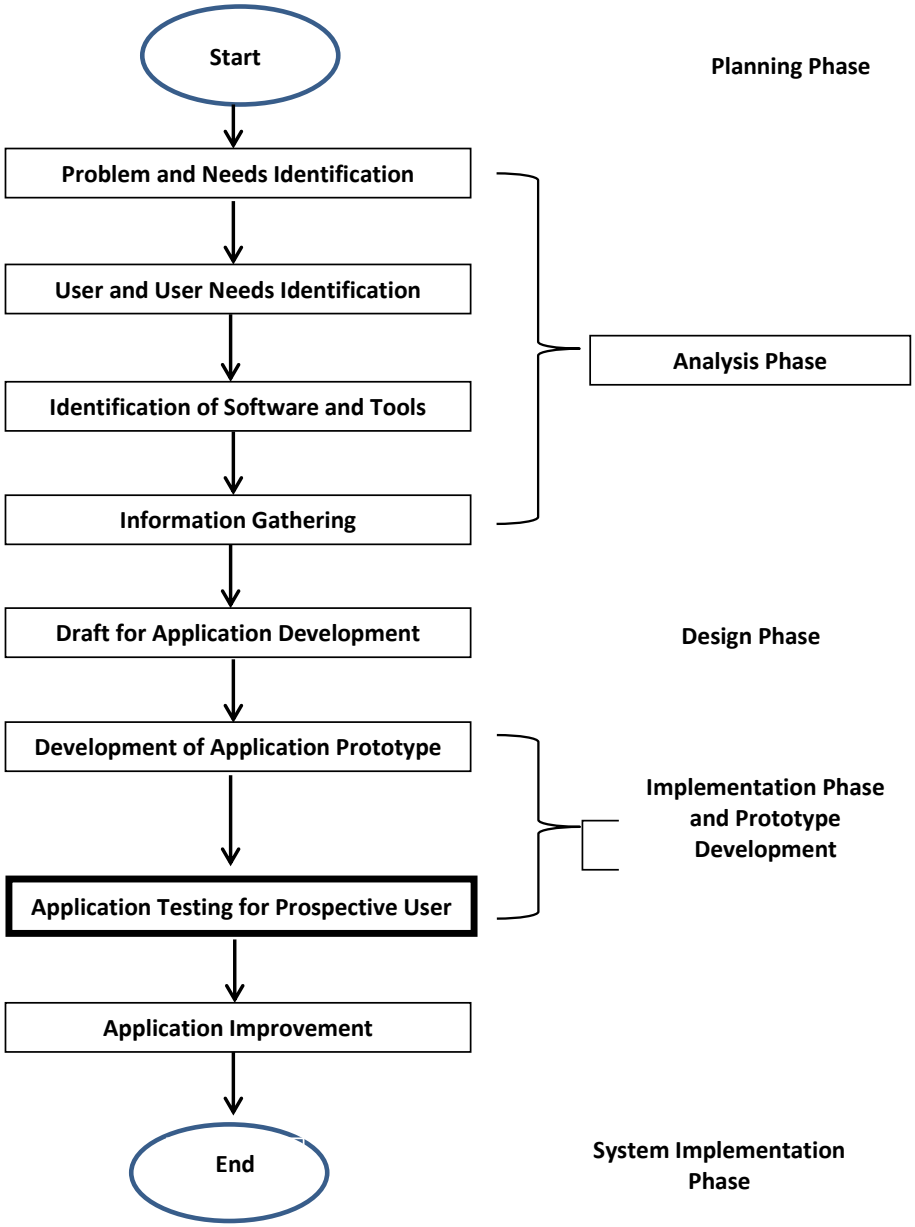


Figure 2. Study flowchart

2.1 Planning Phase

This application was developed using a prototype development model. The developer determines the objectives of the application to be developed, the background of the problem, the knowledge required in developing this application, the target users, and the scope of the study during the planning phase. Developers also determine the hardware, software, and related knowledge requirements. Each of these requirements must be applicable to the application development. Laptops and other software such as Unity 3D, Vofuria, and Balabolka are required to build graphic, animation, and audio elements for *MechyAR* "Mechanical Learning" applications. In addition, the developer also uses android mobile phones to display the AR for which this application is set for all android mobile phones up to 4.0 and beyond

