ISSN: 3026-4596
Journal of Computer-based Instructional Media, Vol. 2, No. 2, pp. 69-85, 2024

Bringing interactive elements into classes: Augmented reality-based learning media development for electrical measurement subjects in vocational education

Murtita Mardiah Putri[1], Noverta Effendi[1,*], Fitri Farida[1] and Gulzhaina Kuralbayevna Kassymova[2,3]

[1] Study Program of Vocational Education of Electronics Engineering, Faculty of Teacher Training and Education, Universitas Muhammadiyah Riau, **Indonesia**
[2] Abai Kazakh National Pedagogical University, **Kazakhstan**
[3] Institute of Metallurgy and Ore Beneficiation JSC, Satbayev University, **Kazakhstan**

*Corresponding Author: nover@umri.ac.id
Received 27th August 2024; Revised: 13th October 2024; Accepted: 20th October 2024

https://doi.org/10.58712/jcim.v2i2.135

Abstract: This study aims to develop and evaluate Augmented Reality (AR)-based learning media to improve student interest at SMKN 1 Kuantan Mudik. AR, which integrates virtual objects into the real world, is expected to enrich the learning experience through innovative visual and interactive elements. This research employs a Research and Development (R&D) which includes preliminary research, prototype creation, student response assessment, and systematic reflection. The AR-based learning media prototype was developed using Assemblr Edu software and evaluated by media experts, content specialists, and students. The validation results indicate that the media is highly viable, receiving a score of 92.7% from content experts and media specialists. Student trials produced ratings of 88.9% for effectiveness and 90.3% for engagement. The findings demonstrate that AR-based learning media significantly enhance student interest and involvement in the learning process. This study concludes that augmented reality learning media substantially improve educational experiences in vocational settings, showing potential for broader implementation across various subjects. However, this research is limited to expert validation processes and primarily focuses on student responses rather than measuring learning outcomes. This study is anticipated to provide a foundation for developing more comprehensive and effective learning media.

Keywords: Information, Media and Technology; Quality education; Engaging learning tools; Interactive media

1. Introduction

In the current digital era, education faces increasingly complex challenges, particularly enhancing students' learning motivation (Prasetya et al., 2024; Samala et al., 2024; Waskito et al., 2024). One key factor influencing the success of the learning process is the medium used for instruction. Students often perceive Traditional learning media as less engaging, resulting in low levels of motivation and classroom participation (Jumaroh et al., 2023; Pinnegar & Cutri, 2022; Sabitri et al., 2024). Hence, innovation was needed to develop more interactive and engaging learning tools to enhance student motivation. In this context, Augmented Reality (AR) technology emerges as a potential solution because it provides a more dynamic and immersive learning experience.

In recent years, educational research has increasingly focused on leveraging digital tools to enhance student engagement and motivation, mainly through Augmented Reality (AR). However, previous studies on AR's application in education have not sufficiently addressed the specific needs of diverse

student populations or the long-term effects of AR on motivation and learning outcomes (Fortuna et al., 2024; Samala et al., 2023; Ziden et al., 2022). While earlier research has highlighted the potential of AR to improve engagement and conceptual understanding (Karpagam et al., 2022; Oueida et al., 2023), it often lacks a clear strategy for developing AR-based learning media tailored to the characteristics of specific learners, such as vocational students. Moreover, the scalability and adaptability of AR solutions across different subjects remain underexplored.

Furthermore, student learning motivation is a critical factor in determining their academic success (Jumaroh et al., 2023; Martínez-Gómez et al., 2022), and low motivation is often linked to traditional teaching methods that fail to integrate relevant technology (Manca, 2020; Radović et al., 2023). Therefore, developing learning strategies that utilize AR technology will enrich the learning experience and stimulate students' interest in learning. AR allows abstract concepts to be visualized more concretely, provides more apparent context, and facilitates more enjoyable learning experiences (Fortuna, Kurniawan, et al., 2023; Fortuna, Rahmansyaf, et al., 2023).

Based on observations in Class X TITL at SMK Negeri 1 Kuantan Mudik, current teaching methods rely heavily on lectures, blackboards, and PowerPoint presentations. This passive learning environment often leads to student boredom, disengagement, and difficulty grasping complex concepts, particularly in technical subjects like electrical engineering. The over-reliance on traditional methods fails to align with the learning preferences of today's digitally-native students, underscoring the need for more interactive tools like AR to foster deeper engagement and improve learning outcomes.

The novelty of this study lies in its focus on addressing these gaps by developing an AR-based learning media specifically designed for vocational education, a field where students require practical and engaging learning tools. This research builds on the educational design research model and aims to create an interactive learning experience that visualizes abstract concepts and aligns with the real-world skills required in technical fields. By integrating AR into the classroom, this study seeks to overcome the monotony of traditional teaching methods that rely heavily on lectures and static media (Jumaroh et al., 2023; Sabitri et al., 2024), providing a dynamic alternative that enhances student motivation and participation.

This research contributes to the advancement of Science and Technology by introducing a novel approach to instructional media development tailored to vocational students. Additionally, it provides a framework for designing and implementing AR-based tools that are effective in both the short and long term (Dargan et al., 2023). The study's findings will offer valuable insights into how AR can be integrated into the educational curriculum to enhance student motivation and participation. Accordingly, this study aims to develop effective strategies for implementing AR-based learning media to improve student motivation. It will identify key design elements, such as interactive features and engaging content, contributing to a more effective learning experience. Ultimately, the results are expected to offer a new education approach that enhances student participation and learning outcomes.

2. Methods

2.1 Research design

The development method employed in this study is the Research and Development (R&D) approach. The R&D method aims to generate new knowledge through primary research, as well as to develop educational outcomes by validating or addressing specific practical issues through applied research, which is designed to enhance educational practices (Daryanes et al., 2023; Nuraini et al., 2023). The

Education Design Research Model will be utilized to develop augmented reality-based learning media (Nieveen et al., 2016).

