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Implementation of Augmented Reality Teaching and Learning Kit to Enhance Visualization, Motivation and Understanding among TVET Students

Mohd Erfy Ismail[1,*], Che Mohammad Fattihi Ekhmal Che Mut[1], Khairul Azhar Mat Daud[2], Md Baharuddin Abdul Rahman[3], Mohd Fazrul Hisyam Mohd Nor[4], Pipit Utami[5]

1 Faculty of Technical & Vocational Education, Universiti Tun Hussein Onn Malaysia, Parit Raja, 86400 Batu Pahat, Johor, Malaysia
2 Faculty of Creative Technology and Heritage, Universiti Malaysia Kelantan, 16310 Bachok, Kelantan, Malaysia
3 School of Educational Studies, Universiti Sains Malaysia, Minden, 11700 Gelugor, Pulau Pinang, Malaysia
4 Standard and Industrial Research Institute of Malaysia (SIRIM) Berhad, 40700 Shah Alam, Selangor, Malaysia
5 Universitas Negeri Yogyakarta, Daerah Istimewa Yogyakarta 55281, Indonesia

ABSTRACT

Augmented Reality (AR) technology is one of the increasingly preferred choices for educational development of education. This study aims to identify the level of visualization, motivation and understanding by designing and developing an AR application for the topic of Engineering Drawing. This application enhances the user's clarity and comprehension on the types of drawings and the form of the drawing to be presented. The design and development process of this AR application uses the Hannafin and Peck model as a guideline. The research instruments used are expert review forms for product development and questionnaires. The study included a total of 52 students from Sungai Buloh Vocational College, Selangor, as participants. The findings were analysed descriptively using the Statistical Package for the Social Sciences (SPSS) software version 27. The evaluation was conducted on three (3) aspects, namely the level of visualisation, motivation and comprehension of the students, as well as the significance of research to examine the gender differences between the three aspects. The findings of the study revealed that the use of the AR application produced for the three (3) components yielded a favourable outcome with a reliability value of r=0.855, which demonstrates that the instrument possesses a high level of reliability. However, no significant difference was found between the genders of the students that participated in the study. In general, the findings of the study indicate that the implementation of the AR teaching and learning kit has yielded positive outcomes in terms of enhancing students' visualisation skills, motivation levels and comprehension of the Engineering Drawings subject.

Keywords:
Augmented reality (AR); motivation; understanding; visualization; teaching and learning kit

* *Corresponding author.*
E-mail address: erfy@uthm.edu.my

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1. Introduction

The world is currently witnessing remarkable developments in IT communication systems and Malaysia's education system is not an exception to this trend. These advancements are particularly significant in the domain of Technical and Vocational Education (TVET), where the focus is on equipping students with practical skills. This transformation is primarily driven by the evolving needs of various industries, with a strong emphasis on Industry 4.0. As we embrace the Information and Communication Technology (ICT) era, it has ushered in more interactive and engaging methods of teaching and learning. Notably, the Ministry of Education Malaysia (MOE) has increasingly recognized the pivotal role of ICT, leading to several changes, restructuring efforts and curriculum enhancements in Technical and Vocational Colleges. These actions align seamlessly with the ICT policy announced by the Malaysian Minister of Education back in 2010, which made ICT a central teaching medium and shifted the role of teachers towards that of facilitators [15].

From an educational standpoint, traditional education systems that have been employed for many years place significant emphasis on passive forms of engagement, while frequently neglecting activities that promote critical thinking, concept formation and the formulation of useful theories [28]. In Malaysia, TVET education stands as a national initiative aimed at producing a skilled workforce to bolster economic competitiveness, aligning with the Vision 2020 goals. Vocational Colleges play a pivotal role in the TVET landscape, churning out highly skilled individuals who significantly contribute to the nation's economic growth. To meet the stringent standards set by the Technical and Vocational Education Division, students are expected not only to grasp the learning process but also to attain a high level of proficiency in their chosen skills [10].

In this ever-evolving landscape, technology plays an indispensable role in supporting skill development within the education sector. This research leads to examine the potential advantages of AR technology as an interactive teaching medium capable of capturing students' attention and fostering engagement during their learning journey. According to Saforrudin *et al.,* [23], the effectiveness of AR in education hinges on the teacher's competence and the specific content they intend to convey. The integration of AR into education holds the promise of injecting fresh vitality into the field of education, offering educators the flexibility to choose the most suitable technology to complement their teaching methods. Furthermore, e-learning acceptance, self-efficacy, computer playfulness and enjoyment have positively influenced the students' perceived ease of use and usefulness of e-learning systems [29].

