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Research Article

The Effectiveness of an AR Module in Enhancing Achievement and Interest in Learning Mechanical Components

Muhammad Firdaus Zamuri[1], Suhazlan Suhaimi[1*], Hazrullah[2]

[1]*Faculty of Computing and Meta-Technology, Universiti Pendidikan Sultan Idris, Tanjung Malim, Perak, Malaysia; m20212003482@siswa.upsi.edu.my; suhazlan@meta.upsi.edu.my*
[2]*Universitas Islam Negeri Ar-Raniry Banda Aceh, Indonesia; hazrullah@ar-raniry.ac.id*

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corresponding author

Abstract

This study explores the effectiveness of using an Augmented Reality (AR) Module on students' achievement and interest in learning the topic of mechanical components within the Form Two Design and Technology (RBT) curriculum. Specifically, the research aimed to (i) identify the need for AR in teaching and learning, (ii) determine key mechanical components to be included in the AR module, (iii) examine the impact of the AR module on student achievement, and (iv) evaluate the relationship between AR usage and student interest. A mixed-method approach was adopted, including document analysis, teacher questionnaires, and a quasi-experimental design involving 100 Form Two students from two secondary schools in Negeri Sembilan, Malaysia. The students were divided into treatment (AR module) and control (conventional method) groups. Written tests and interest questionnaires were used as research instruments. Findings revealed that all 20 mechanical components assessed were considered suitable for inclusion in the AR module, based on high agreement levels from 17 RBT teachers (M = 4.50, SD = 0.52). The experimental data showed that students exposed to the AR Module achieved significantly higher scores (t (98) = 19.099, $p < .001$, $\eta^2 = .788$) and expressed stronger interest in the topic. A very strong positive correlation was found between achievement and interest ($r = 0.973$, $p < .01$). The results confirm that the AR module is an effective tool to enhance both academic performance and engagement in learning mechanical components, supporting the integration of AR in technical education.

Keywords: augmented reality, effectiveness, learning, mechanical components, quasi-experiment.

INTRODUCTION

Learning techniques today are rapidly evolving in line with current technology to address educational challenges. The 21st-century learning approach is applied from schools to higher education institutions. According to Rusli et al. (2021), technology has become one of the crucial elements involving all aspects of life, including knowledge. This clearly shows that the development of technology within the context of teaching and learning processes in education is essential to keep pace with current generations who can access information anywhere. Furthermore, modern information technology facilities can have a broad impact on the education system by improving the quality of teaching and learning (Sudin et al., 2022).

Currently, many teaching and learning methods can be applied depending on the topic being studied. Therefore, choosing the appropriate teaching and learning methods is crucial for enhancing the effectiveness of teaching and learning sessions conducted by teachers (Ghafar et al., 2023; Budiastuti et al., 2023). Learning objectives will undoubtedly be achieved if the instruction is carried out using the right techniques or methods, thus helping students to master the knowledge imparted by the teacher. Kiflee et al. (2020) stated that the use of elements and colors directly can capture students' interest and attention. The integration of various media such as graphics, audio, video, animation, and text is gaining increasing attention in studies across various fields, including education (Rusli et al., 2021; Zolkipli et al., 2023).

Augmented Reality is one of the rapidly growing technologies in the field of education (Fadzil & Noor, 2023). Furthermore, Fadzil and Noor (2023) noted that AR technology has been promoted to enhance teaching and learning experiences in classrooms. AR is a technology that integrates digital content created using computer applications with the real world, and it can be viewed on user screens through camera-equipped devices. The use of this multimedia-related technology can greatly enhance students' understanding, thereby positively impacting their performance. This statement is supported by research conducted by Nashir et al. (2022), who highlighted that the application of multimedia-based learning methods can effectively address various challenges in understanding theoretical knowledge and practical skills.

The Design and Technology (RBT) subject is part of TVET (Technical and Vocational Education and Training) education. RBT was also introduced in the KSSM (Secondary School Standard Curriculum) to replace the Integrated Living Skills (KHB) subject for lower secondary students, with the addition of various new subtopics for students. This subject is an elective, emphasizing designing and creating technology-based products. Additionally, RBT equips students with skills to solve problems through creative, critical, and innovative thinking. According to Samawi and Khalid (2022), the use of AR in RBT teaching and learning can help teachers enhance student comprehension if the form and content of AR are appropriately used, enabling students to focus better during lessons. AR technology integrates virtual objects into the real world, allowing users to interact with these virtual objects simultaneously. This module will include displays of mechanical models in AR and can be used anywhere for learning sessions.

PROBLEM STATEMENT

According to the Standard Curriculum and Assessment Document (DSKP), RBT is an elective subject that emphasizes designing and producing technology-based products. Furthermore, this subject aims to nurture students who can create meaningful and simple products. Sahaat et al. (2020) stated that the RBT subject is divided into two parts: theory and application. Student comprehension in the RBT subject is assessed using a rubric based on performance standards (Samawi & Khalid, 2022). Teachers are required to teach according to learning standards, while the level of student understanding and mastery is evaluated using these performance standards.

The use of AR technology is expanding within the field of education (Samawi & Khalid, 2022). The quality of education can be improved through AR technology as it introduces an innovative culture in teaching, making the teaching and learning process more interactive (Rosly et al., 2017). The integration of AR technology is critical in today's educational world due to its significant potential for teaching and learning, particularly in the context of RBT. AR applications can be integrated to enhance curriculum standards by incorporating text, graphics, video, and audio displayed in real-life contexts, allowing students to learn more effectively (Johar & Abdullah, 2019). AR-based learning can create an engaging and enjoyable learning environment (Ziden et al., 2022).

The use of technology in education must align with current technological advancements, as educators need to transition from conventional approaches to more modern learning methods that cater to the needs of the millennial generation (Ngadengon et al., 2021; Hasbullah et al., 2022). Nevertheless, challenges remain, particularly in RBT, where some teachers still adhere to conventional methods. There is a tendency among some current teachers to exhibit apprehension towards technology use, coupled with a lack of skills in applying it within educational contexts (Samuri et al., 2016). In teaching and learning sessions, the role of technology is becoming increasingly important. Thus, to optimize teaching and learning sessions, interventions are necessary for teachers with limited technological expertise through continuous training and courses. (Sahaat et al., 2020) emphasized the importance of enhancing the RBT curriculum, particularly through continuous training support for teachers. They also highlighted the need to improve the provision of teaching aids, resources, and learning modules at the school level to help overcome implementation challenges in RBT teaching and learning.