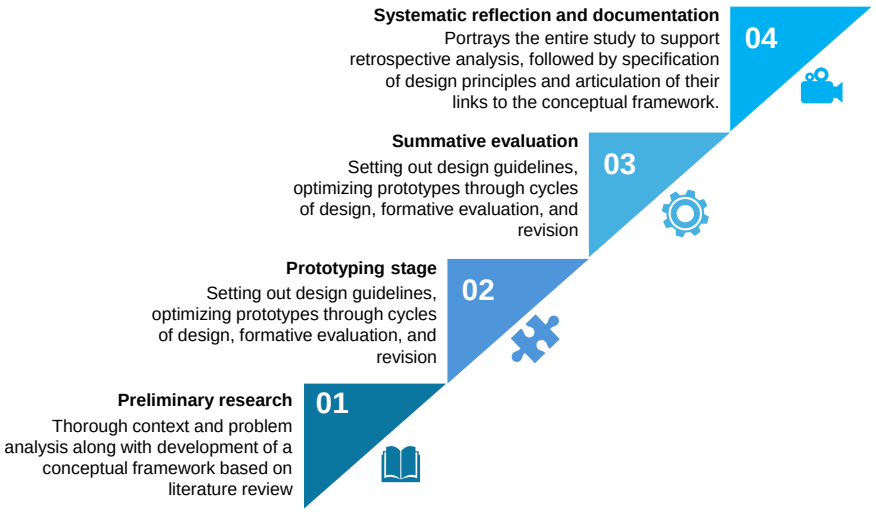


Figure 1. Education design research (Nieveen et al., 2016)

2.2 Development procedure

The development procedure for augmented reality-based learning media involves several stages. The first stage in the Education Design Research Model is conducting a preliminary study to clearly understand the research to be undertaken (Azmi et al., 2022; Sutikno, 2024). Data collection at this stage is carried out through direct observation and interviews. Based on the preliminary research conducted in January, it was found that the use of technology-based media in the learning process at SMKN 1 Kuantan Mudik was still limited. Teachers predominantly used PowerPoint as a learning tool, resulting in a lack of variety in teaching methods. Following the preliminary study, the next step is the creation of a learning media prototype. This stage begins with a needs assessment to identify specific requirements, followed by developing the prototype using augmented Reality (Pons et al., 2020; Voinea, 2018). A flowchart, storyboard, and augmented reality-based learning media design incorporating Android markers and marker books were created based on the needs analysis. The prototype was then subjected to feasibility testing involving media and content experts (Baliyan & Mokoena, 2024; Naser et al., 2023).

Once experts validated the prototype, the next stage was to evaluate its effectiveness and practicality through implementation with students. This process began with introducing augmented reality to students, followed by distributing marker books and installing the augmented reality application (Nurhikmah et al., 2024). An evaluation was conducted by administering questionnaires to students to gather feedback on using augmented reality-based learning media in the learning process (Hamilton et al., 2021; Malecka et al., 2022; Yan et al., 2023). The final stage in the Education Design Research Model is reflection and documentation of the entire research process, which includes reporting on the stages of the learning media development trials.

2.3 Test subjects in learning media

The subjects of the trials in this development research include one lecturer as a media expert, one teacher as a content expert, and 16 students from the X TITL class at SMKN 1 Kuantan Mudik. The augmented reality-based learning media trials will be conducted to evaluate its effectiveness and feasibility within the learning context (Lampropoulos et al., 2022). The trial will test the design, interactivity, and students' responses to the developed learning media. During the trials, students will

use the designed learning media while experts will assess the quality of the media in terms of content presentation and relevance to the curriculum. The data obtained from this trial will be analyzed to determine the success rate of the learning media in enhancing student interest and engagement and identify potential improvements before broader implementation.

The developed learning media prototype will undergo validation by content and media experts. After the validation process, the prototype will be revised according to the experts' feedback before implementation. The next stage involves trials with students, which includes distributing markers and marker books and installing the Assemblr Edu software (Carrión-Robles et al., 2023; Prasetya, Fortuna, et al., 2023). Students will also receive a questionnaire to assess their responses to using augmented reality-based learning media.

2.4 Data collection technique

The data collection techniques encompass various methods used to acquire, gather, and analyze data in research (Sabitri et al., 2024). Effective data collection is a crucial aspect of achieving research objectives and requires the application of appropriate methods. This research employs questionnaires and observations for data collection (Ruiz-cantisani et al., 2020). The questionnaires are designed to obtain direct information from respondents regarding their assessments of specific aspects of the learning media, such as effectiveness and material appropriateness. The questionnaires are structured with a Likert scale to measure various variables systematically and quantitatively.

On the other hand, observations are conducted to gather qualitative data by directly observing the conditions and dynamics in the field, including the school environment, available facilities, and interactions during the learning process (Isnaeni et al., 2021). This observation aims to understand better the implementation and acceptance of augmented reality-based learning media in real-world settings. Lastly, the data collection instruments used in this study include questionnaires and observation sheets designed to collect specific information from respondents and research situations (Lisá et al., 2019). The questionnaires provide a series of questions that respondents must answer in writing, enabling structured and easily analyzable quantitative data collection (Prasetya et al., 2021). Additionally, observation sheets are utilized to systematically record and analyze phenomena occurring in the field, such as how students use the learning media and their reactions to the presented material. Combining these two instruments allows researchers to obtain comprehensive and triangulated data, enhancing the validity and reliability of the research results (Prasetya, Syahri, et al., 2023).

2.5 Data analysis technique

The data analysis technique applied in developing augmented reality-based learning media at SMKN 1 Kuantan Mudik is descriptive analysis. This analysis process includes evaluating the feasibility of the learning media based on assessments from media and content experts and feedback from students involved in the trials. The data collected through observations and questionnaires are analyzed using a qualitative descriptive approach to identify existing issues in the school. The questionnaires used for expert validation and assessment by students are processed using a Likert scale, where the quantitative data obtained are interpreted into qualitative data. Respondents are asked to select answers available on the quantitative scale, allowing the analysis to provide a more detailed depiction of the effectiveness and acceptance of the learning media. Table 1 presents the assessment criteria for validation and feasibility of the developed augmented reality media (Prasetya, Syahri, et al., 2023).