As highlighted by Sallehin & Halim [24], nearly all educators concur that multimedia-based Teaching Aids (TA) have the potential to significantly enhance the implementation of teaching and learning sessions. These aids facilitate smoother information retrieval and comprehension. Consequently, the development of engaging TA is paramount in our pursuit of successful 21st-century learning during the era of the 4th industrial revolution. These appealing teaching aids not only serve to motivate students but also exert a positive influence on their cognitive development.

In summary, this paper will delve into the intriguing realm of AR technology and its potential applications in education, with a particular focus on Malaysia's Technical and Vocational Education (TVET) system. The role of AR as an interactive teaching medium will be explored, assessing its effectiveness and its potential to reshape students' learning experiences. In addition, according to Shahidan, Ismail and Abd Kadir [25] visuals play a significant role in facilitating deeper engagement, understanding and emotional connection. Furthermore, we will discuss the vital importance of multimedia-based Teaching Aids (TA) in modern education, particularly in enhancing the teaching and learning process amid the backdrop of the 4th industrial revolution.

1.1 Research Background

In engineering drawing, students may be able to use and master graphic knowledge such as symbols, conventions, basic techniques and certain principles and at the same time, they may also be able to master the skills of using drawing geometric tools, but they may not be able to master visualization skills [16]. There are skill variations between male and female students, with the degree of visualisation skills among female students being found to be weaker than it is among male students [28]. Visualization skills are techniques that need to be taught by understanding concepts, where students will only understand something if they can see the structure of that object [28]. According to Ramli *et al.,* [21] students are unable to depict something learned if they do not see the operation that occurs.

The shift from traditional face-to-face instruction to digital learning has presented significant obstacles and constraints for students, particularly in their limited proficiency in effectively navigating and utilising digital resources [19], limitations on the necessary digital resources, including devices and internet access [20] and the lack of social interaction among students physically [5]. These pressures and challenges have the potential to affect students' motivation [31]. The effects of the change in learning make it difficult for students to collaborate in learning and most of them face difficulties in adjusting to understand all the information presented, hence they need to work hard to understand the interactions [30].

The exposure to the integration of Augmented Reality (AR) in Engineering Drawing is still not at a widespread level. According to the Technical and Vocational Education Division [2], the Engineering Drawing subject offered to schools is to provide students with the opportunity to interact confidently in current technology. The need for understanding engineering drawing is very important because the engineering field requires initial drawings before the next process is carried out. As a result of the high need for skilled labour, an efficient approach is needed to address this issue and the use of technology in this subject is necessary, such as Augmented Reality (AR) which allows students to understand the main principles and concepts better. As stated by Haryani & Triyono [11], the 3-dimensional view of Augmented Reality (AR) can be clearly seen by the user and can stimulate the user's perception and interaction with the real world. Although, if viewed from a different perspective, traditional teaching has its own advantages such as saving time and having a controlled classroom environment, but techniques like this prove to be ineffective in cooperative teaching and learning session [27].

1.2 Research Objectives

The objectives of the study are as follows:

i. To develop an augmented reality (AR) based teaching and learning kit for engineering drawing for the Welding Technology program for teaching and learning in the Engineering Drawing course.
ii. To test the functionality of the AR-based teaching and learning kit for engineering drawing on vocational college students.
iii. To assess the level of acceptance of interactive multimedia visualization elements, as well as the development of motivation and understanding of the AR-based teaching and learning kit among vocational college students.
iv. To identify the differences between male and female students regarding their acceptance and assessment of interactive multimedia visualization elements, as well as their

development of motivation and understanding of the AR-based teaching and learning kit among vocational college students.

This table presents the null hypothesis (Ho) and alternative hypothesis (H1) on gender differences among vocational college students in their minimum score level of acceptance and student evaluation of interaction with interactive multimedia visualization, motivation and understanding elements in teaching and learning kits based on Augmented Reality (AR). The hypotheses play a crucial role in shaping the research direction and determining the significance of gender-related differences in this educational context.

Table 1
The null hypothesis (Ho) and the alternative hypothesis (H1) between two groups

Elements	Null Hypothesis (Ho)	Alternative Hypothesis (H1)
Visualization Motivation Understanding	There is no statistical difference between male and female students in terms of the minimum score level of acceptance and student evaluation of interaction with interactive multimedia visualization / motivation / understanding elements towards teaching and learning kits based on Augmented Reality (AR) among Vocational College students.	There is a statistical difference between male and female students in the minimum score level of acceptance and student evaluation of interaction with interactive multimedia visualization / motivation / understanding elements towards teaching and learning kits based on Augmented Reality (AR) among Vocational College students.