Table 1: Content standards in RBT

No.	Content	Hours
1.0	Inventive Problem Solving	
	1.1 Identifying Problems	6
	1.2 Function Analysis	
	1.3 Physical Contradictions	
2.0	Application of Technology	
	2.1 Manufacturing Technology	10
	2.2 Mechanical Design	10
	2.3 Electrical Design	8
	2.4 Electronic Design	10
	2.5 Aquaponics System Design	10
	2.6 Food Design	10
	Total	**64**

Refer to Table 1 shows that based on the Standard Curriculum and Assessment Document (DSKP) for RBT, the mechanical design chapter is allocated only 10 hours per year. Within this limited time, students are expected to acquire theoretical knowledge, understand the functions of 20 mechanical components, and complete a functional project as the final product. However, this limited time allocation may disrupt the teaching and learning process, especially in the introduction to mechanical components, which requires detailed explanation, observation, and hands-on practice. When a significant amount of time is spent on explaining and understanding the basic mechanical components, less time is available for the subsequent stages, including design, problem-solving, and project development. This situation forces teachers to rush through the theoretical content and minimize practical activities, reducing students' opportunities for exploration and critical thinking. As a result, students often focus merely on completing their projects for assessment purposes without fully understanding the design process.

This scenario is supported by the analysis conducted by Sahaat et al. (2020), which showed that students frequently manage to produce RBT projects that only meet the minimum required criteria due to time constraints. The inability to allocate sufficient time for students to understand and apply the knowledge effectively has a direct impact on their performance and the quality of their projects. Moreover, their overall analysis also revealed that the time allocated for learning, especially for producing high-quality projects, is insufficient. To address this issue, this study explores the potential of AR technology in facilitating a better understanding within a shorter time frame. AR provides interactive, visual, and immersive learning experiences that help students grasp complex mechanical concepts more effectively, which may lead to the production of higher-quality RBT projects despite limited instructional time.

This study primarily focuses on improving students' performance and interest in the topic of mechanical components in RBT through the use of an AR-based module. While the limitations of conventional teaching methods serve as the underlying rationale, the objective of the study is to evaluate the effectiveness of AR technology in enhancing achievement and engagement in the learning process. The main aim of this research is to design and develop an introduction module for mechanical components using AR and to evaluate the effects of using AR technology on student interest and achievement. The topic of mechanical components was selected because it serves as a foundational concept in the broader Mechanical Design module. Mastery of these components is essential for understanding and applying more advanced design skills in subsequent topics. Difficulties in this early stage often lead to misconceptions and reduced confidence, which can hinder overall performance in the RBT subject. Therefore, strengthening students' understanding at the introduction level is considered crucial for holistic learning progression.

RESEARCH OBJECTIVES

Based on the issues identified and the research aims mentioned earlier, the objectives of this study are to explore and understand various aspects related to the use of AR technology in the teaching and learning of Form Two Design and Technology subjects. The research objectives are outlined as follows:

i. To identify the need for the use of an AR module in teaching and learning related to the introduction of mechanical components for the Form Two RBT subject.
ii. To determine the types of mechanical components required in the AR module.
iii. To study the effects of using the AR module on student achievement.
iv. To identify the relationship between the use of the AR module and student interest.

The first objective was to identify the need for an AR module in teaching the topic of mechanical components. This was achieved through an analysis of mid-year examination papers involving 130 Form Two students from the Seremban district. The findings revealed that students performed poorly on related exam questions. In Section A, over 63% to 70% of students answered incorrectly for all three questions related to the topic. Similarly, most students in Sections B and C were only able to score one mark, with no students achieving high scores in the open-ended questions. These results indicate that conventional teaching methods may not sufficiently support students in grasping complex and abstract mechanical concepts. The integration of AR technology is therefore deemed necessary, as it provides interactive and visual learning experiences that can enhance understanding, engagement, and the development of critical 21st-century skills such as creativity, problem-solving, and critical thinking.

The second objective aimed to determine the types of mechanical components required in the AR module. A questionnaire was distributed to RBT teachers with varying years of teaching experience to gather their input. This objective focuses on identifying the essential mechanical components that should be integrated into the AR module for the Form Two RBT subject. A questionnaire was administered to 17 RBT teachers with varying teaching experience to obtain expert feedback on the necessity of including specific components in the AR module. Table 2 below presents the mean scores and agreement levels for each mechanical component as rated by the teacher respondents.

The analysis showed a high level of agreement among the respondents, with an overall mean score of 4.50 and a standard deviation of 0.52, indicating strong consensus regarding the importance of these components. The results revealed that all 20 evaluated mechanical components were deemed relevant for inclusion. Items such as levers, ball bearings, miter gears, pulleys, cam shafts, and belts received particularly high mean scores, reflecting their perceived importance in supporting students' conceptual understanding and practical application. These components are also aligned with the curriculum objectives, which require students to eventually build functioning mechanical products. The integration of these components into the AR module can enhance students' engagement and support the development of both theoretical and hands-on skills.

Table 2: Mean scores and agreement levels of mechanical components for inclusion in the AR module

No.	Mechanical Component	Mean	Standard Deviation (SD)	Agreement Level
1	Lever	4.71	0.47	Very High
2	Ball Bearing	4.65	0.49	Very High
3	Miter Gear	4.59	0.51	Very High
4	Pulley	4.59	0.50	Very High
5	Cam Shaft	4.59	0.50	Very High
6	Belting	4.59	0.50	Very High
7	Screw Gear	4.53	0.51	Very High
8	Internal Gear	4.53	0.51	Very High
9	Spur Gear	4.47	0.51	High
10	Herringbone Gear	4.47	0.51	High
11	Helical Gear	4.41	0.51	High
12	Rack and Pinion Gear	4.41	0.51	High
13	Spiral Bevel Gear	4.41	0.51	High
14	Bevel Gear	4.35	0.49	High
15	Crank Shaft	4.35	0.49	High
16	Slider	4.35	0.49	High
17	Worm Gear	4.35	0.61	High
18	Chuck	4.35	0.61	High
19	Linkage	3.76	0.56	Moderate to High
20	Chain	3.41	0.51	Moderate
	Overall	**4.50**	**0.52**	**High**

n=17

The third objective was to examine the effectiveness of using the AR module on students' achievement. A quasi-experimental design was implemented involving 100 students from SMK Senaling and SMK Jelai, divided into treatment (AR module) and control (conventional method) groups. Post-tests were conducted to measure differences in performance. The fourth objective was to assess students' interest in learning the topic using the AR module. A questionnaire was administered to the treatment group, and the data were analysed to evaluate the relationship between AR usage and student interest. Overall, this research adopted a mixed-method approach involving document analysis, surveys, and quasi-experimental techniques to ensure comprehensive and reliable findings. Two main hypotheses were tested: the effect of AR on student achievement, and the correlation between AR usage and student interest in the topic.

