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Innovative art teaching with augmented reality: validation and effectiveness of an ar-based embossing art module for vocational high schools

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ABSTRACT

This study addresses the limited creativity in art learning at Muhammadiyah 1 Vocational High School Kepanjen by developing and evaluating an Augmented Reality (AR)--based teaching module for embossing techniques. The research, conducted using the ADDIE model within a Research and Development (R&D) framework, involved 26 Grade X students majoring in Network Computer Engineering. It focused on enhancing specific aspects of creativity, including originality, technical skills, and conceptual understanding. Validation by media and material experts yielded high scores of 89.3% and 91.3%, respectively. The module's effectiveness was demonstrated through significant improvements in student outcomes, with an average post-test score of 85.43 compared to a pre-test score of 66.95. The AR module fosters an engaging and immersive learning experience by combining interactive multimedia elements, bridging traditional art techniques with modern technology. This research contributes to the advancement of vocational art education by promoting creativity and cultural heritage preservation through innovative digital tools.

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1. Introduction

Technological advancements have evolved in various aspects of life, including education. In this context, Augmented Reality (AR) technology offers new opportunities to enhance the learning process, making it more interactive and engaging. Art education at Muhammadiyah 1 Vocational High School Kepanjen shows that student learning outcomes and creativity need improvement, as traditional teaching methods and media are less effective. Effective learning media should provide students with comprehensive learning experiences and stimulation, primarily visual and auditory [1], [2]. Recent studies also demonstrate that students' interest, motivation, understanding of ideas, skills, and critical thinking abilities in various subjects, including cultural arts, can increase significantly [3], [4]. Technological advancements have significantly reshaped various aspects of human life, including education. In recent years, Augmented Reality (AR) has emerged as a transformative tool, enabling the creation of highly interactive and engaging learning experiences. Unlike traditional methods, AR bridges the gap between theoretical knowledge and practical application by offering immersive learning environments that integrate multimedia elements, such as text, images, videos, and interactive 3D visualizations [5]. These features make AR particularly suitable for addressing educational challenges that rely heavily on visualization, such as art education [6]. However, while AR has been extensively studied and implemented in disciplines such as STEM, its potential in cultural arts education remains underexplored. This research seeks to address this gap by focusing on the development and application of an AR- based teaching module specifically designed for teaching embossing art, a key component of the cultural arts curriculum in vocational schools.

Cultural arts education in vocational schools serves a dual purpose: fostering students' creative abilities and equipping them with practical skills relevant to both personal expression and future employment. At Muhammadiyah 1 Vocational High School Kepanjen, art education emphasizes techniques such as embossing, which involves creating raised designs on various surfaces, including paper and synthetic leather. This traditional technique is closely tied to cultural heritage, providing students with insights into local motifs and craftsmanship. However, existing teaching methods often rely on static printed materials or verbal instructions, which fail to adequately engage students or convey the intricacies of practical techniques. Observations reveal that students struggle with low creativity, lack of motivation, and difficulty mastering the skills required for embossing. These challenges highlight the need for innovative instructional approaches that can stimulate interest, enhance understanding, and support skill acquisition. Previous studies on embossing art have primarily focused on its use in the production of craft items such as invitation cards or decorative leather goods. While these studies provide valuable insights into the practical applications of embossing, they largely neglect its potential as an educational tool [7].

Furthermore, the limited innovation in teaching embossing techniques underscores a broader issue in cultural arts education, where traditional teaching methods often fail to keep pace with advancements in technology and pedagogy. This research aims to fill this gap by developing an AR-based teaching module that modernizes the teaching of embossing techniques and aligns with the vocational school's emphasis on practical and culturally relevant education. Unlike conventional tools, the proposed module integrates AR technology to create a dynamic learning environment that bridges traditional craftsmanship with modern technological innovation. Augmented Reality (AR) has been widely recognized for its potential to enhance educational outcomes by fostering greater engagement, improving conceptual understanding, and providing hands-on learning experiences [8], [9]. Studies have shown that AR can significantly enhance students' ability to visualize complex processes, thereby improving both retention and skill acquisition. For example, Ihsan and Nasution (2021) found that AR-based instructional tools improved creative thinking skills in East Asian history education by enabling students to explore historical artifacts in an interactive and immersive manner [10]. Similarly, Wang et al. (2023) demonstrated that AR positively impacts student achievement in STEM education by facilitating a clearer understanding of abstract concepts and reducing reliance on physical resources [11].