These hypotheses are essential in guiding the research process and data analysis. If the null hypothesis (Ho) is supported by the data, it implies that gender is not a significant factor influencing students' perceptions and evaluations of interactive multimedia elements in their educational experience with Augmented Reality-based teaching and learning kits. On the other hand, if the alternative hypothesis (H1) is supported, it suggests that there are meaningful gender differences that need to be explored and addressed, potentially leading to tailored approaches in educational design and implementation for male and female vocational college students.

In summary, these hypotheses serve as a critical foundation in investigating the role of gender in shaping students' interactions with AR-based educational materials and their overall learning experiences. The results of the study will provide valuable insights for educators and researchers in optimizing the effectiveness of such instructional tools for both male and female students.

2. Methodology

The validity and reliability of the instrument will be assessed to ensure that the items given to the sample candidates are appropriate for the objectives to be achieved. An interface diagram will be provided to show the process of development and functionality of this teaching and learning kit. Feedback from sample candidates will also be evaluated to determine the effectiveness or improvements in this teaching and learning kit. To obtain good and high-quality research results, information and data from previous research focus will be used in the development of this learning kit, so that the research methodology can be planned in an orderly and systematic manner. The researcher chose the Hannafin & Peck learning model and integrated the DDR methodology into this research for their alignment with researcher objectives. The model's focus on creating Computer-Aided Learning-based mediums aligns with the researcher's goal of developing a teaching and learning kit [36]. DDR ensures research-based design and usability testing for effectiveness, which is crucial for students with special needs. This research design aims for coherence in integrating components for better outcomes. Using a descriptive quantitative method, the collected data aims to provide insights into the effectiveness of the kit. In summary, this approach is well-suited for the development and evaluation of the researcher's kit designed for students with special needs in vocational skill training.

2.1 Research Design

The process of developing the teaching and learning kit, following the Hannafin & Peck learning model, is employed to address the problem outlined in the problem statement. This process includes all the steps required in the Hannafin & Peck model, which are the analysis phase, the design phase, the development phase and the final evaluation phase. Evaluation is carried out at each phase. This model is chosen because its goal is to form a Computer-Aided Learning-based medium, so it is very suitable for this study [7]. The Design and Development Research (DDR) methodology, popularized by Richey & Klein [22], is used within the Hannafin & Peck Model. The Hannafin & Peck model consists of four distinct phases aimed at creating effective instructional solutions. In the Analysis phase, the focus is on understanding the problem and the learners' needs, involving activities like problem identification, gathering learner information and setting clear objectives. In the Design phase, the emphasis shifts to planning the solution, where instructional strategies are developed, learning materials are designed and assessment methods are defined. The Development and Implementation phase involves creating the actual learning materials, building necessary technology components and delivering instruction while providing learner support. Finally, in the Evaluation phase, continuous assessments and feedback are used to assess the effectiveness of the instruction, driving revisions and improvements. This systematic approach ensures that instructional design aligns with learner needs and continually evolves to provide meaningful learning experiences. Additionally, several tests will be run to test the teaching and learning kit emphasized in Design and Development Research (DDR) to demonstrate its usability before it is used. The design of the study is an essential strategy chosen by the researchers to integrate all the components of the study in a cohesive and logical way, to guarantee that the objectives set in the study can be achieved effectively. Research design is the structure of a researcher's chosen research methodologies and procedures. The study is using a descriptive quantitative method to investigate the perception of students with special needs towards vocational skill training and to identify the level of visualization, motivation and understanding of students.

2.2 Sampling and Population

Krejcie & Morgan's table was chosen for sample size determination due to its established credibility and pragmatic utility. While a large population is ideal for robust results, it often entails excessive costs and time. By opting for a sample, these constraints are mitigated. Krejcie & Morgan's table, renowned since 1970, offers a reliable framework. It aligns with Acharya *et al.,* [1] principle of selecting a representative sample from the larger population. Tailored to vocational college students, it ensures context-specific precision. Its user-friendliness simplifies the process, especially vital with resource constraints. Emphasizing representativeness, it enhances the study's validity, efficiently balancing statistical significance with resource optimization, meeting the study's cost and time reduction objectives.