2.2 Analysis Phase

This phase entails gathering information to develop the application, analyzing the information based on the suitability of the application and deciding how to implement it. During the analysis phase, product requirements are explained in detail by researchers interviewing targeted users to gather the information needed to meet their needs. Following that, the developer distribute instrument to secondary school teachers who teaches Design and Technology subject. Research instruments are tools used by researchers to collect data to obtain information prior to the development of a product. This study employs a quantitative approach by distributing questionnaires to Form 2 Design and Technology teachers from six national secondary schools in Skudai, Johor. The survey results are used to guide and assist in understanding the project's needs and achieving project objectives.

2.3 Design Phase

Following the analysis phase, the developer created this AR application by first creating a flash card on mechanical components using free online resources. Mechanical components can be found from any device, piece of equipment, or vehicle. The image in the figure depicts the 3D image obtained from the searched site.

Figure 3. 3D model sample

The developer then designs the product for the design phase by creating a "Story Board" with the information obtained so that the developer can get an overview of the product that is to be developed. This application development strategy has been thoroughly examined to ensure that it satisfies the requirements for developing this application. If no resources are obtained from the website, the developer must also know how to build 3D objects at this stage. The developer compiles all product materials and then edits them using software during the implementation phase. The prototype development phase was extended by utilizing materials already on-site. After the prototype is created, it is tested by giving it to a user. Following that, the developer creates the product design using Utility 3D and Vuforia.

2.4 Implementation and Prototype Phase

This implementation phase involves the process of finding 3D objects and designing markers that will be used in the application. Figure 4 below shows the main page of the AR application that was developed in this application. On this page there are three menu options which are “start”, “instruction” and “about” before user can start the application to the next screen.

Figure 4. Application main menu

When the user presses the ENTER button, the application will navigate to the next page as shown in Figure 5. There will be two options on this site: DOWNLOAD and CAMERA. For the CAMERA, the lens will scan the flash card, and the 3D model will be projected on the smartphone screen. When the user clicks DOWNLOAD, user will be able to obtain the flash card resource for use with this application.

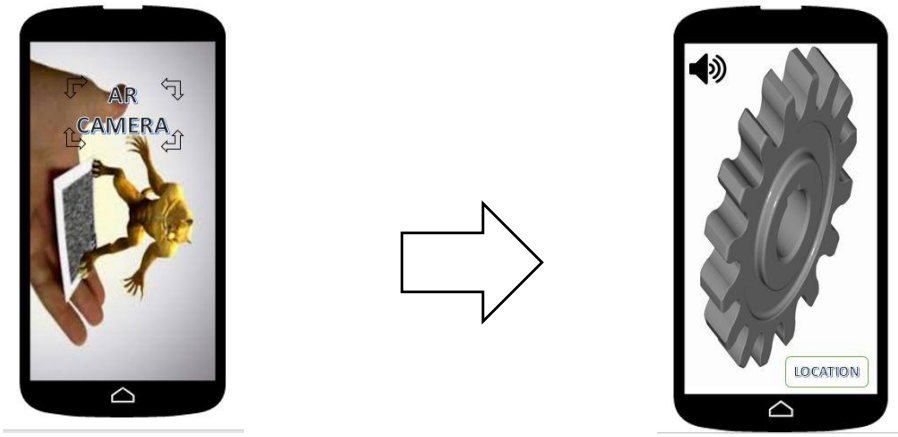


Figure 5. Example of AR CAMERA and 3D Model sample on screen

When the user scans the flash card, the 3D model appears, along with text indicating the component's name and audio describing its function. The mechanical component can be found by pressing the LOCATION button (Figure 6). The diagram depicts a static image of the location of the mechanical component in the mechanical tool.

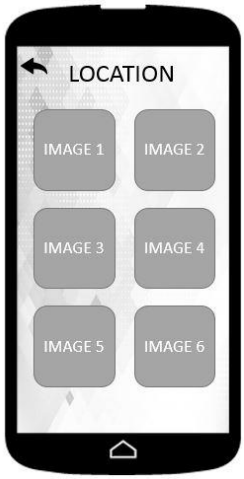


Figure 6. Example of image arrangement for location where the mechanical components can be found

2.5 Implementation and System Phase

This augmented reality mechanical learning application has been tested to ensure that it meets the needs of users while also meeting the developer's objectives. Products are amended and revised in response to testing comments and evaluations based on expert judgment process. Expert teachers were selected based on their years of experience in the teaching and learning of Mechanical Design subject. Finally, once this application has been successfully developed, the developer documented the benefits and drawbacks of mechanical learning using this AR application for use as a reference and guide for future improvement.