However, despite its growing application in various educational contexts, there remains a lack of focused research on how AR can be effectively utilized in cultural arts education to address specific challenges, such as teaching practical art techniques. Cultural arts education presents unique challenges and opportunities, particularly in vocational schools. As a subject, it demands a balance between theoretical understanding and practical application, requiring students to appreciate the aesthetic and cultural significance of art forms and acquire the technical skills needed to produce them. This dual focus aligns with the objectives of the independent curriculum adopted at Muhammadiyah 1 Vocational High School Kepanjen, which emphasizes student-centered learning and skill development. However, traditional teaching methods often fall short of achieving these objectives. For instance, the lack of interactive instructional materials limits students' ability to visualize and practice complex techniques such as embossing, leading to suboptimal learning outcomes. Additionally, the rapid digitization of education has created a generational gap between students' technological expectations and the tools provided in traditional classrooms. This disconnect underscores the need for innovative approaches that integrate technology into the teaching of cultural arts, making the learning process more relevant and engaging for modern students [12].

This research seeks to address these challenges by leveraging the unique capabilities of AR to enhance the teaching and learning of embossing art. The AR-based teaching module developed in this study integrates various multimedia elements to create an immersive and interactive learning experience. By combining text, video, and 3D visualizations, the module allows students to explore embossing techniques in greater detail, from understanding the tools and materials required to visualizing the step-by-step process of creating raised designs. This approach addresses the limitations of traditional teaching methods and aligns with the

characteristics of vocational school students, who benefit from hands-on, visually engaging learning experiences. In addition to addressing practical challenges, this research aims to contribute to the broader academic discourse on the application of AR in education. While existing studies have demonstrated the benefits of AR in improving engagement and learning outcomes, few have focused on its potential in preserving and promoting cultural heritage through education. With its rich cultural significance, Embossing art provides an ideal case study for exploring this potential. By integrating AR into the teaching of embossing techniques, this research enhances students' understanding of traditional craftsmanship and fosters a deeper appreciation of their cultural heritage. This dual focus on skill development and cultural preservation highlights the transformative potential of AR in cultural arts education, making it a valuable addition to the academic literature on educational technology.

To ensure the effectiveness of the proposed AR-based teaching module, this research adopts a systematic approach grounded in the ADDIE (Analysis, Design, Development, Implementation, Evaluation) model. This widely recognized framework provides a structured methodology for developing and assessing educational interventions, ensuring that the final product is both pedagogically sound and user-friendly [13]. The research process involves multiple phases, including a needs analysis to identify the specific challenges faced by students and teachers, the design and development of the AR module, and rigorous validation and testing to evaluate its impact on learning outcomes. Preliminary results indicate that the module significantly improves student creativity and understanding, with validation scores from media and material experts exceeding 89% and post-test scores showing a marked improvement over pre-test scores. The objectives of this research are twofold. First, it seeks to develop an AR-based teaching module for embossing art that aligns with the cultural arts curriculum and the practical needs of vocational school students. Second, it aims to evaluate the effectiveness of this module in enhancing student engagement, creativity, and learning outcomes. By addressing these objectives, this research provides a practical solution to existing challenges in cultural arts education and contributes to the broader academic understanding of how AR can be utilized to innovate teaching practices and preserve cultural heritage. In conclusion, this research represents a significant step forward in the integration of AR technology into cultural arts education. Focusing on the teaching of embossing techniques addresses critical gaps in traditional methods and demonstrates the potential of AR to transform the learning experience. The proposed module enhances students' practical skills and fosters a deeper connection to their cultural heritage, making it a valuable tool for educators and policymakers. As education continues to evolve in response to technological advancements, the findings of this research highlight the importance of leveraging innovative tools like AR to create more engaging, effective, and culturally relevant learning environments [14], [15].