Table 1. Validation assessment criteria and feasibility test criteria

Score	Description	Interval (%)	Criteria
5	Very good	81 – 100	Very Feasible
4	Good	61 – 80	Feasible
3	Fairly Good	41 – 60	Feasible Enough
2	Not Good	21 – 40	Less Feasible
1	Very Poor	0 – 20	Very Less Feasible

According to (Hakiki et al., 2022), the percentage of answers from the validation assessment aspects and student responses and student interest can be calculated using the following formula:

$$P = \frac{\sum x}{N \times \sum x_1} \times 100\%$$

Description:

P = Feasibility Percentage
∑x = Skor total Validator
∑xi = Maximum Score
N = Number of questionnaire items

3. Results

3.1 Initial product development

This research resulted in the development of augmented reality-based learning media for electrical measuring instruments in the essential vocational subject of electrical engineering at SMKN 1 Kuantan Mudik. This learning media was developed using the Assemblr Edu software, following the Education Design Research Model, which involves several stages: Preliminary Research, Prototype Development, Assessment of Students, and Systematic Reflection and Documentation. In the preliminary research stage, the researcher conducted an initial analysis to identify the problems and needs of students at SMKN 1 Kuantan Mudik through direct observation. This analysis included interviews with teachers and observations of the learning process to understand the curriculum and teaching modules implemented, particularly in the X Electrical Power Installation Engineering class. The Merdeka Curriculum used at SMKN 1 Kuantan Mudik emphasizes two essential elements of electrical measuring instruments that will be included in the augmented reality-based learning media: (1) students' understanding of the types and functions of electrical measuring instruments and (2) students' ability to use electrical measuring instruments.

Afterward, the researcher began with a needs analysis in the prototype development stage. Observations and interviews revealed that during the learning process, teachers more frequently utilized PowerPoint presentations and blackboards, leading to lower student engagement and frequent feelings of boredom. Furthermore, the lack of innovation in learning media caused students to become unfocused and inattentive to the teacher's explanations. Based on interviews with students and confirmation from the principal, it was determined that there is a need to renew the learning media to reduce student boredom and increase the variety of teaching media teachers use.

3.2 Prototyping stage

The storyboard design for developing augmented reality as a learning medium was created to tackle the identified challenges. In the media development process, the stage of object collection involves integrating diverse elements, including 3D images, educational videos, and other visual components.

These elements were systematically organized to align with the learning flow, enhancing students' comprehension of the concepts and materials. This structured arrangement of objects aims to foster a more interactive and comprehensive learning experience.

The next step involves designing the augmented reality-based learning media, ensuring that each visual or interactive component follows a logical path that is easy for students to understand. This approach aims to maximize the learning experience by providing engaging visual and interactive stimuli, thereby enhancing student understanding and motivation to learn. Consequently, this learning media design is expected to function optimally in increasing student participation and supporting a more dynamic learning process. The results of the augmented reality-based learning media design on the topic of electrical measuring instruments are presented in Figure 2.

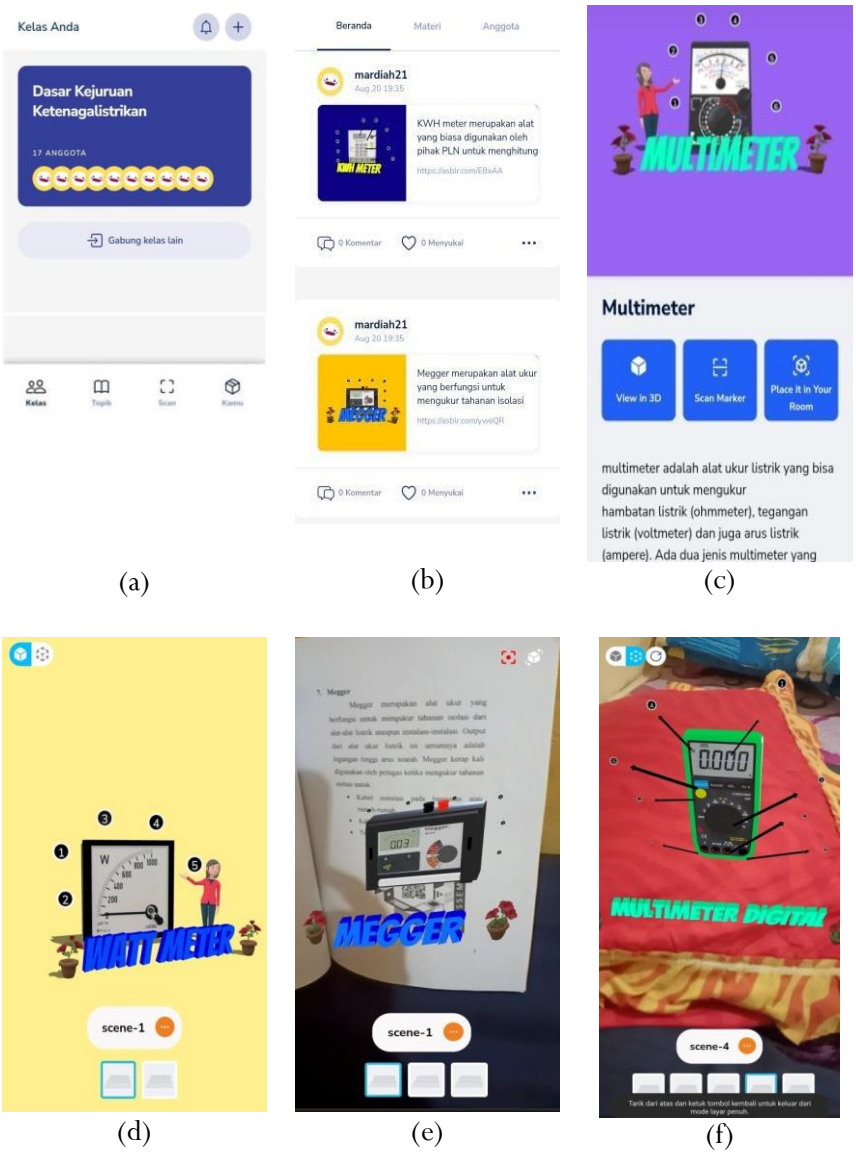


Figure 2. Augmented reality-based learning media design. (a) Main menu, (b) Material selection display, (c) Material display, (d) 3D display, (e) Scan marker display, (f) Augmented reality