2.3 Research Procedure

The workflow chart (Figure 1) serves as a crucial guideline to ensure that the study is carefully developed and implemented in accordance with the correct stages of the Hannafin & Peck Model. Thus, the product development process flowchart based on the Hannafin & Peck Model has been executed.

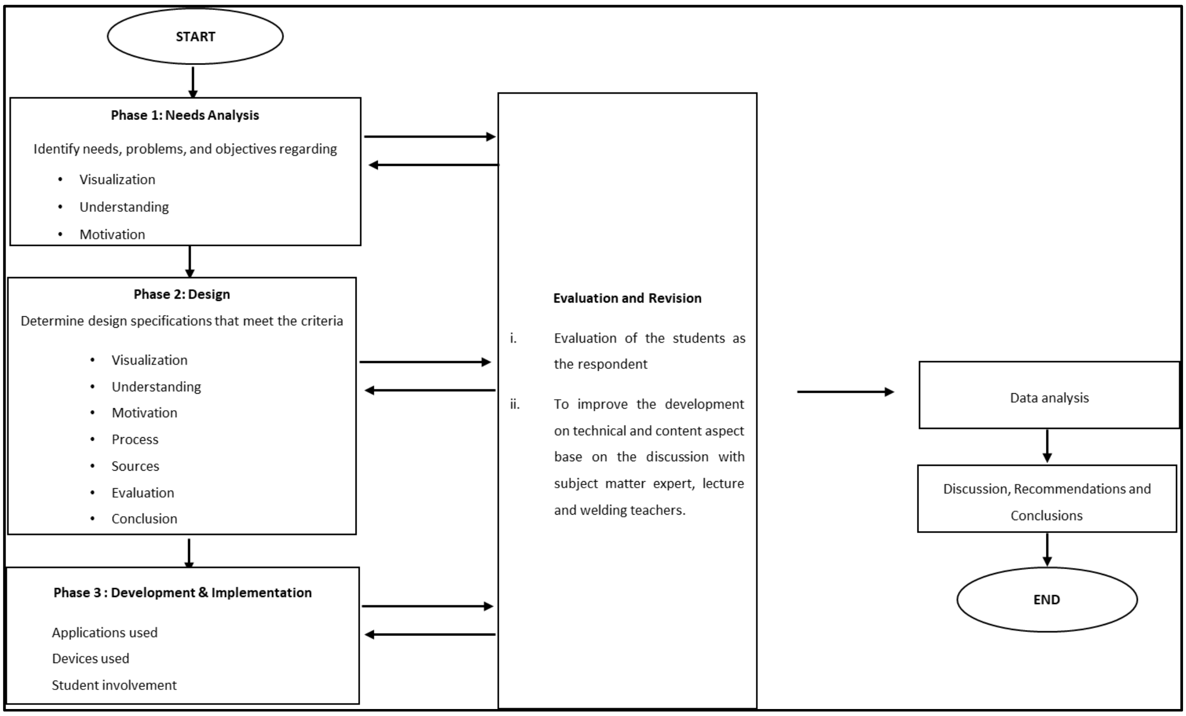

Fig. 1. Development of AR teaching and learning kit using Hannafin & Peck model

2.4 Research Instrument

This study utilizes a questionnaire as a primary data collection method involving 52 students at Sungai Buloh Vocational College, Selangor. The questionnaire is structured into four main sections:

i. Section A (Demographics)
ii. Section B (Visualization)
iii. Section C (Understanding)
iv. Section D (Motivation).

These sections have distinct focuses, with Section A gathering essential background information while ensuring the confidentiality of student data. Section B aims to assess the impact of visualization within the teaching and learning kit on students. Section C delves into students' comprehension of the subject matter, specifically within the domain of Engineering Drawing. Lastly, Section D is designed to gauge student enthusiasm and motivation, particularly as it pertains to the utilization of the forthcoming teaching and learning kit.

The selection of a 4-point Likert scale as the response format for this questionnaire warrants further justification. In educational and social science research, the Likert scale is a widely utilized psychometric tool [13]. However, the decision to employ a 4-point scale requires clarification. We acknowledge that a 4-point scale introduces a challenge in distinguishing a neutral response, as it lacks a central point, unlike scales with an odd number of response options. This choice is aligned with common practices in various social studies [35], but it is essential to provide additional empirical or theoretical reasoning for favouring a 4-point Likert scale over alternative options. Such reasoning would reinforce the suitability of this scale for this study. Firstly, it offers adequate sensitivity for variables with relatively few nuances, simplifying both data collection and analysis. Secondly, it reduces respondent burden and survey fatigue, particularly valuable in large-sample or complex-questionnaire contexts.