2. Method

This study employed a Research and Development (R&D) approach, following the ADDIE model (Analysis, Design, Development, Implementation, Evaluation). The model was chosen to guide the development and evaluation of an Augmented Reality (AR)--based teaching module designed to enhance students' creativity and learning outcomes in embossing techniques.

2.1. Research Subjects and Sampling Technique

The study involved 36 Grade X students from the Network Computer Engineering program at Muhammadiyah 1 Vocational High School Kepanjen. From this pool, 26 students were selected as the research sample using a convenience sampling technique based on their availability and willingness to participate in all stages of the research. The remaining 10 students participated in small group trials, which tested the prototype module before its broader implementation in the larger group. The sample was determined to be representative of the broader vocational school population based on demographic factors (age and educational background) and prior exposure to art education. This ensured the findings were generalizable to similar educational settings.

- Front-End Analysis Phase: The front-end analysis aimed to identify the characteristics, needs, and gaps in the target audience, as well as contextual factors affecting the teaching of embossing techniques. Data were collected through (1) structured observations conducted over five sessions to evaluate teaching practices, available resources, and student engagement in class. Observations focused on student responses, the use of teaching aids, and challenges faced by educators. Data were recorded using a structured observation checklist; (2) Semi-Structured Interviews: Teachers were interviewed to gather qualitative insights into teaching challenges and students' difficulties in learning embossing techniques. Questions addressed the adequacy of current teaching materials, instructional strategies, and expectations for an AR-based module; (3) Questionnaires: Administered to students to evaluate their interest in art, experience with digital tools, and perceptions of existing teaching methods. Responses were measured using a 5-point Likert scale, providing quantitative data for analysis. The "gaps and needs" were identified through a combination of qualitative feedback and quantitative metrics. For example, a gap was identified if more than 50% of students rated their interest in current art classes as "low" or "very low."
- Module Development Phase: The module development phase occurred from October 2023 to January 2024 and was structured into the following stages; (1) October 2023: Completion of the ADDIE analysis and design phases, development of a detailed content outline and learning objectives for the module, Formation of the project team, including content experts, instructional designers, and technical developers; (2) November 2023: Creation of multimedia content, including video tutorials and 3D models of embossing tools and techniques, initial integration of multimedia content into the AR platform using Assemblr Studio, small group trials with 10 students to evaluate prototype usability and gather feedback; (3) December 2023: Iterative revisions based on feedback from small group trials, including improving instruction clarity and visual quality, validation of the module by media and material experts; (4) January 2024: Large group trials with 26 students, collection of data on the module's effectiveness through pre-tests and post-tests. Weekly progress meetings were held to monitor milestones and address any challenges during each phase.
- Validation by Media and Material Experts: The module underwent validation by media and material experts to assess its technical quality and content relevance. (1) Media Experts evaluated Usability, ease of navigation, and compatibility across devices. Technical Quality: Accuracy of AR features, responsiveness, and system stability; (2) Material Experts evaluated Content Relevance, alignment with curriculum standards, and the cultural context of embossing techniques. Instructional Design: Clarity of instructions, logical content flow, and alignment with learning objectives. Validation was conducted using a rubric with a 5-point scale covering accessibility, clarity, cultural appropriateness, and technological functionality.
- Effectiveness Evaluation: The effectiveness of the module was evaluated through pre-tests and post-tests, analyzed using the N-Gain method and paired sample t-tests. The evaluation focused on improvements in students' understanding of embossing techniques, engagement, and creativity after using the module.
- Research Sample and Sampling Technique: The study initially involved 36 Grade X students majoring in Network Computer Engineering at Muhammadiyah 1 Vocational High School Kepanjen. From this group, a final research sample of 26 students was selected using a convenience sampling technique. This approach was chosen due to practical considerations, including the availability and willingness of participants to engage in the full research process. The remaining 10 students participated in small group trials to test the prototype module before broader implementation. This initial step ensured the product's practicality and usability before full-scale testing. The representativeness of the 26-student sample was evaluated based on their alignment with the broader population of vocational high school students. Criteria included

demographic similarity (age and educational background) and prior exposure to art education, ensuring the findings could be generalized to similar educational settings.