RESEARCH HYPOTHESES

The hypotheses of this study are formulated to test the effects of using the AR module in the topic of introducing mechanical components on students' achievement and interest. The hypotheses proposed are as follows:

i. Is there a significant difference in the level of achievement between the treatment group and the control group?
ii. Is there a positive relationship between the use of the AR module and students' interest in the topic of mechanical components introduction?

LITERATURE REVIEW

The AR technique is also well-suited for use in teaching and learning activities, as, according to Idris et al. (2019), this technology can help cultivate students who are more competitive in the 21st century. Moreover, AR technology has been widely adopted in various fields, especially in education. According to Idris et al. (2019), AR technology integrates virtual objects into the real world and allows users to interact with these virtual objects realistically. Teachers using creative multimedia, such as cartoons and animation software, can captivate students' interest and eliminate boredom during learning sessions (Fadzil & Noor, 2023; Ahmad Shahrizal et al., 2022). This indicates that incorporating multimedia elements into learning activities can effectively attract students' attention and encourage participation.

Additionally, Indahsari and Sumirat (2023) highlighted that the realistic visuals and interactive simulations offered by AR technology can enhance students' understanding of complex concepts. Indahsari and Sumirat (2023) also stated that AR-based learning techniques can have a positive impact on students' learning performance and motivation. AR technology, as a mobile application, is gaining popularity in education due to its potential to improve the quality of teaching and learning processes by engaging students and enhancing comprehension during lessons (Fadzil & Noor, 2023).

Thus, the researcher chose AR technology to develop an AR module focusing on mechanical components. According to Nashir et al. (2022), the multimedia module they developed successfully received positive feedback on its use in teaching and learning processes. The purpose of developing this AR module is to determine whether its use can positively impact students' achievements and increase their interest in learning this topic.

RESEARCH METHODOLOGY

The study design is based on a quasi-experimental approach involving two groups of Form Two students from two secondary schools in Negeri Sembilan. The treatment group received lessons using an AR module, while the control group was taught using conventional teaching methods. According to Creswell and Creswell (2017), a quasi-experimental design is a type of study where respondents are not randomly assigned to groups. Musrifah et al. (2020) highlighted that quasi-experimental designs have many advantages, one of which is their ability to control extraneous variables.

The study sample consists of 100 students selected randomly. Data collection is conducted through written tests to evaluate students' academic achievement and questionnaires to measure their interest and motivation toward learning. Experimental test questions were chosen to provide objective and standardized measures of students’ cognitive understanding, allowing for comparison between the control and treatment groups. In educational research, tests are effective tools for assessing students’ academic performance objectively (Fraenkel et al., 2018).

Questionnaires were selected because they are widely used and validated tools in educational research to assess affective domains such as interest and motivation. According to Creswell and Creswell (2017), questionnaires are effective instruments to measure attitudes, opinions, and perceptions of respondents in educational studies. This study is carried out in three main phases: a pre-test, an intervention phase using the AR module, and a post-test. Table 3 shows a total of 54 students from SMK Senaling and 46 students from SMK Jelai. Each school is divided into two groups: a treatment group and a control group. The treatment group uses the AR module, while the control group employs conventional teaching techniques during the teaching and learning process.

Table 3: Total number of students involved in the experiment

Group	Group 1	Group 2	Total
Treatment	27 students	23 students	50 students
Control	27 students	23 students	50 students
Total	54 students	46 students	100 students

The research instruments used in this study consist of a questionnaire and experimental test questions. The questionnaire is used to identify the types of mechanical components needed in the AR module, distributed to experienced teachers teaching the RBT subject, and to assess students' interest in the topic. The questionnaire is structured based on a five-point Likert scale, allowing quantitative measurement of students' attitudes and perceptions. The test papers are used to assess students' academic performance before and after using the AR module. Both instruments were reviewed by teachers and experts to ensure validity and reliability. Using accurate and high-quality instruments is essential to ensure that the collected data is relevant, accurate, and reliable, thus enhancing the credibility of this study.

Before the actual study was conducted, a pilot test involving 30 Form Two students was carried out to evaluate the reliability and consistency of the research instruments. For the achievement test, a test-retest reliability method was employed. The same group of students answered two sets of tests with items rearranged. Based on table X shows that the Pearson correlation coefficient between the two test sessions was $r = 0.597$, $p < 0.01$, indicating a moderate to high reliability, suggesting the achievement test is stable and consistent across time. Moreover, Table 4 shows the descriptive statistics and test-retest reliability for the achievement test. The Pearson correlation indicates that the test has a moderate to high level of reliability and consistency across two different sessions.

Table 4: Descriptive statistics and test-retest reliability for the achievement test in the pilot study

Test Session	Mean Score	Standard Deviation (SD)	Pearson Correlation (r)	p-value	Interpretation
Achievement Test (Session 1)	30.00	2.82			Baseline performance
Achievement Test (Session 2)	34.97	2.87	**0.597**	**< 0.01**	Moderate-High reliability

For the questionnaire, Table 5 shows that a Cronbach's Alpha value of 0.97 was obtained, indicating excellent internal consistency. This confirms that the items used to measure students' interest were reliable and consistent in assessing the intended construct (Creswell & Creswell, 2017; Amir et al., 2024). Prior to the intervention, students' mean score for the first achievement test was 30.00 (SD = 2.82), suggesting that students had a relatively low level of understanding of the topic of mechanical components. Thus, the Cronbach's Alpha coefficient shows that the interest questionnaire has excellent internal consistency, making it a reliable instrument for the actual study. This reinforces the need for a new teaching approach, such as the AR module, to improve their comprehension and interest.