(a) (b) (c)

(d) (e) (f)

3.3 Assessment of learning media based on validation and feasibility

The prototype developed using augmented reality technology was evaluated for feasibility by involving media and subject matter experts. This evaluation aimed to assess the viability of the learning media before it is implemented with students. The feasibility testing process for the augmented reality-based learning media included validation by both subject matter and media experts.

3.3.1 Material expert validation

Validation by subject matter experts was conducted by the instructor of the essential vocational subject of electrical engineering at SMKN 1 Kuantan Mudik. A questionnaire was utilized for validation purposes, encompassing two assessment aspects with 11 statement items. The assessment was conducted using a Likert scale, with a score range from 1 to 5. The evaluation results from the subject matter expert regarding the augmented reality-based learning media developed using Assemblr Edu software are presented in Table 2.

Table 2. Material expert assessment results

Indicators Assessment	Assessment Aspect	Score
Material	The material presented is following the core components of the teaching module.	5
	The material is following the learning objectives.	4
	The material presented follows the needs of students	5
	The material presented has been arranged systematically	5
	The material presented is easier to understand	4
Feasibility Presentation	The material presented has been explained in order	5
	The text display of the material can be read clearly	5
	The use of font type and size is appropriate	5
	The choice of background color is appropriate so that images and text can be read clearly.	4
	The image presented is already 3D	4
	The image presented is already	5
Overall		**51**

$$P = \frac{\sum x}{N \times \sum x_1} \times 100\% = \frac{51}{11 \times 5} = \frac{51}{55} \times 100\% = 92.7\%$$

Based on the evaluations obtained from the validation sheets completed by the subject matter expert, the data analysis results indicate that the augmented reality-based learning media has a feasibility level of 92.7%. This percentage falls within the "very feasible" category according to the criteria outlined in Table 2. Therefore, it can be concluded that subject matter experts highly regard the development of augmented reality-based learning media at SMKN 1 Kuantan Mudik for use in the learning process. These validation results indicate that the developed learning media not only meets quality standards regarding content but is also relevant to classroom learning needs. This validation is the basis for proceeding to the implementation and field testing phases to gather further feedback from students and teachers. This subsequent evaluation will assist in making necessary adjustments to enhance the effectiveness and appeal of the augmented reality-based learning media.

3.3.2 Media expert validation

The validation by media experts was conducted by a lecturer from the Vocational Education Study Program in Electronic Engineering at Universitas Muhammadiyah Riau. The instrument used in this validation process was a questionnaire consisting of two assessment aspects with 11 statement items. The assessment was conducted using a Likert scale, with a score range from 1 to 5. The validation results from the media expert regarding the development of augmented reality-based learning media are presented in Table 3.

Table 3. Media expert assessment results

Indicators Assessment	Assessment aspect	Score
Presentation	Easy-to-use learning media	4
	The assembler edu software is easy to install on a mobile phone.	4
	The use of fonts is appropriate	5
	The writing can be read clearly	5
	The image presentation on the learning media is appropriate.	5
	The image used is already 3D	4
	The layout of the picture is appropriate	4
	The use of background is appropriate	5
	Markers can be scanned	5
Communication visual	Media display engaging learning media	5
	The language used is communicative	5
Overall		**51**

$$P = \frac{\sum x}{N \times \sum x_1} \times 100\% = \frac{51}{11 \times 5} = \frac{51}{55} \times 100\% = 92.7\%$$

The feasibility outcome can be observed from the assessment results on the validation sheets completed by the media expert. After analyzing the data according to the validation results provided by the media expert, a feasibility score of 92.7% was obtained, which falls within the "very feasible" criteria based on the presentation of assessment results in Table 3. Based on this evaluation, the validation aims to assess the visual and functional aspects of the media, such as graphic quality, ease of navigation, and interactivity. The feedback obtained from the media expert will be used to refine and optimize the technical elements within the learning media, thereby providing a more engaging and practical learning experience for students. This refinement process is crucial to ensure that the augmented reality media is visually appealing and user-friendly, ultimately enhancing student engagement and motivation.

3.4 Assessment to students

The assessment to students stage involves testing the students' use of augmented reality-based learning media. This trial aims to evaluate the effectiveness and outcomes of the learning media developed using Assemblr Edu software. The trial began with an orientation session for tenth-grade students in the Electrical Installation Engineering (TITL) program at SMKN 1 Kuantan Mudik. This orientation aimed to provide an initial understanding of using augmented reality learning media and involved 16 students as respondents.

3.4.1 Students response results

The student response questionnaire was designed with four assessment aspects, consisting of 15 statement items, using a Likert scale with a score range of 1 to 5. The assessment data from the 16 students regarding the augmented reality-based learning media can be seen in Table 4. These results provide important insights into student acceptance of this new learning media and its effectiveness in enhancing student engagement and understanding during the learning process. Based on student responses, further refinements can be made to optimize the use of augmented reality technology in teaching and learning. This assessment of students also aids in understanding the extent to which this media can enhance student interest and motivation in their studies.