3. RESULTS AND DISCUSSION

3.1 Objective 1: Identify the appropriate multimedia elements for *MechyAR* application

A survey among teachers was conducted to identify appropriate multimedia elements for use in the application development. Questionnaires were distributed to Design and Technology subject teachers to identify appropriate multimedia elements to be used in application development. The data were analyzed using SPSS 25.0 which are then used as a guide for the researcher to develop *MechyAR* application.

Demographic Profile

The total number of subject-matter experts involved in this study is a total of 33 Design and Technology teachers consisting of seven (7) male teachers and twenty-six (26) female teachers from academic secondary schools in Skudai, Johor (see Table 1).

Table 1. Distribution of respondents teaching experience

Years of experience	Frequency (f)	Percentage (%)
1 – 5 years	5	15.2
5 -10 years	14	42.4
More than 11 years	14	42.4
Total	33	100

Table 2. Mean Value and Standard Deviation of Each Element

Element	Mean Score	Standard Deviation	Level
Graphic	4.33	0.475	High
Animation	4.34	0.485	High
Video	4.27	0.447	High
Audio	4.24	0.447	High

Based on Table 2, all elements are suitable for inclusion in the application development with high mean scores, indicating a high level of agreement. The animation element is the most dominant, followed by the graphic element, the video element, and finally the audio element. This signifies the importance of these elements to be used in the development of *MechyAR* application for the Mechanical Design topic in the Design and Technology Form 2 teaching content. The result is in line with previous studies [30] which found that hypermedia elements such as animation, sound, graphics, hypertext, and color made the presentation more engaging and able to increase students' engagement. Multimedia in education improves learning efficiency and makes it easier to describe what needs to be conveyed. Additionally, a screen can display text, audio, video, and animation in a variety of colors and patterns simultaneously as a positive and effective communication medium. Multimedia can be used to convey information quickly and accurately, as well as act as an attractant to create a fun learning environment. [31, 32].

3.2 Objective 2: The development of *MechyAR* - a mechanical component learning application featuring Augmented Reality

This application was developed using software and hardware (i.e., Unity, Vuforia and Balabolka) that were selected to aid researcher in the development process. Additionally, a user manual is being developed to assist teachers in implementing *MechyAR* during the teaching and learning process. Teachers can also use this application with a laptop or computer equipped with a webcam. LCD display is also required to ensure that the screen is visible to all students during the teaching and learning process. This is to facilitate teachers' use of the application in the classroom.

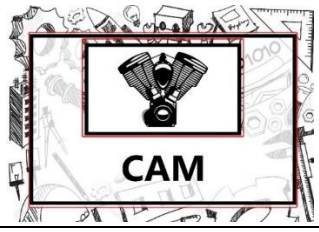
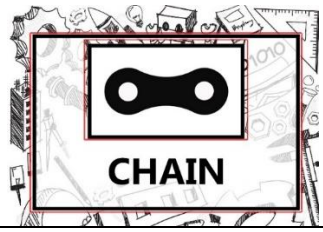
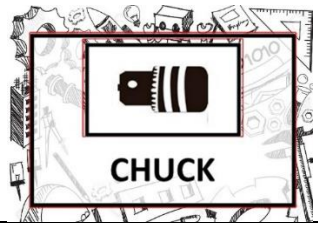
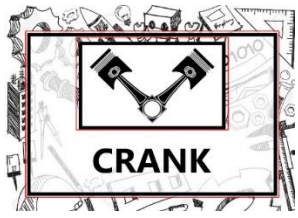
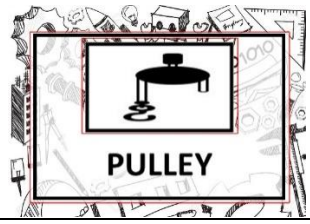
Studies in augmented reality and learning autonomy shows that students will have the ability to receive information better if using a combination of information approach in the form of images, graphics, audio, video, and animation [33,34]. The content in this *MechyAR* application combines these five multimedia elements to help the learning process of students. The content is designed to assist users in

becoming more effective and efficient during the teaching and learning process. Inconsistent content organization will influence both the teaching and learning outcomes of students and teachers. Therefore, the design phase is crucial as an overview about the overall product, structure, teaching approach, type of multimedia elements and technology used.