Thirdly, the clear and straightforward interpretation of responses as strongly agree, agree, disagree or strongly disagree simplifies result presentation and reduces the likelihood of misinterpretation. Fourthly, consistency with prior research employing 4-point Likert scales can facilitate comparisons and meta-analyses [35]. Additionally, if the theoretical framework underpinning the study supports the notion that the construct can be effectively captured with four response options, this serves as a theoretical rationale. Furthermore, the questionnaire's design can be adapted to mitigate the absence of a neutral midpoint. Lastly, consideration of the characteristics of the study sample, such as their familiarity with Likert-type scales, can influence the choice of a simpler 4-point scale. Ultimately, the choice of Likert scale should align with the study's specific objectives, the nature of the constructs being measured and the characteristics of the respondents [35]. Pilot testing and cognitive interviews can further ensure the suitability of the chosen scale for the research context.

2.5 Analysis

Data analysis is a process used to extract useful insights and conclusions from raw data. One commonly used tool for data analysis is the Statistics Packages for Social Science (SPSS) version 27.0 software. This software is specifically designed to assist researchers in analysing data for social science studies. Descriptive statistical methods, such as frequency distribution, mean and standard deviation, are often used in data analysis to summarize and describe the characteristics of a dataset. For example, in this study, descriptive statistics such as mean scores may be used to describe the level of depression experienced by students. This can provide a general understanding of the prevalence of depression among the student population, as well as insights into the severity of the condition. In addition to descriptive statistics, SPSS software also offers other methods of data analysis such as inferential statistics, which allow researchers to generalize about the population based on a sample of data.

3. Results

In this chapter, the testing and expert evaluation process is carried out to test the usability of the developed Augmented Reality (AR) application. Four experts were selected, comprising of professors who are experts in content, design and mechanical skills, as well as vocational college teachers in the field of welding. Fifty-two students were selected using random sampling method. Data analysis was conducted using the Statistical Package for the Social Sciences (SPSS) version 27 for each survey question answered by the students. In this study, the researcher used Descriptive Statistics (standard deviation) and Central Tendency (mean) methods. The analysis conducted has four (4) demographic sections, visualization, motivation and understanding.

3.1 Interpretation Data

Every data collected is an important component for the analysis. The use of the 4-point Likert scale has been used to measure each question item. The scores used are "strongly disagree" is 1, "disagree" is 2, "agree" is 3, while the last "strongly agree" is 4. Table 2 is the minimum score of the Likert scale that has been interpreted by Hadi and Manurung [9]. The interpretation of the mean score for this survey instrument involves three constructs that have been stated in the second research question, namely "to what extent the level of assessment of students towards the elements (visualization, motivation and understanding) of teaching and learning engineering drawing based on Augmented Reality (AR) technology for welding technology students". Each construct has six different questions according to the statement of the problem.

Table 2
Interpretation value using a 1-4 scale

Mean Score	Interpretation	
	Product Testing	Question Items
X ≥ 3.25	Very Acceptable	Very Acceptable
3.25 > X ≥ 2.50	Acceptable	Acceptable
2.50 > X ≥ 1.75	Doubtful	Doubtful
1.75 > X ≥ 1.00	Rejected	Rejected

3.2 Analysis Data of Element Visualization, Motivation and Understanding

The results obtained from vocational college students who responded to items V1 to V6 were analysed using Descriptive Statistics (standard deviation) and Central Tendency (mean) and translated to Table 3, in which the central tendency (mean) has a high value based on the interpretation of the mean score as shown in Table 2. The calculated mean value shows that the majority of students agree with the items of the questions given to them in the survey. The lowest mean score in this visualization construct is on the first item, "I feel that the AR-based teaching and learning kit helps in improving my visualization in the Engineering Drawing topic" with an average mean of 3.44 but still at an acceptable level. Meanwhile, the highest score is the sixth item, "I am able to translate an object into a drawing" with an average mean of 3.62. From the data, the researcher found that students' visualization improves by using the AR-based teaching and learning kit.