Table 4. Student response assessment results

Indicators assessment	Assessment aspect	Score
Materials	The material has been presented clearly pictures and writing.	70
	Augmented learning media is easy to use and understand.	72
	The images and materials presented are more attractive.	67
	The material presented is easier to understand.	77
	The material follows student needs for achievement indicators	71
Efficiency	Augmented reality-based learning media is more straightforward to present, more explicit, and more detailed.	73
	Assemblr edu software is easy to use and more straightforward to understand.	66
Presentation feasibility	Learning using media simplifies the learning process learning process in the classroom.	76
	Augmented reality-based learning media has been presented in order and accordingly.	70
	Learning using media facilitates the learning process in class.	70
	Augmented reality-based learning media follows the conditions and situations of student learning in the classroom.	64
Graphics	The font type and font size used are appropriate.	73
	The writing can be read clearly	73
	The image presentation contained in the learning media is clear and precise.	73
	The placement of images and text is appropriate and organized.	72
Overall		**1067**

$$P = \frac{\sum x}{N \times \sum x_1} \times 100\% = \frac{1067}{(15 \times 16) \times 5} = \frac{1067}{1200} \times 100\% = 88.9\%$$

Based on the analysis of the student response questionnaire regarding the augmented reality-based learning media, which encompasses four assessment indicators, a percentage of 88.9% was obtained. Referring to Table 4 regarding the assessment criteria, a percentage range between 81-100% is classified as "very feasible." Therefore, it can be concluded that, according to student responses, the development of this augmented reality-based learning media falls within the "very feasible" category for use in the learning process. These results indicate that students accept the augmented reality-based learning media well and are also perceived as effective in enhancing their engagement and understanding of the learning material. Consequently, further development and application of this media could be expanded to include various other learning topics, aiming to create a more interactive and innovative learning environment.

3.4.2 Students interest response results

Student interest was evaluated to measure the extent of their engagement with the augmented reality-based learning media as a learning aid. This evaluation aims to understand the effectiveness of augmented reality learning media in capturing students' attention and motivating them to become more actively involved in the learning process. A high level of interest may indicate that this technology-based approach is relevant and has the potential to enhance learning outcomes in a more interactive and engaging manner. The interest assessment data from the 16 students who participated in this study can be seen in Table 5.

Table 5. Student interest response results

Indicators assessment	Assessment aspect	Score
Feelings of pleasure	Able to foster student enthusiasm in learning.	73
	Provide awareness to students to learn through technological developments.	72
	Able to increase students' seriousness in learning in class.	69
	It can increase students' willingness to learn.	72
Learning Interest	Able to attract students to pay attention to the teacher in class.	75
	Increase students' interest in learning lessons about electrical measuring instruments.	70
	The use of appropriate media increases students' interest in learning.	74
Attention to Learning	Can improve student concentration	70
	Can add comfort to students during learning	72
Engagement Students	Able to increase student activeness in learning	72
	It is easier to understand learning, so the time used is more efficient.	76
Overall		**795**

$$P = \frac{\sum x}{N \times \sum x_1} \times 100\% = \frac{796}{(11 \times 16) \times 5} = \frac{795}{880} \times 100\% = 90.3\%$$

Based on the analysis of data obtained from the student interest questionnaire, the percentage of student interest in learning reached 90.3%. Referring to Table 5 regarding the assessment criteria, this result indicates that the use of augmented reality-based learning media to enhance the interest of Class X

TITL students in the vocational subject of electrical engineering at SMKN 1 Kuantan Mudik falls into the "very feasible" category. These findings demonstrate that integrating augmented reality technology in learning media is relevant and effective in attracting students' interest in learning. With the high level of recorded interest, this media can enhance student engagement in the learning process, enrich their learning experiences, and create a more interactive and innovative learning environment. These results provide strong evidence for educators and curriculum developers to continue adopting and developing augmented reality-based technology as part of modern teaching strategies.

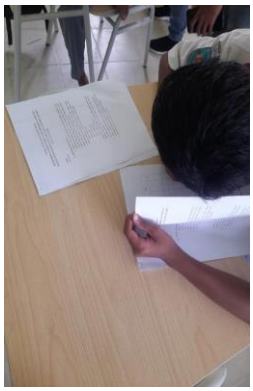
3.5 Systematic reflection and documentation

The systematic reflection and documentation stage is where reports and evidence from the research trials are compiled and presented in detail. This research trial was conducted during the evaluation phase on August 28-29, 2023, in Class X TITL at SMKN 1 Kuantan Mudik. The trial began with an awareness campaign on the use of augmented reality-based learning media. This campaign aimed to provide students with an initial understanding of using this learning media before further trials were conducted. Figure 3 illustrates the awareness campaign that took place at the school.

Figure 3. Socialization of the use of augmented reality-based learning media

Socialization activities include introducing augmented reality-based learning media developed using Assemblr Edu software to students. In this activity, students were asked to install Assemblr Edu software on their respective cell phones. After that, they were directed to enter the virtual class by using the class code provided to access the materials available in the class. After the socialization session was completed, a trial use of this learning media was conducted, followed by filling out a questionnaire that assesses student responses and a questionnaire that measures student interest in learning, presented through the documentation in Figure 4.

Figure 4. Completion of the assessment questionnaire



4. Discussion and contribution

The results of this study align with previous research emphasizing the role of interactive and engaging learning media in enhancing students' motivation and participation in the learning process (Prasetya et al., 2024; Sabitri et al., 2024). Traditional instructional methods, such as lectures and PowerPoint presentations, have contributed to student disengagement, as observed in Class X TITL at SMKN Negeri 1 Kuantan Mudik. This disengagement is linked to a monotonous learning atmosphere that fails to maintain student interest, corroborating findings from (Jumaroh et al., 2023; Pinnegar & Cutri, 2022). Hence, this study sought to address this issue by developing augmented Reality (AR)-based learning media that could provide a more interactive and stimulating environment, consistent with the recommendations of (Karpagam et al., 2022; Oueida et al., 2023).

The application of AR in this study was designed to integrate 3D visualizations and interactive elements into the learning process, enhancing the clarity of abstract concepts, such as those related to electrical measuring instruments. This innovation builds upon theories emphasizing the importance of visual and experiential learning in improving student comprehension and engagement (Muskhir et al., 2024; Waskito et al., 2024). The validation results from material experts and media experts show that the AR-based media developed by 92.7% of the material experts and media experts, both of which fall into the "very feasible" category, are not only feasible but also very effective in meeting students' learning needs, as indicated by the overall feasibility score of 88.9%. This finding aligns with Martínez-Gómez et al. (2022), who stated that well-designed learning media can significantly improve learning outcomes.