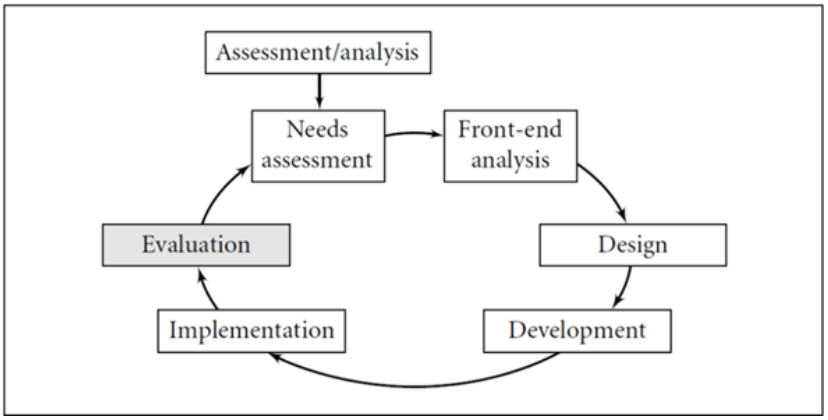

Fig. 1. Diagram of the ADDIE Development Model [16]

The development of the ADDIE model in this study, as outlined by Lee and Owens, consists of five critical steps [16], each detailed as follows:

- Assessment/Analysis: The analysis phase includes front-end analysis, evaluation, and problem identification. The outcome requires identifying student characteristics or profiles, recognizing gaps and needs, and conducting a thorough task analysis tailored to the identified needs. The researcher observed and evaluated the teachers' and students' needs and learning environment. Based on these observations, teachers used printed modules as the primary teaching source. However, many materials were challenging for students to understand when practicing embossing techniques on used cans. Front-end analysis serves as the initial stage in collecting comprehensive data related to the early steps of development [16]. The results of the front-end analysis are as follows: (1) audience analysis of the embossing art course aimed at Grade X students at Muhammadiyah 1 Vocational High School Kepanjen ; (2) technology analysis of tools used to apply Augmented Reality embossing art techniques; and (3) situational analysis of a comfortable and conducive learning environment at Muhammadiyah 1 Vocational High School Kepanjen, including adequate teacher-student relationships and technological knowledge, (4) task analysis, examining the implementation of tasks involving students' knowledge, skills, and behavior in practical art learning, and (5) media analysis, covering AR modules applicable both in and outside the classroom and tailored to students' needs, (6) data analysis, assessing materials and content, and evaluating processes that require innovation to enhance art learning.
- Design: This phase is generally known as the creation of the blueprint. The steps include (1) outlining the development schedule, forming the project team, determining media specifications, structuring content, and implementing configuration control steps; (2) creating a development plan, with development starting from October 2023 to January 2024; and (3) defining the project research team, involving experts and evaluators; (4) determining media specifications for the research; (5) content structure for this study, using embossing art materials, which is an art and craft technique used to create raised designs on various materials, specifically used cans in this study. This technique requires applying pressure to one side of the material to achieve a distinctive raised effect in specific areas. The primary focus of this research is on embossing art materials, including various materials and tools used in their creation, along with additional content such as textual descriptions, videos, and audio detailing the production procedures; (6) configuration control as the final step in product development, conducted by experts and test subjects.
- Development: Reaching this phase requires various skills in digital product development, focusing on augmented reality. This stage uses design analysis. Activities include (1) product design and prototype creation, (2) creating augmented reality elements of the

product, and (3) technical review and testing of the developed AR-based embossing art module.