Table 5: Cronbach's Alpha for the Interest questionnaire in the pilot study

Instrument	No. of Items	Cronbach's Alpha (α)	Interpretation
Interest Questionnaire	10	0.97	Excellent

Therefore, these findings from the pilot study confirm that the instruments used in this research, namely the achievement test and the interest questionnaire, are reliable and valid. The achievement test demonstrated moderate to high test-retest reliability ($r = 0.597$, $p < 0.01$), while the questionnaire yielded a Cronbach’s Alpha of 0.97, indicating excellent internal consistency. Therefore, both instruments are deemed suitable for use in the main study.

The quasi-experimental approach was chosen as the methodology because it involves manipulating the independent variable to measure its effect on the dependent variable. This study adopts a quantitative (quasi-experimental) approach, as it involves numerical data and enables objective measurement of variables. According to Creswell and Creswell (2017), quantitative research is systematic, structured, and designed to test hypotheses and assess relationships between variables using statistical procedures. Additionally, this method is used to examine the effect of applying AR technology on students' academic achievement in the topic studied and whether there is a positive correlation between AR use and students' interest in mechanical component introduction. Furthermore, the quasi-experimental method is relevant to real-life conditions as it allows researchers to investigate in a natural setting, making the results more applicable and practical.

This study is also quantitative as it measures the difference in test score percentages. Data collected is analyzed using the Statistical Package for Social Sciences (SPSS) for Windows, through descriptive statistics such as mean scores and percentages. This quantitative data, collected from test results and questionnaires, is verified by experts to ensure credible findings. The quantitative design of this study involves only descriptive statistical analysis in the form of percentages and mean values. This study aims to examine whether the application of the AR module contributes to enhancing students’ academic achievement and learning interest in the topic of mechanical components. The research objectives formulated in this study are explicitly designed to address the core issues identified in the problem statement. The main challenges of the study include students’ difficulties in understanding mechanical components, the ineffectiveness of conventional teaching methods, low achievement levels, and a lack of student interest. These problems are systematically addressed through four interconnected research objectives.

Firstly, the objective to determine whether the use of the AR module is necessary in teaching and learning directly responds to the concern regarding the adequacy of current instructional practices. It explores whether the integration of AR technology is needed to improve lesson delivery. Secondly, the objective to identify the types of mechanical components required in the AR module ensures that the developed content is relevant, accurate, and aligned with curriculum standards. This addresses the issue of insufficient or unfocused instructional content in current teaching materials.

Thirdly, the objective that examines the effectiveness of the AR module in improving students’ achievement tackles the central concern of low academic performance. It allows for a data-driven evaluation of whether the module can enhance learning outcomes compared to conventional methods. Finally, the objective to assess the module’s impact on student interest focuses on motivation and classroom engagement. This responds directly to the problem of low student enthusiasm and aims to improve learning through more interactive and appealing approaches.

Overall, these four objectives are carefully structured to offer a comprehensive solution to the major instructional and learning challenges in the RBT subject. The quasi-experimental design used in this study supports the alignment between these objectives and the core problems by providing evidence of effectiveness through comparison between control and treatment groups.

RESEARCH FINDINGS

The study on the effects of using the AR module in teaching and learning indicates that AR can enhance students' achievement and interest. The following is a detailed explanation of the study's findings. A descriptive statistical analysis using SPSS was conducted on both groups: the treatment group and the control group. The results of the descriptive statistical analysis are shown in Table 6. The treatment group, which used the AR module, had a mean score (M = 44.06, SD = 3.02). The control group, which did not use the AR module, had a mean score (M = 30.68, SD = 3.92). This descriptive statistical analysis provides a general overview of the data collected in the study, including the calculation of means, standard deviations, and other measures that help in understanding the key characteristics of the data.

Table 6: Descriptive statistics for treatment and control groups

Group	N	Mean	Standard Deviation (SD)	Standard Error of the Mean (SEM)
Treatment	50	44.06	3.02	0.427
Control	50	30.68	3.92	0.554

These statistics are the first step in data analysis and serve as the foundation for further statistical testing. The mean aims to measure the average achievement of participants in each group. A higher mean in the treatment group indicates that the use of the AR module has a positive impact on participants' performance. The Standard Deviation (SD) measures the variation or dispersion of scores around the mean. A lower standard deviation indicates more consistent data. The treatment group has a smaller standard deviation (3.02) compared to the control group (3.92), suggesting that the achievement of participants in the treatment group is more homogeneous.

A Shapiro-Wilk normality test was conducted using SPSS to evaluate the distribution of scores in both groups. As presented in Table 7, the results indicate that the data in the treatment group do not follow a normal distribution ($p < 0.001$), whereas the data in the control group do not show a significant deviation from normality ($p = 0.052$). The Shapiro-Wilk statistic is used to indicate the extent of deviation from normality. A lower statistical value and a significant p-value indicate a deviation from a normal distribution. Additionally, Table 4 shows that for the treatment group, the very low p-value (0.000) suggests a significant deviation from normality, while the control group's p-value, which is close to 0.05, indicates that the data may be approximately normal.

Table 7: Normality test for treatment and control groups

Group	Statistic	df	Sig.
Treatment	0.812	50	0.000
Control	0.954	50	0.052

Furthermore, an independent t-test was conducted to compare the mean scores between the two different groups. This test helps determine whether there is a significant difference in achievement between the treatment and control groups. As shown in Table 8, the results indicate a significant difference between the two groups. The t-test results show that there is a statistically significant difference between the groups. Table 3 presents the mean achievement score for the treatment group (M = 44.06, SD = 3.02), which is higher than that of the control group (M = 30.68, SD = 3.92). Table 5 shows $t(98) = 19.099$, $p < .001$. The mean difference of 13.36 illustrates the average difference between the treatment and control groups, indicating that the treatment group scored significantly higher. The high t-value (19.099) with 98 degrees of freedom suggests that the difference between the groups is highly significant. The very low p-value (< 0.001) indicates that these results are unlikely due to chance, signifying a genuine relationship between the use of the AR module and the improvement in achievement.

Table 8: Detailed results of the independent samples t-test between the treatment and control groups

Variable	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval
Achievement (Equal var. assumed)	5.445	0.022	19.09	98.00	0.000	13.36	0.700	11.972 – 14.748
Achievement (Equal var. not assumed)	-	-	19.09	91.97	0.000	13.36	0.700	11.971 – 14.749

To measure the effect size of this difference, eta squared (η^2) was calculated. Using the formula displayed in Equation 1, with a t-value of 19.099 and degrees of freedom (df) of 98, the calculation yielded an eta squared value of 0.788. This indicates that approximately 78.8% of the variance in achievement can be explained by the difference between the treatment and control groups, demonstrating a very large effect size. There is a significant difference between the treatment and control groups, with $t = 19.099$ and $p < 0.001$. Further analysis using eta squared shows that the effect size is very large ($\eta^2 = 0.788$), indicating that the use of the AR module has a significant impact on student achievement.

$$n^2 = \frac{t^2}{t^2 + df} \tag{1}$$

where t is the t-statistic obtained from the t-test and df is the degrees of freedom associated with the t-test.