Table 3
The mean value obtained from items V1 to V6

No	Items	Mean	Standard Deviation	Criteria
V1	I feel that this AR-based teaching and learning kit helps in improving my visualization in the topic of Engineering Drawing.	3.44	0.53	Very Acceptable
V2	I believe that I can have a high level of creative thinking to dimension objects.	3.56	0.57	Very Acceptable
V3	I can draw lines for an object in engineering drawing.	3.56	0.57	Very Acceptable
V4	I can translate an object into a drawing.	3.50	0.50	Very Acceptable
V5	I can master the skill of drawing to study the topic of Engineering Drawing.	3.62	0.56	Very Acceptable
V6	I believe that 2D and 3D animation objects help my visualization in the topic of Engineering Drawing.	3.46	0.50	Very Acceptable

The results obtained from vocational college students who responded to items M1 to M6 and has been translated into means and standard deviations as shown in Table 4. The researcher found that there were 9 students who disagreed, but the average value for all items in this construct still showed a level of acceptance. The lowest mean value is still the first item with a value of 3.42, "I feel happy using AR-based teaching and learning kit to learn Engineering Drawing topics," but the mean value, if seen from Table 2, is still at a very acceptable level. The item that achieved the highest mean value in this construct is item six, "I find the use of this innovation in the classroom interesting and attracts students to learn Engineering Drawing topics," with a mean value of 3.60. The conclusion that can be made by the researcher is that student motivation increases with the use of AR-based teaching and learning kit.

Table 4
The mean value obtained from items M1 to M6

No	Items	Mean	Standard Deviation	Criteria
M1	I am happy to use AR-based teaching and learning kit to learn the topic of Engineering Drawing.	3.42	0.53	Very Acceptable
M2	I am happy to use AR-based teaching and learning kit to learn the topic of Engineering Drawing.	3.58	0.60	Very Acceptable
M3	I believe that this AR-based teaching and learning kit supports self-learning.	3.50	0.60	Very Acceptable
M4	I am excited because this AR-based teaching and learning kit provides motivation for me to complete Engineering Drawing assignments.	3.56	0.53	Very Acceptable
M5	I find that the use of this innovation in the classroom interest's students in learning the topic of Engineering Drawing.	3.58	0.53	Very Acceptable
M6	I find that the use of this innovation in the classroom interest's students in learning the topic of Engineering Drawing.	3.60	0.49	Very Acceptable

The results obtained from vocational college students who responded to items K1 to K6 and has been translated into means and standard deviations as shown in Table 5. From the calculations of the items in this motivation construct, the researcher found that only 3 students disagreed but the average value for all items in this construct still shows a very acceptable level. The lowest mean value is item six, "I feel that the AR-based teaching and learning kit makes it easier for me to study Engineering Drawing with the help of summary notes" with a mean value of 3.40. However, the mean value is still at a very acceptable level when viewed from Table 2 interpretation. There are two items that achieved the highest mean value in this construct, namely item three "I can understand the differences in line usage in each Engineering Drawing" and item four "I understand that this innovation in the classroom can improve my understanding of Engineering Drawing" with mean values of 3.63 respectively. From the data obtained, the researcher found that the students' understanding improved with the use of AR-based teaching and learning kit.

Table 5
The mean value obtained from items K1 to K6

No	Items	Mean	Standard Deviation	Criteria
K1	I can master the content of the Engineering Drawing subject to study the topic of Engineering Drawing.	3.44	0.53	Very Acceptable
K2	I believe that the content of the Engineering Drawing subject becomes easier to understand.	3.56	0.53	Very Acceptable
K3	I can understand the differences in the use of lines in each Engineering Drawing.	3.63	0.48	Very Acceptable
K4	I understand that this innovation in the classroom can enhance my understanding of the topic of Engineering Drawing.	3.63	0.48	Very Acceptable
K5	I believe that this AR-based teaching and learning kit helps me to draw Engineering Drawings correctly to complete Engineering Drawing assignments.	3.52	0.50	Very Acceptable
K6	I feel that this AR-based teaching and learning kit makes it easier for me to learn the topic of Engineering Drawing with the help of brief notes.	3.40	0.53	Very Acceptable

3.3 Significance of Visualization, Motivation and Understanding Elements Towards Gender

To address the question of differences in visualization, motivation and understanding between male and female, a test needs to be conducted, namely the t-test. According to De Winter [32], the use of the t-test is very suitable when the sample size is extremely small. With a small sample size, the results of a statistically non-significant test almost do not show the existence of a real effect, while with a large sample size, the effect may be statistically significant but not practically or theoretically relevant [14]. Therefore, it is important to consider both statistical and practical interests when analysing the results of the study. If the sample being studied is not normal, the use of the Mann-Whitney U test should be used.

3.4 Normality Test

P-values are translated into two categories where a decision is declared "statistically significant" if the p-value is at or above a certain threshold (usually 0.05) and declared "nonsignificant" otherwise [8].