Moreover, the positive student responses further support the effectiveness of AR-based learning media in fostering motivation. The ability of AR to transform abstract and complex content into more comprehensible visual forms likely contributed to the observed increase in student engagement and satisfaction. These findings resonate with (Fortuna, Rahmansyaf, et al., 2023) and (Manca, 2020), who suggest that technology in education should be aligned with students' everyday experiences to increase relevance and interest. As a result, this study presents a novel approach to addressing the challenges of traditional teaching methods by leveraging AR technology to create a more engaging and effective learning environment. The results demonstrate that the AR-based learning media not only enhances students' understanding of the subject matter but also significantly boosts their motivation, aligning with the findings of previous studies while offering a new perspective on the use of AR in educational settings.

This research contributes to educational technology by offering practical solutions to enhance student engagement through Augmented Reality (AR)--based learning media. The development of this media, grounded in ducational design research model, provides a systematic framework for creating interactive learning tools adaptable to various subjects. The findings demonstrate that integrating AR into the curriculum can overcome the limitations of traditional teaching methods, which often rely on lectures, by offering a more engaging and interactive alternative that caters to the needs of modern students. Additionally, this study presents a comprehensive methodology for educators and instructional designers interested in developing AR-based media. The validation process, involving expert evaluation and student feedback, ensures that the developed media meets educational standards and desired learning outcomes. The development and evaluation process documentation also serves as a valuable reference for future research focused on educational innovation through AR.

By emphasizing the visualization of abstract concepts more tangibly, this research contributes to creating a more engaging and effective educational environment. These findings can serve as a guide for policymakers, educators, and technology experts regarding the potential and challenges of AR

adoption in education, as well as provide a foundation for further research and development aimed at enhancing the learning process with this technology.

5. Conclusion

This study demonstrates that developing Augmented Reality (AR)-based learning media at SMKN 1 Kuantan Mudik significantly enhances student interest and engagement. The AR media, designed using Education Design Research Model, addresses the shortcomings of conventional media, which are often perceived as monotonous. By utilizing AR, abstract concepts can be visualized concretely, improving students' comprehension and motivation to learn. After being evaluated by media and subject-matter experts and tested with students, the prototype developed proved effective in creating a dynamic and engaging learning experience. The results show that the AR media developed using Assemblr Edu received high ratings, with a feasibility score of 92.7% from media and content experts. Student feedback was also positive, with a feasibility score of 88.9%, reflecting improved clarity, engagement, and understanding of the material.

However, this study has certain limitations. The testing was restricted to a single class, focusing solely on student responses rather than measuring learning outcomes. As a result, the findings do not reflect the actual improvement in learning but rather the ease with which students could benefit from the Augmented Reality (AR) learning media. Although validation was conducted by subject matter and media experts, student feedback may vary depending on individual backgrounds and learning styles. Furthermore, the study did not explore the long-term impact of AR media on students' understanding and skills in using electrical measurement tools. Future development will require additional resources for research and broader implementation.

For future research, it is essential to explore the long-term effects of AR on learning outcomes and student engagement. Incorporating feedback from a broader educational context could provide insights into the adaptation of AR. Moreover, AR media development should address technical issues identified during trials and aim to integrate more advanced interactive features to sustain student interest. Future studies should also examine the scalability and integration of AR-based learning solutions with existing educational technologies. By refining the application of AR in education, we can create more effective and engaging learning environments to meet the needs of students in the digital age.

Acknowledgement

We would like to express our deepest appreciation to the lecturers and staff of the Electrical Engineering Vocational Education Program at Universitas Muhammadiyah Riau for their unwavering support and guidance throughout the research process. Their insights and expertise were invaluable in shaping our research. We would also like to thank the students of SMKN 1 Kuantan Mudik for their enthusiastic participation in the evaluation of the augmented reality-based learning media. Their feedback and involvement were crucial in validating the effectiveness of the developed media.

Declarations

Author contribution

Murtita Mardiah Putri: Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Data curation, Writing – original draft, Writing – review & editing, Visualization. Noverta Effendi: Conceptualization, Methodology, Validation, Investigation, Resources, Writing –

review & editing, Supervision. Fitri Farida: Conceptualization, Methodology, Data curation, Writing – review & editing, Project administration, Funding acquisition.

Funding statement

The research is independent and not funded by any person or institution.

Conflict of interest

No conflicts of interest in this research.

Ethical clearance

The involvement of teachers and students as subjects in this study was in accordance with the Declaration of Helsinki. This research has obtained permission from the Education Office of the Riau Provincial Government with number 421.5/SMKN-01/6.4/2023/211. The school management, teachers, and students have agreed to the publication of data obtained from research at SMKN 1 Kuantan Mudik.

References

Azmi, Z. L., Fathurohman, A., & Marlina, L. (2022). Validity and Practicality of Student Worksheets on Waves and Sounds for Junior High School Students. *Jurnal Penelitian Pendidikan IPA*, *8*(4), 2058–2064. https://doi.org/10.29303/jppipa.v8i4.1797

Baliyan, S. P., & Mokoena, S. (2024). Students' Choice Management: Recipe for Improving Enrollment in Private Higher Education Institutions. *Asian Journal of University Education*, *20*(1), 206–220. https://doi.org/10.24191/ajue.v20i1.26030

Carrión-Robles, F., Espinoza-Celi, V., & Vargas-Saritama, A. (2023). The Use of Augmented Reality through Assemblr Edu to Inspire Writing in an Ecuadorian EFL Distance Program. *International Journal of Engineering Pedagogy (IJEP)*, *13*(5), 121–141. https://doi.org/10.3991/ijep.v13i5.38049