Following the descriptive analysis, normality test, and independent t-test, the study findings reveal that the use of the AR module significantly improves participants' achievement scores compared to conventional teaching methods. The data show that the treatment group achieved higher scores with a statistically significant difference compared to the control group. This study aimed to evaluate the effectiveness of using the AR module in enhancing students' achievement in the topic of introducing mechanical components. This analysis addresses the third research ojbective: whether the use of the AR module in teaching and learning is effective in improving students' achievement in the study topic.

Table 9: Frequency distribution and percentage of test score achievement

Category	Score	f(%) Control Group	f(%) Treatment Group
Excellent	A (41-50)	0 (0.00%)	43 (86.00%)
Credit	B (31-40)	19 (38.00%)	7 (14.00%)
Satisfactory	C (21-30)	30 (60.00%)	0 (0.00%)
Weak	D (11-20)	1 (2.00%)	0 (0.00%)
Very Weak	E (0-10)	0 (0.00%)	0 (0.00%)
Total		50	50

n=50

Based on Table 9 and Figure 1, the study findings reveal a significant difference in achievement between the control and treatment groups. Table 9 displays the frequency distribution and percentage of test score achievement, indicating that the treatment group, which used the AR module, performed significantly better compared to the control group that used conventional teaching methods.

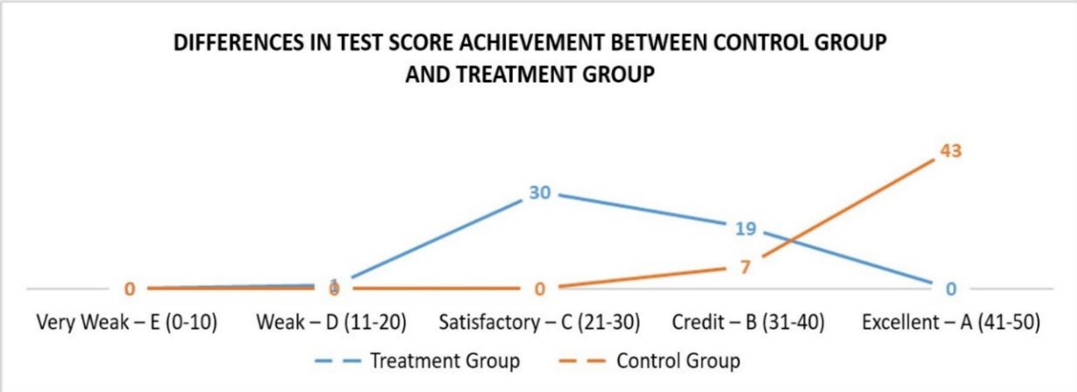

Figure 1: Differences in test score achievement between the control group and the treatment group

From Table 9, a total of 43 students, or 86%, from the treatment group achieved an excellent level. This is a very high percentage, indicating that the use of the AR module had a positive impact on enhancing student achievement. In contrast, none of the students from the control group reached the excellent level. This suggests that without the AR module, students in the control group were unable to attain as high an achievement as those in the treatment group.

Additionally, seven students, or 14%, from the treatment group achieved a distinction level. Although this number is lower compared to those with excellent achievement, it still shows that nearly all students in the treatment group were at a high level of achievement. On the other hand, in the control group, 19 students, or 38%, achieved a distinction level. While this indicates that some students in the control group had good achievement, the percentage remains far lower compared to the treatment group. In the satisfactory achievement category, the control group had a higher number, with 30 students or 60%. This means that the majority of students in the control group only reached a moderate level of achievement. In contrast, there were no students in the treatment group within this category, showing that the AR module helped students achieve a higher-than-satisfactory level.

No students in the treatment group were categorized as weak or very weak. This is a positive indicator that the use of the AR module in teaching not only helped students reach excellent and distinction levels but also prevented them from falling into the lower achievement categories. In the control group, one student, or 2%, was categorized as weak, and none were very weak.

These observations demonstrate that the treatment group, which used the AR module, showed better achievement compared to the control group that used conventional methods. The AR module not only helped students achieve excellent and distinction levels but also reduced the number of students in the lower achievement categories. This proves that the use of the AR module can significantly enhance student achievement in the topic of introducing mechanical components.

This study is supported by findings from Fajari et al. (2022), which showed that the use of AR also helps improve critical thinking skills and digital literacy among primary school students. Therefore, it not only enhances academic achievement but also aids in developing other essential skills. In conclusion, the use of the AR module in teaching and learning is an effective approach that can have a substantial positive impact on student achievement.

Table 10 illustrates the demographic differences between respondents from the two schools involved in the study on the effectiveness of using the AR module in the topic of Introducing Mechanical Components.

SMK Senaling contributed 54% of the total respondents, with 27 students out of a total of 50. Meanwhile, SMK Jelai contributed 46% of the total respondents, with 23 students out of the same total. Therefore, the percentage of respondents from both schools indicates a notable difference in their contribution to this study. This difference in the number of respondents should be taken into account in data analysis and the evaluation of the effectiveness of the AR module in learning the topic of Introducing Mechanical Components.

Table 10: Demographics of respondents of the feedback survey

School	Frequency (*f*)	Percentage (%)
SMK Senaling	27	54
SMK Jelai	23	46
Total	50	100

n=50

Findings from the questionnaire responses provided to the treatment group reveal some interesting insights, as shown in Table 11, which presents the distribution of Mean and Standard Deviation. Overall, the mean for all items is 4.484 with a standard deviation (SD) of 0.462, indicating a high level of agreement among respondents regarding the use of AR techniques in teaching and learning the topic of mechanical introduction. Based on the item comparison summary, all items in the study show a high mean interpretation level, with mean values exceeding 3.34. Generally, respondents expressed strong support for the use of AR techniques in the teaching and learning process of Design and Technology.

This finding suggests that the AR module successfully captured students' interest, with respondents from both schools involved demonstrating a significant increase in interest in learning the topic of introducing mechanical components. This result is further supported by the analysis of the standard deviation, where items with lower standard deviations indicate less variation in responses, signifying uniformity in students' interest toward the use of the AR module. Therefore, it can be concluded that the use of the AR module in teaching not only enhances students' interest but also makes the learning process more interactive and engaging.