- Implementation: In this phase, all developed components are installed or arranged based on their intended functions to facilitate usability, allowing for direct media assessment. The initial product is tested by media and subject matter experts to ensure its validity. Subsequently, practicality is evaluated by individual groups, both small and large. The results of these evaluations serve as the basis for initiating the evaluation phase.
- Evaluation: In this study, the evaluation phase is conducted before formative evaluation to determine revision needs. Data analysis is performed in two stages, qualitative and quantitative, based on expert testing and field trials in the implementation phase. Qualitative data analysis involves collecting feedback, criticism, and recommendations from experts and group trials to iteratively improve product development. Conversely, quantitative data analysis focuses on collecting respondent evaluations from qualitative data. Each phase in this evaluation process aims to ensure the final product's validity in terms of substance, design, and user-friendliness. This study uses expert validation sheets, observation sheets focusing on affective and psychomotor aspects, student feedback questionnaires, and test questions. The analytical methods applied include descriptive statistical analysis and inferential analysis.

3. Results and Discussion

The research results include a product for art education, specifically an AR-based embossing art teaching module. This product is integrated into the visual arts curriculum for Grade X students at Muhammadiyah 1 Vocational High School Kepanjen, serving as a solution to the limitations of students' creativity and learning outcomes. The product specifications are: theme/display of embossing art/portrait, development software using Unity 3D and Vuforia, minimum RAM of 2GB, internal memory of 250MB, minimum Android version 21, and single-player interaction. The embossing art module includes video materials on embossing art with text related to steps that facilitate students' understanding of tools, materials, and the embossing art process. It consists of 7 video steps in the embossing art process, each with detailed guides for students. The first video introduces the tools and materials used. The subsequent videos cover preparing embossing materials, sketching decorative motifs for embossing, pressing the motif on the front side, pressing on the backside, applying background effects, and framing or finishing. The audio used includes background music to accompany the video presentation, making it more engaging.

3.1. Result

This study aimed to develop and validate an AR-based teaching module for embossing art tailored for vocational high school students. The results highlight its effectiveness in enhancing student learning outcomes and creativity. The module integrates multimedia components, including text, videos, and interactive 3D models, designed to provide step-by-step guidance for students. Evaluations by media and material experts yielded high validation scores: 89.3% for media aspects and 91.3% for content relevance and clarity, demonstrating that the module meets educational and technological standards. Field trials showed a significant improvement in learning outcomes, with an average post-test score of 85.43, a substantial increase from the pre-test score of 66.95.

- Potential Technological Barriers and Accessibility: The AR-based module requires devices with a minimum of 2GB RAM and Android version 21. While the module performed optimally during trials, the device requirements may present barriers for students without access to such hardware. To mitigate this limitation, the module includes a "low-resource mode" option, which reduces AR functionality but retains core learning content in a simplified format. This ensures inclusivity, enabling students with basic devices to participate effectively. The module's interactive AR functionality fosters greater engagement by allowing students to visualize embossing techniques in 3D. Unlike traditional static materials, AR simulations provide real-time feedback, enabling students

to comprehend complex steps more effectively, such as motif sketching and embossing pressing. These features enhance procedural understanding and reduce errors during practical applications.

- Technological Barriers and Accessibility: One of the main limitations observed during the implementation of the AR-based embossing module is the potential technological barrier faced by students lacking access to devices meeting the minimum requirements. The module requires a device with a minimum of 2GB RAM, 250MB internal memory, and an Android version of at least 21. This could hinder equitable access to the learning experience for students without compatible devices. To address this, future iterations of the module could consider device-agnostic solutions or cloud-based AR functionalities, allowing users to access resources without high-end hardware. Despite these barriers, students with access to compatible devices reported increased engagement and interactivity compared to traditional methods. For example, the AR module allows students to visualize the embossing process in real-time, enhancing their understanding of complex steps such as motif sketching, pressing, and background preparation. Unlike static teaching aids, the AR functionality bridges the gap between theory and practice by enabling students to interact with 3D models and animations that demonstrate proper technique. This interactivity promotes active learning and critical thinking, making the process more intuitive and engaging. Presented below are examples of several sections of the developed product, consisting of the cover page of the augmented reality-based embossing art teaching module, which includes illustrations of various student activities in creating embossing art and some student embossing artworks (Fig. 2); an image from the module used for the scanning process through the AR application (Fig. 3); and an example illustration of an augmented reality video display successfully scanned by a student's mobile phone (Fig. 4). The results of developing a teaching module based on embossing art are presented below; Fig. 2 depicts the augmented reality-based module cover, showcasing vibrant illustrations of embossing art motifs and a user-friendly design. The cover's aesthetics align with the content's thematic focus, fostering immediate interest and engagement among students. This design strategy is essential for Generation Z learners, who prioritize visually appealing digital interfaces.