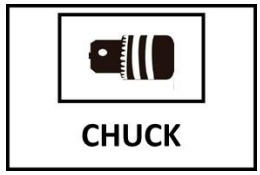
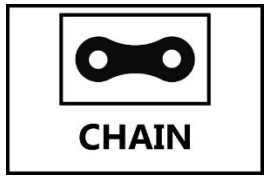
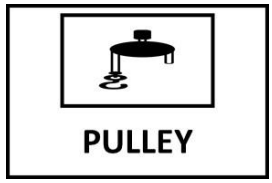
The front page of *MechyAR* application's user manual features the title of the mechanical component, and a suitable background image. The next flash card contains an instruction manual that will teach the user how to use this application. The following page serves as an introduction to mechanical components. Each marker on the flash card will be scanned by the user. There are ten (10) mechanical component flash cards that display 3D objects and explain the function of those mechanical components. Each 3D component display includes an image of the component object and a video demonstration of the component in action. The flash card will be included in the *MechyAR* application's user manual (see Table 3.

Systematic planning is critical to achieving the highest possible product quality. Each software package should be thoroughly examined prior to developing a product. To avoid issues, the design process must be organized. The multimedia and augmented reality elements included in the application, as well as the user manual, should be engaging to pique users' interest and aid teachers' comprehension of how to use it [35].

Table 3. List of *Flash card* and *Marker* for *MechyAR* application

Flash card for *MechyAR* application	
	
	
	
	
	

List of *Marker* for *MechyAR* application

3.3 Objective 3: Usability of *MechyAR* application

The aim is to test the functionality of the *MechyAR* application as a new virtual learning method that employs virtual technology in the teaching and learning of Mechanical Design topic in Design and Technology subject. Experts evaluated the application's usability positively based on the analysis. However, there is a little drawback to this application: the conversion to the camera scene is quite slow, and the image of the mechanical component, for example, is less clear on some 3D

components of the object. The conversion to the camera scene is found to be slow due to the presence of numerous 3D objects in a single interface. Such vulnerabilities can be controlled by the developer by reducing 3D objects in the same interface. In general, the displayed 3D objects, animations, graphics, audio, and video are all functional. Based on expert consensus regarding *MechyAR* application functionality, the application can function properly and completely within the scope of the project, achieving the project's objectives. According to experts, this application can assist students in identifying these mechanical components as well as their function. Table 4 presents the expert's feedback on the application usability.

Table 4. Expert Opinion on Usability of *MechyAR* application

No	Item: Content	Expert 1	Expert 2	Expert 3
1	The name of the 3D object component is displayed on the screen while the marker is scanned on the mechanical component flash card	/	/	/
2	The 3D object helps the students recognize the mechanical component	/	/	/
3	The displayed images in the MechyAR Augmented Reality application are easily identified	/	/	/
4	Videos on the functions of mechanical component is appropriate and easily understood	/	/	/

A simple, user-friendly, and less technical augmented reality authoring tool that is also responsive to the needs of teachers is critical to enabling the expansion of technology use in education [36].

4. CONCLUSION

Overall, this study aims to examine the appropriate multimedia elements to be taken into consideration when designing the *MechyAR* application for Mechanical Design topic in Design and Technology subject for secondary schools. The data gathered indicates that graphic, video, animation, and audio elements are all suitable for inclusion in the development of AR-enabled applications. Following the completion of the *MechyAR* application development, experts who have tested and evaluated the *MechyAR* application have made some observations and suggestions. The user experience testing resulted in a positive result, indicating

that this virtual reality-based learning media application was deemed outstanding. As a result, this application could be used as a supplement to the teaching and learning process in an academic secondary school for the subject of Design and Technology, with a focus on Mechanical Design.

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