Table 11: Distribution of mean and standard deviation from the feedback survey

No.	Item	Mean	Standard Deviation	Mean Interpretation Level
1	I am interested in the use of Augmented Reality (AR) techniques in the teaching and learning of Design and Technology.	4.60	0.49487	High
2	I can answer the teacher’s questions related to mechanical component topics after using Augmented Reality (AR) techniques.	4.52	0.50467	High
3	I feel more motivated to participate in teaching and learning sessions that utilise Augmented Reality (AR) techniques.	4.16	0.37033	High
4	The teacher’s teaching is not boring when using materials based on Augmented Reality (AR) techniques.	4.76	0.43142	High
5	I look forward to upcoming learning activities that incorporate Augmented Reality (AR) techniques in class.	4.20	0.49487	High
6	I find it easier to understand the lesson when the teacher uses Augmented Reality (AR) techniques.	4.76	0.43142	High
7	Augmented Reality (AR) techniques help improve my focus during the teaching and learning process.	4.36	0.48487	High
8	The use of materials based on Augmented Reality (AR) techniques is an engaging form of learning.	4.72	0.45356	High
9	I enjoy attending classes that utilise Augmented Reality (AR) techniques because they are engaging.	4.24	0.43142	High

10	The use of Augmented Reality (AR) techniques in the teaching of Design and Technology makes learning sessions more interesting compared to textbooks.	4.52	0.50467	High
	Overall	**4.484**	**0.462**	**High**

n=50

Table 12 presents the results from a correlation analysis conducted using SPSS to examine the impact of the AR module on interest and achievement. The Pearson Correlation Coefficient (r) measures the strength and direction of the linear relationship between two variables. Referring to Table 9, the findings indicate a very strong positive linear relationship (r = 0.973) that is significant ($p < 0.01$) between the achievement of the treatment group using the AR module and their interest in learning. This implies that the use of the AR module has a positive effect on students' interest in learning. Furthermore, it indicates that as the use of the AR module increases, interest in learning also increases, and vice versa. The high correlation coefficient value of 0.973 and the significance level of 0.000 demonstrate that the relationship between these two variables is very strong and significant.

Table 12: Correlation between treatment achievement and interest

Variable	Treatment Achievement	Interest
Treatment Achievement	1	0.973**
Sig. (2-tailed)	-	0
N	50	50
Interest	0.973**	1
Sig. (2-tailed)	0	-
N	50	50

DISCUSSION OF FINDINGS

The summary of this study affirms that the integration of the AR module in the teaching and learning of the topic Introduction to Mechanical Components in the Form Two RBT subject is both necessary and effective. The overall mean score from teacher evaluations indicated a high level of agreement regarding the need for the AR module, reflecting strong support for its implementation. Survey results also showed that the mechanical components included in the AR module were highly relevant, with most items receiving mean scores exceeding 3.34. This suggests that the components enhanced students' ability to visualize, understand, and engage with the topic more effectively.

Furthermore, a comparative analysis between the control and treatment groups revealed that students who were exposed to the AR module not only demonstrated greater interest in the topic but also achieved higher academic performance. The treatment group recorded a mean score of 82.28 (SD = 4.39), while the control group scored significantly lower, with a mean of 55.12 (SD = 3.54). The independent samples t-test confirmed a statistically significant difference, $t(98) = 19.099$, $p < .001$, with a large effect size ($\eta^2 = 0.788$). Additionally, students' interest in learning through AR was reflected in a high overall mean score of 4.484 (SD = 0.462), while a Pearson correlation analysis showed a very strong positive relationship between student interest and achievement ($r = 0.973$, $p < .01$).

These findings are consistent with previous research. Hamzah et al. (2023) noted that AR technology motivates students through intuitive and user-friendly interactions, enhancing comprehension during learning. Similarly, Billinghurst and Duenser (2020) stated that AR allows users to view and interact with virtual content in real-time environments, making learning more immersive. Siti Salwah and Jamaludin

(2013) highlighted that the use of educational technology supports sustained interest and promotes self-directed learning among students.

Table 13: Scale of mean interpretation (Adapted from Jamian et al., 2020)

Mean value	Level of Mean interpretation
0.00 – 1.66	Low
1.67 – 3.33	Moderate
3.34 – 5.00	High

The findings in Table 2 reveal the distribution of mean scores and agreement levels among 17 RBT teachers regarding the necessity of including 20 mechanical components in the AR module. The analysis shows a high level of agreement, with an overall mean score of 4.50 and a standard deviation of 0.52, indicating strong consensus among respondents. All 20 components received a mean score above 3.34, which, based on the interpretation scale in Table 13, falls within the "High" agreement level. This suggests that every component listed is considered relevant and valuable for inclusion in the AR module.

The highest-rated component was the Lever (M = 4.71, SD = 0.47), followed by Ball Bearing (M = 4.65), Miter Gear, Pulley, Cam Shaft, and Belting (each M = 4.59). These components are fundamental to basic mechanical systems and are frequently encountered in both theoretical instruction and real-world applications, making them essential for supporting students' conceptual understanding in an immersive AR environment. On the other hand, Chain (M = 3.41, SD = 0.51) received the lowest mean score, yet still falls within the "Moderate" level of agreement, indicating that it may still be beneficial to include in certain contexts, albeit less critically than others.

Overall, the results demonstrate that the majority of the mechanical components assessed are viewed as necessary by educators, thus validating their inclusion in the AR module. These insights offer valuable guidance for the development of content that aligns with both curriculum requirements and teaching needs.

According to Hadi et al. (2020), the use of smartphones is recommended in the teaching of the Form Two Mechanical Design topic in the RBT subject to enable the effective application of AR technology. This recommendation aligns with the requirements outlined in the Standard Curriculum and Assessment Document (DSKP) for RBT under the Kurikulum Standard Sekolah Menengah (KSSM) (BPK, 2017), which emphasises the flexibility of teaching approaches using technological tools. Smartphones are essential in displaying AR objects to students during teaching and learning sessions. Hadi et al. (2020) also stated that smartphones are easier and more flexible to use during RBT teaching and learning sessions. Consequently, all respondents agree on the inclusion of all 20 mechanical components in the AR module, supported by the researchers' assertion that RBT teachers require gadgets such as smartphones for their teaching sessions.