Referring to Table 6, the p-value for the visualization element for male students is 0.000 while for female students it is 0.056, the data shows a non-normal distribution for male students. For the motivation element, the p-values for male (0.001) and female (0.009) students respectively show a non-normal distribution. The last element is understanding where the p-value for male students is 0.000 while for female students it is 0.386. Overall, this data shows a non-normal distribution for male students and a non-normal distribution for female students. According to Orcan [17], if one group has a normal distribution and one group has a non-normal distribution, the normality of the data is considered to be contaminated or disturbed for that sample data and if that is the case, non-parametric tests such as the Mann-Whitney U test should be conducted by Soetewey [26]. This is supported by Zimmerman & Zumbo [34], where from the perspective that has been explained in the introductory text for several decades, that non-parametric tests are the answer to violations of this kind. This study is consistent with the theory of the ARE value for the Mann-Whitney-Wilcoxon test compared to the T-Test [12] for various distributions and also in previous simulation studies [4,18,33].

Table 6
Result of Shapiro Wilk test

Elements	Gender	Statistic	N	p-Value
Visualization	Male	.847	38	.000
	Female	.879	14	.056
Motivation	Male	.884	38	.001
	Female	.821	14	.009
Understanding	Male	.853	38	.000
	Female	.937	14	.386

In this test, a boxplot was included to show whether the collected data had outliers or not. This is one way to determine whether the t-test will be used or not. If there are outliers, the Mann-Whitney U test needs to be used to determine the difference between the two groups of gender. The boxplot for the scores of visualizations, motivation and understanding of male and female students show that all three graphs have outliers except for the understanding element for female students and the study needs to use the Mann-Whitney U test because it does not meet the requirements for using the non-parametric t-test.

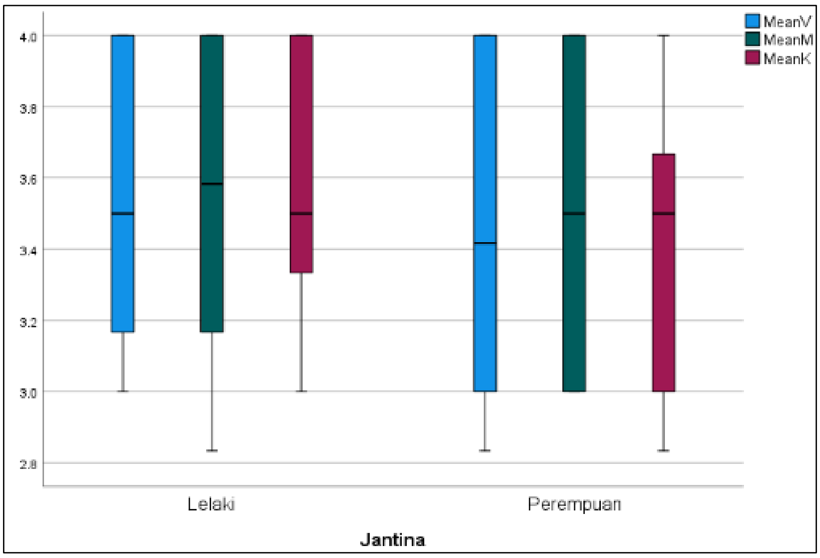

Fig. 2. Boxplot graph for the scores of visualizations, motivation and understanding of male and female students

3.5 Mann-Whitney Test

The null hypothesis can be determined or not by performing the Mann-Whitney U test. The p-value should be on a scale below 0.05 (p-value < 0.05) to reject the null hypothesis. Table 7 shows the rank statistics for male and female students while Table 8 shows the results of the Mann-Whitney U test based on male and female students for the elements of visualization, motivation and understanding.

Table 7
Value of rank for male students and female students

	Gender	N	Mean Rank	Sum of Ranks
Visualization	Male	38	27.54	1046.50
	Female	14	23.68	331.50
	Total	52		
Motivation	Male	38	26.66	1013.00
	Female	14	26.07	365.00
	Total	52		
Understanding	Male	38	27.76	1055.00
	Female	14	23.07	323.00
	Total	52		