Dargan, S., Bansal, S., Kumar, M., Mittal, A., & Kumar, K. (2023). Augmented Reality: A Comprehensive Review. *Archives of Computational Methods in Engineering*, *30*(2), 1057–1080. https://doi.org/10.1007/S11831-022-09831-7/METRICS

Daryanes, F., Darmadi, D., Fikri, K., Sayuti, I., Rusandi, M. A., & Situmorang, D. D. B. (2023). The development of articulate storyline interactive learning media based on case methods to train student's problem-solving ability. *Heliyon*, *9*(4), e15082. https://doi.org/10.1016/j.heliyon.2023.e15082

Fortuna, A., Kurniawan, A., Andriani, W., & Alimin, M. (2023). Designing Learning Media Using Augmented Reality for Engineering Mechanics Course. *Journal of Engineering Researcher and Lecturer*, *2*(1), 18–27. https://doi.org/10.58712/jerel.v2i1.20

Fortuna, A., Prasetya, F., Samala, A. D., Andriani, W., Rawas, S., S., A. R., Chai, H., Compagno, M., Abbasinia, S., & Nabawi, R. A. (2024). Enhancing Occupational Health and Safety Education: A Mobile Gamification Approach in Machining Workshops. *International Journal of Information and Education Technology*, *14*(9), 1227–1238. https://doi.org/10.18178/ijiet.2024.14.9.2152

Fortuna, A., Rahmansyaf, I., Prasetya, F., Syaputra, W. Z., Rahmadhani, D., Saklaili, S., Bagus, M. I., Linda, E. S., Andriani, W., Muhammad, T., & Deria, A. (2023). Design of Prototype Model Augmented Reality-Based Disaster Mitigation Learning Media as a Disaster Education Facility. *PAKAR Pendidikan*, *21*(1), 1–9. https://doi.org/https://doi.org/10.24036/pakar.v21i1.287

Hakiki, R., Muchson, M., Sulistina, O., & Febriana, A. (2022). The Development of Learning Media Based on Augmented Reality, Hologram, and Ludo Game on The Topic of Molecular Shapes. *International Journal of Interactive Mobile Technologies*, *16*(4), 70–84. https://doi.org/10.3991/ijim.v16i04.28989

Hamilton, D., McKechnie, J., Edgerton, E., & Wilson, C. (2021). Immersive virtual reality as a pedagogical tool in education: a systematic literature review of quantitative learning outcomes and experimental design. In *Journal of Computers in Education* (Vol. 8, Issue 1). Springer Berlin Heidelberg. https://doi.org/10.1007/s40692-020-00169-2

Isnaeni, W., Sujatmiko, Y. A., & Pujiasih, P. (2021). Analysis of the Role of Android-Based Learning Media in Learning Critical Thinking Skills and Scientific Attitude. *Jurnal Pendidikan IPA Indonesia*, *10*(4), 607–617. https://doi.org/10.15294/jpii.v10i4.27597

Jumaroh, J., Pernanda, D., Ulum, M., & Tin, C. T. (2023). Practicality of Smart Apps Creator-based Instructional Media on 2D Animation Subject. *Journal of Computer-Based Instructional Media*, *1*(1), 1–8. https://doi.org/10.58712/jcim.v1i1.8

Karpagam, M., Shankar, B. M., Janaranjan, M., Jaganath, M. S., Harivarathan, R., & Maniram, G. (2022). Augmented Reality based Monitoring System. *International Conference on Sustainable Computing and Data Communication Systems*, 1–4. https://doi.org/10.1109/ICSCDS53736.2022.9760855

Lampropoulos, G., Keramopoulos, E., Diamantaras, K., & Evangelidis, G. (2022). Augmented Reality and Gamification in Education: A Systematic Literature Review of Research, Applications, and Empirical Studies. *Applied Sciences (Switzerland)*, *12*(13), 1–43. https://doi.org/10.3390/app12136809

Lisá, E., Hennelová, K., & Newman, D. (2019). Comparison between employers' and students' expectations in respect of employability skills of university graduates. *International Journal of Work-Integrated Learning*, *20*(1), 71–82. https://www.ijwil.org/files/IJWIL_20_1_71_82.pdf

Malecka, B., Boud, D., & Carless, D. (2022). Eliciting, processing and enacting feedback: mechanisms for embedding student feedback literacy within the curriculum. *Teaching in Higher Education*, *27*(7), 908–922. https://doi.org/10.1080/13562517.2020.1754784

Manca, S. (2020). Snapping, pinning, liking or texting: Investigating social media in higher education beyond Facebook. *Internet and Higher Education*, *44*, 100707. https://doi.org/10.1016/j.iheduc.2019.100707

Martínez-Gómez, M., Bustamante, E., & Berna-Escriche, C. (2022). Development and Validation of an E-Learning Education Model in the COVID-19 Pandemic: A Case Study in Secondary Education. *Sustainability (Switzerland)*, *14*(20), 1–28. https://doi.org/10.3390/su142013261

Muskhir, M., Luthfi, A., Watrianthos, R., Usmeldi, U., Fortuna, A., & Samala, A. D. (2024). Emerging Research on Virtual Reality Applications in Vocational Education: A Bibliometric Analysis. *Journal of Information Technology Education: Innovations in Practice*, *23*, 1–26. https://doi.org/10.28945/5284

Naser, K., Alamassi, S., Shana, Z., Yousef, J., & Halili, S. H. (2023). Designing of a Flipped STEM Classroom Engineering-Based Module: Fuzzy Delphi Approach. *International Journal of Interactive Mobile Technologies (IJIM)*, *17*(10), 4–29. https://doi.org/10.3991/ijim.v17i10.38217

Nieveen, N., Mckenney, S., & Akker, J. van den. (2016). The value of variety. In J. van den Akker, K. Gravemeijer, S. McKenney, & N. Nieveen (Eds.), *Educational design research* (First). Taylor & Francis e-Library.