The findings revealed a significant difference in achievement levels between the treatment and control groups after the implementation of the AR module. As shown in Table 14, students in the treatment group scored considerably higher (M = 82.28, SD = 4.39) compared to those in the control group (M = 55.12, SD = 3.54). Furthermore, 86% of students in the treatment group achieved excellent scores, while none of the students in the control group reached that level. An independent samples t-test confirmed that this difference was statistically significant, $t\ (98) = 19.099$, $p < .001$.

Table 14: Post-test achievement comparison between treatment and control groups

Group	Mean Score	Standard Deviation (SD)	Excellent Achievement (%)
Treatment (AR)	82.28	4.39	86%
Control	55.12	3.54	0%

In addition to academic performance, the study also explored students' interest in learning with the AR module. Based on the interest questionnaire, students reported a high level of interest, with an overall mean score of 4.484 (SD = 0.462). A Pearson correlation analysis, presented in Table 15, revealed a very strong positive relationship between interest and achievement ($r = 0.973$, $p < 0.01$). This suggests that students who were more interested in using the AR module also tended to perform better academically.

Table 15: Correlation between student interest and achievement

Variables	Correlation Coefficient (r)	Significance (p)	Relationship Strength
Interest and Achievement	0.973	< 0.01	Very Strong Positive

According to Aziz and Abd Rahman (2018), teachers will become more prepared and confident when equipped with a module, enabling a shift from conventional teaching to higher-order thinking skills (HOTS)-based teaching. Additionally, Aziz and Abd Rahman (2018) emphasized that teachers require modules and supporting materials as guidelines to successfully implement HOTS in teaching and learning, not only in RBT but also in other subjects. Multimedia-based modules for other topics in the RBT subject should also be increased to engage students in enjoyable learning sessions (Ismail et al., 2022).

The above statements support the notion that the use of modules in learning significantly aids teachers in conducting meaningful teaching and learning sessions, producing positive effects on students.

CONCLUSION

The teaching and learning process must continue to adapt to rapid advancements and shifts in the educational landscape. Implementing effective teaching strategies is essential in addressing students' varied learning needs, especially within the RBT subject. This study has successfully addressed all the research objectives, providing evidence of the benefits of using AR in enhancing the teaching and learning of mechanical components. The findings revealed a statistically significant improvement in achievement scores among students exposed to the AR module, compared to those taught using conventional methods. Additionally, data collected through student interest questionnaires indicated that the AR module positively influenced learners' engagement and motivation. These results affirm that the use of AR in the classroom supports deeper understanding and improved learning outcomes.

Previous studies also support this view. Aziz and Abd Rahman (2018) highlighted the importance of equipping teachers with effective teaching modules to enhance students' higher-order thinking skills. Similarly, Ismail et al. (2022) and Roslin et al. (2022) emphasized that multimedia-based modules can create more enjoyable and engaging learning environments, thereby improving student participation and comprehension. Based on these insights, it is recommended that teachers integrate AR technologies into their pedagogical approaches to facilitate the learning of abstract and technical concepts. In line with these findings, the Ministry of Education Malaysia is urged to provide continuous training and sufficient resources to support the implementation of AR-enhanced instruction. Future research may consider developing more comprehensive AR modules across other RBT topics and evaluating their effectiveness in broader and more diverse educational contexts.

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CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

DECLARATION OF GENERATIVE AI

During the preparation of this work, the authors used ChatGPT to enhance the clarity of the writing. After using ChatGPT, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

DATA AVAILABILITY STATEMENT

Data available within the article or its supplementary materials.

REFERENCES

Ahmad Shahrizal, A. Z. S., Rahmatullah, B., Ab Majid, M. H., Mohamad Samuri, S., Hidayanto, A. N., & M. Yas, Q. (2022). A systematic literature review on the use of podcasts in education among university students. *ASEAN Journal of Teaching & Learning in Higher Education, 14*(1), 222–236. http://dx.doi.org/10.17576/ajtlhe.1401.2022.10

Amir, S. S., Hashim, S. R. M., & Abdullah, K. (2024). Kesahan dan kebolehpercayaan instrumen kebimbangan matematik sekolah rendah. *Jurnal Pemikir Pendidikan, 12*(1).

Aziz, F. A. A., & Abd Rahman, F. (2018). Sorotan kajian kesediaan dan keperluan guru Bahasa Melayu dalam pelaksanaan Kemahiran Berfikir Aras Tinggi (KBAT) Di Bilik Darjah: Literature review: Readiness and needs of teachers in implementing Higher Order Thinking Skills (HOTS). *PENDETA*, *9*, 80-101.

Billinghurst, M., & Duenser, A. (2020). Augmented reality in the classroom. In M. S. Khine (Ed.), *Springer International Handbook of Augmented Reality* (pp. 711-727). Springer.

Budiastuti, P., Khairudin, M., Santosa, B., & Rahmatullah, B. (2023). The use of personal learning environment to support an online collaborative strategy in vocational education pedagogy course. *International Journal of Interactive Mobile Technologies, 17*(2), 24–41. https://doi.org/10.3991/ijim.v17i02.34565.

Creswell, J. W., & Creswell, J. D. (2017). *Research design: Qualitative, quantitative, and mixed methods approaches*. Sage Publications.

Fadzil, M. Z. M., & Noor, N. A. Z. M. (2023). Mengintegrasikan augmented reality dalam pembelajaran bentuk 2D dan 3D. *Journal of Engineering, Technology, and Applied Science (JETAS)*, *5*(1), 12-22.

Fajari, L. E. W., & Meilisa, R. (2022). The development of augmented reality to improve critical thinking and digital literacy skills of elementary school students. *DWIJA CENDEKIA: Jurnal Riset Pedagogik, 6*(3), 688-702.

Fraenkel, J. R., Wallen, N. E., & Hyun, H. H. (2018). *How to design and evaluate research in education* (10th ed.). McGraw-Hill Education.