The results of the Mann-Whitney U test conducted on the visualization, motivation and understanding elements found that all three variances showed values above 0.05 in the red box. P-values that exceed 0.05 for the visualization, motivation and understanding elements make the null hypothesis (Ho) accepted and the alternative hypothesis (H1) rejected. There is no statistical difference between male and female students in the minimum visualization score for the Augmented Reality (AR) based teaching and learning kit between male students (Min Rank=27.54, Σ=1046.50) and female students (Min Rank=23.68, Σ=331.50), (U=226.50, Z=0.835). Furthermore, there is no statistical difference between male and female students in the minimum understanding score for the Augmented Reality (AR) based teaching and learning kit between male students (Min Rank=26.66, Σ=1013.00) and female students (Min Rank=26.07, Σ=365.00), (U=260.00, Z=0.127). Lastly, there is no statistical difference between male and female students in the minimum motivation score for the Augmented Reality (AR) based teaching and learning kit between male students (Min Rank=27.76, Σ=1055.00) and female students (Min Rank=23.07, Σ=323.00), (U=218.00, Z=1.009).

Table 8
Result of Mann-Whitney test

	Visualization	Motivation	Understanding
Mann-Whitney U	226.500	260.000	218.000
Wilcoxon W	331.500	365.000	323.000
Z	-.835	-.127	-1.009
Asymp. Sig. (2-tailed)	.404	.899	.313

Table 9 shows the effect size calculation for the Mann-Whitney U test. Effect size calculation refers to the method of determining the magnitude of difference between two groups when using the Mann Whitney U test. The Mann-Whitney U test is a non-parametric test used to compare the medians of two groups. It is used when data is not normal or when the variances of the two groups are not equal. Effect size also serves as a measure of the strength of the relationship between two groups, represented by numbers such as Cohen [6] d, r or eta-squared.

Table 9
The effect size calculation for the Mann-Whitney U test

	Mann-Whitney U	Z	Asymp. Sig. (2-tailed) / P-values
Visualization	226.500	-.835	.404
Motivation	260.000	-.127	.899
Understanding	218.000	-1.009	.313

It is useful in understanding the practical significance of the results obtained. The calculation of r value can be determined using the following formula Eq. (1) with the interpretation of r value as shown in Table 10 and recorded in Table 11.

$$r = \frac{Z}{\sqrt{N}} \tag{1}$$

Table 10
The strength of effect size value for the Mann-Whitney U test

Mean Score	Interpretation
r < 0.3	Small
0.5 ≥ r ≥ 0.3	Medium
r > 0.5	Large

Table 11
Calculation of effect size r value for the Mann-Whitney U test

	Z	N	r-Value	Effect Size
Visualization	-.835	52	0.116	Small
Motivation	-.127	52	0.018	Small
Understanding	-1.009	52	0.140	Small

4. Discussion

These findings align with previous research in the field of education and AR technology. Research has shown that AR-based teaching methods can enhance motivation, understanding and visualization for both male and female students. This study contributes to the existing literature by specifically examining gender differences and finding that the AR-based teaching and learning kit was equally effective for both male and female students in these aspects.

The theoretical implications of this study are significant. It reinforces the idea that AR technology can be a valuable tool for enhancing various aspects of learning, including motivation, understanding and visualization. The study also highlights that these benefits are not influenced by gender, making AR an inclusive educational tool. Practically, the study suggests that educators and curriculum developers can confidently incorporate AR-based teaching and learning tools into their pedagogical approaches, knowing that these tools are effective for both male and female students. Moreover, it emphasizes the importance of interactive interfaces and well-designed animations within AR applications to engage students and make learning more meaningful and effective.

It's essential to acknowledge potential limitations and biases in this study. One limitation is the relatively small sample size, particularly for female students, which may affect the generalizability of the results. Additionally, the study did not explore other potential factors, such as prior familiarity with AR technology, which could impact the outcomes. There may also be biases related to self-reporting, as the data was collected through surveys. Students might provide responses they believe are socially desirable rather than reflecting their true experiences. Future research could employ additional methods, such as qualitative interviews or observation, to complement the findings. This study underscores the effectiveness of AR-based teaching and learning kits in enhancing motivation, understanding and visualization for both male and female students. It contributes to the existing literature and has practical implications for educators and developers. However, it's crucial to consider the limitations and potential biases when interpreting the results and further research with larger and more diverse samples is recommended.

5. Conclusions

In conclusion, AR teaching and learning kit is an interactive way that can produce more meaningful and effective while teaching engineering drawing subject. From this study shown that gender differences were not significant, indicating that AR technology can benefit both between male and female students equally. The use of animation elements in this AR application has effectively enhanced students' visualization, motivation and understanding in engineering drawing subject. Furthermore, the animation elements can create a more attractive and entertaining experience for students, potentially increasing their interest in using this teaching and learning kit

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