Nuraini, N., Asri, I. H., & Fajri, N. (2023). Development of Project Based Learning with STEAM Approach Model Integrated Science Literacy in Improving Student Learning Outcomes. *Jurnal Penelitian Pendidikan IPA*, *9*(4), 1632–1640. https://doi.org/10.29303/jppipa.v9i4.2987

Nurhikmah, Ropianto, M., & Adi, N. H. (2024). Intelligent system for college selection with analytical hierarchy process method case study approach. *Journal of Computer-Based Instructional Media*, *2*(1), 42–52. https://doi.org/10.58712/jcim.v2i1.130

Oueida, S., Awad, P., & Mattar, C. (2023). Augmented Reality Awareness and Latest Applications in Education: A Review. *International Journal of Emerging Technologies in Learning (IJET)*, *18*(13), 21–44. https://doi.org/10.3991/ijet.v18i13.39021

Pinnegar, S., & Cutri, R. M. (2022). Insights in teacher education. In *Frontiers in Education* (pp. 1–161). https://doi.org/10.3389/978-2-8325-4831-8

Pons, J. J., Villalba Sanchis, I., Insa Franco, R., & Yepes, V. (2020). Life cycle assessment of a railway tracks substructures: Comparison of ballast and ballastless rail tracks. *Environmental Impact Assessment Review*, *85*(July), 106444. https://doi.org/10.1016/j.eiar.2020.106444

Prasetya, F., Fajri, B. R., Syahri, B., Ranuharja, F., Fortuna, A., & Ramadhan, A. (2021). Improved learning outcomes of CNC programming through Augmented Reality jobsheet learning media. *INVOTEK: Jurnal Inovasi Vokasional Dan Teknologi*, *21*(3), 221–233. https://doi.org/10.24036/invotek.v21i3.957

Prasetya, F., Fortuna, A., Samala, A. D., Fajri, B. R., Efendi, F., & Nyamapfene, A. (2023). Effectiveness of Distance Learning Computer Numerical Control Based on Virtual Laboratory Using a Metaverse Platform to Improve Students' Cognitive Ability and Practice Skills. *International Journal of Interactive Mobile Technologies (IJIM)*, *17*(24), 4–21. https://doi.org/10.3991/ijim.v17i24.45019

Prasetya, F., Fortuna, A., Samala, A. D., Rawas, S., Mystakidis, S., Syahril, Waskito, Primawati, Wulansari, R. E., & Kassymova, G. K. (2024). The impact of augmented reality learning experiences based on the motivational design model: A meta-analysis. *Social Sciences and Humanities Open*, *10*(February), 100926. https://doi.org/10.1016/j.ssaho.2024.100926

Prasetya, F., Syahri, B., Fajri, B. R., Wulansari, R. E., & Fortuna, A. (2023). Utilizing Virtual Laboratory to Improve CNC Distance Learning of Vocational Students at Higher Education. *TEM Journal*, *12*(3), 1506–1518. https://doi.org/10.18421/TEM123-31

Radović, S., Hummel, H. G. K., & Vermeulen, M. (2023). The mARC instructional design model for more experiential learning in higher education: theoretical foundations and practical guidelines. *Teaching in Higher Education*, *28*(6), 1173–1190. https://doi.org/10.1080/13562517.2021.1872527

Ruiz-cantisani, M. I., Ipiña-sifuentes, R., Lima-Sagui, F. del C., Flores, E. G. R., & Aceves-Campos, N. (2020). Virtual Reality as a tool for active learning and student engagement: industrial engineering experience. *IEEE Global Engineering Education Conference*, 1031–1037. https://doi.org/10.1109/EDUCON45650.2020.9125225

Sabitri, Z., Rahayu, S., & Meirawan, D. (2024). The implementation of augmented reality-based flipbook learning media in improving vocational school students ' critical thinking skills in the era of society 5 . 0. *Jurnal Pendidikan Teknologi Kejuruan*, *7*(1), 22–31. https://doi.org/10.24036/jptk.v7i1.35223

Samala, A. D., Govender, T., Tsoy, D., Bojic, L., Samala, A. G., Samala, M. P., Prasetya, F., Tri, D., Yanto, P., Zainul, R., & Fortuna, A. (2024). 3D Visualizations in Learning : An Evaluation of an AR + Core Application for Computer Hardware Education using the Hedonic Motivation System Adoption Model. *TEM Journal*, *13*(1), 466–475. https://doi.org/10.18421/TEM131-48

Samala, A. D., Usmeldi, Taali, Ambiyar, Bojic, L., Indarta, Y., Tsoy, D., Denden, M., Tas, N., & Dewi, I. P. (2023). Metaverse Technologies in Education: A Systematic Literature Review Using PRISMA. *International Journal of Emerging Technologies in Learning (IJET)*, *18*(5), 231–252. https://doi.org/10.3991/IJET.V18I05.35501

Sutikno, S. (2024). Enhancing supervision efficiency and satisfaction : Evaluating the impact of the e-monprakerin model on vocational high school apprenticeship monitoring. *Jurnal Pendidikan Teknologi Kejuruan*, *7*(2), 64–75. https://doi.org/10.24036/jptk.v7i2.36023

Voinea, L. (2018). Formative Assessment As Assessment for Learning Development. *Revista de Pedagogie - Journal of Pedagogy*, *LXVI*(1), 7–23. https://doi.org/10.26755/RevPed/2018.1/7

Waskito, Fortuna, A., Prasetya, F., Wulansari, R. E., Nabawi, R. A., & Luthfi, A. (2024). Integration of Mobile Augmented Reality Applications for Engineering Mechanics Learning with Interacting 3D Objects in Engineering Education. *International Journal of Information and Education Technology*, *14*(3), 354–361. https://doi.org/10.18178/ijiet.2024.14.3.2057

Yan, Z., Panadero, E., Wang, X., & Zhan, Y. (2023). A Systematic Review on Students' Perceptions of Self-Assessment: Usefulness and Factors Influencing Implementation. *Educational Psychology Review*, *35*(3), 1–28. https://doi.org/10.1007/s10648-023-09799-1

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), 1–12. https://doi.org/10.29333/ejmste/11923