Ghafar, N. A., Rahmatullah, B., Razak, N. A., Muttallib, F. H. A., Adnan, M. H. M., & Sarah, L. L. (2023). Systematic literature review on digital courseware usage in Geography subjects for secondary school students. *Journal of ICT in Education, 10*(1), 26-39. https://doi.org/10.37134/jictie.vol10.1.3.2023

Hadi, N. A., Hamzah, M., & Hanif, M. H. M. (2020). Pengukuran kesahan, analisis faktor dan kebolehpercayaan instrumen persepsi kebergunaan terhadap penggunaan telefon pintar dalam kalangan guru Reka Bentuk dan Teknologi sekolah menengah. *International Journal of Education, Psychology and Counseling, 5*(36), Article 002. https://doi.org/10.35631/IJEPC.536002

Hamzah, N., Ghoni, M. Y. A. A., Ariffin, A., Zakaria, N., & Rubani, S. N. K. (2023). Aplikasi Augmented Reality berkaitan tanda-tanda keselamatan dalam makmal sains sekolah. *Innovative Teaching and Learning Journal*, *7*(1), 42-50.

Hasbullah, N. H., Rahmatullah, B., Mohamad Rasli, R., Khairudin, M., & Downing, K. (2022). Google Meet usage for continuity and sustainability of online education during pandemic. *Journal of ICT in Education, 9*(2), 46–60. https://doi.org/10.37134/jictie.vol9.2.4.2022

Idris, S. I. B., Salim, M. S. B., & Idris, N. H. B. (2019). Penerapan teknologi augmented reality untuk memahami fungsi kamera DSLR. *Journal on Technical and Vocational Education*, *4*(3), 106-115.

Indahsari, L., & Sumirat, S. (2023). Implementasi teknologi augmented reality dalam pembelajaran interaktif. *Cognoscere: Jurnal Komunikasi Dan Media Pendidikan*, *1*(1), 7-11.

Ismail, M., Kob, C. G. C., Yusuff, N. N., & Pratama, H. (2022). Modul sequin of fashion design topics, design and technology (RBT) Form One subject: Multimedia elements from the teachers' perspective. *Asian Journal of Vocational Education and Humanities*, *3*(1), 24-32.

Jamian, R., Abidin, N. H. Z., & Arsad, R. (2020). Analisis deskriptif bagi penggunaan aplikasi quizizz ke atas guru dalam penilaian prestasi murid bagi subjek Matematik. *Mathematical Sciences and Informatics Journal*, *1*(2), 87-97.

Johar, S. H., & Abdullah, N. S. (2019). Pembangunan e-Modul augmented reality bagi subjek semiconductor devices untuk guru TVET. *Online Journal for TVET Practitioners, 4*(2), 99-104.

Kiflee, C. S., Hassan, S. A., Maaluot, N., Yusof, R., & Khalid, F. (2020). Analisis keberkesanan kaedah multimedia dalam pengajaran dan pembelajaran terhadap pelajar pintar dan berbakat. *Jurnal Personalia Pelajar*, *23*(2).

Musrifah, M., Sarjoni, M., & Abd Rahman, F. (2020). Keberkesanan aplikasi Google Plus terhadap pencapaian pembelajaran Bahasa Melayu di sekolah SRAI. *Jurnal Al-Umah, 2*, 143–168. https://www.jais.gov.my/wp-content/uploads/2023/12/08-Musrifah-Google.pdf

Nashir, I. M., Zainal, A. Y. D., & Sulaiman, A. (2022). Pembangunan modul multimedia interaktif bagi pembelajaran sains rumah tangga sekolah menengah harian di Malaysia. *Asian Pendidikan*, *2*(1), 8-17.

Ngadengon, Z., Rahmat, F., & Zawawi, N. S. M. (2021). Keberkesanan gamifikasi dalampembelajaran teknologi rekabentuk web. *International Journal of Modern Education, 3*(10), 48-61.

Roslin, A. R., Rahmatullah, B., Zain, N. Z. M., Purnama, S., & Yas, Q. M. (2022). Online learning for vocational education: Uncovering emerging themes on perceptions and experiences. *Journal of Vocational Education Studies, 5*(1), 1-15. https://doi.org/10.12928/joves.v5i1.6097

Rosly, R. M., & Khalid, F. (2017). Gamifikasi: Konsep dan implikasi dalam pendidikan. In *Pembelajaran Abad ke-21: Trend Integrasi Teknologi*. Universiti Kebangsaan Malaysia.

Rusli, N. F. M., Ibrahim, N. F. S. C., Raâ, M., & Nallaluthan, K. (2021). Persepsi pelajar terhadap aplikasi multimedia interaktif dalam proses pengajaran dan pembelajaran abad ke-21: Students' perceptions of interactive multimedia applications in the 21st century teaching and learning process. *Online Journal for TVET Practitioners*, *6*(1), 15-24.

Sahaat, Z., Nasri, N. M., & Bakar, A. Y. A. (2020, August). ADDIE model in teaching module design process using modular method: Applied topics in design and technology subjects. In *1st Progress in Social Science, Humanities and Education Research Symposium (PSSHERS 2019)* (pp. 719–724). Atlantis Press. https://doi.org/10.2991/assehr.k.200824.161

Samawi, N. B., & Khalid, F. (2022, April). Penggunaan bahan augmented reality dalam meningkatkan tahap pemahaman pelajar bagi subjek Reka Bentuk dan Teknologi. In *International Conference on Global Education* (pp. 538–545).

Samuri, S.M., Abdul Ghani, H., Rahmatullah, B., & Ab Aziz, N. S. (2016). Sistem sokongan keputusan untuk menilai dan memantau prestasi guru: Kajian rintis di SMK Bachok, Kelantan. *Journal of ICT in Education, 3*, 55–72.

Sudin, I. A. A., Rahmatullah, B., Abdullah, M. F. W., Tamrin, K. F., Khairudin, M., & Yahya, S. R. (2022). Kajian tinjauan literatur sistematik terhadap pendedahan pelajar universiti kepada percetakan 3D sebagai persediaan ke industri: A systematic literature review study on university students' exposure to 3D printing as preparation for industry. *Journal of ICT in Education, 9*(1), 48–60. https://doi.org/10.37134/jictie.vol9.1.5.2022

Ziden, A. A., Ziden, A. A. A., & Ifedayo, A. E. (2022). Effectiveness of Augmented Reality (AR) on students' achievement and motivation in learning Science. *EURASIA Journal of Mathematics, Science and Technology Education, 18*(4), em2097.

Zolkipli, N. Z., Rahmatullah, B., Samuri, S. M., Árva, V., & Pranoto, Y. K. S. (2023). 'Leave no one behind': A systematic literature review on game-based learning courseware for preschool children with learning disabilities. *Southeast Asia Early Childhood Journal, 12*(1), 79–97. https://doi.org/10.37134/saecj.vol12.1.7.2023