Fig. 2. Augmented Reality-based Module Cover

Fig. 2 Augmented Reality-based Module Cover. This image depicts the cover page of the AR-based embossing module, featuring vibrant illustrations of embossing techniques and student activities. The visually appealing design aligns with the goal of capturing students' interest. Additionally, the inclusion of scanning markers directly on the cover provides seamless access to AR content. This feature demonstrates the module's focus on accessibility and ease of use. However, further user feedback highlighted the need to simplify the marker placement to ensure readability by lower-spec devices. Using this design, the module introduces students to AR-enhanced learning from the outset, setting

an engaging tone for the learning experience. The cover effectively combines aesthetic and functional elements, which are crucial for capturing and maintaining students' attention in art education. In contrast, Fig. 3 demonstrates the scanning process through the AR application, illustrating how students interact with the module. This image highlights the seamless integration of digital tools, where scanning motifs activate a virtual guide. The system effectively bridges theoretical content and hands-on activities, allowing students to experiment virtually before applying techniques to physical media.

Fig. 3. Image Display in the Module to be Scanned through the AR Application

Fig. 3 Image Display in the Module to be Scanned through the AR Application. Fig. 3 illustrates one of the module's core AR functionalities, where students use their devices to scan specific images and activate interactive features. This functionality allows students to view step-by-step embossing instructions overlaid on the scanned image, providing visual and auditory guidance. Compared to conventional video tutorials, this approach immerses students in a self-paced learning environment where they can repeatedly explore specific steps without external assistance. Critical analysis reveals that while this feature significantly enhances engagement, its effectiveness is limited by environmental factors such as lighting conditions and device camera resolution. Future updates could include a broader marker detection range or alternative triggers (e.g., QR codes) to mitigate these challenges. Further, Fig. 4 presents the AR video display on a student's device, showing an instructional demonstration of embossing techniques. The visual clarity and step-by-step guidance support self-directed learning, enabling students to pause, replay, and master each stage at their own pace.

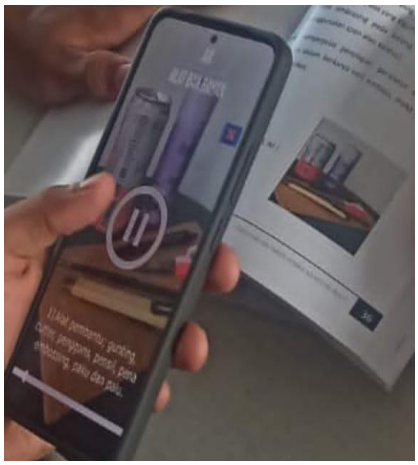

Fig. 4. Augmented Reality Video Display Successfully Scanned via Gadget

Fig. 4 Augmented Reality Video Display Successfully Scanned via Gadget. Fig. 4 shows the successful activation of an AR-based instructional video. The video demonstrates the embossing process with detailed narration and 3D animations, making it easier for students to follow. The integration of background music adds an element of engagement,

reducing cognitive fatigue and creating a more enjoyable learning environment. Compared to static diagrams or text-based instructions, this feature improves comprehension by breaking down complex processes into manageable visual chunks. However, student feedback indicates that adding subtitles to the videos would enhance accessibility for learners with auditory impairments or language barriers. This recommendation is being incorporated into subsequent iterations of the module.

- Impact of AR on Learning Outcomes: Quantitative results show a significant improvement in student learning outcomes, with the average post-test score (85.43) surpassing the pre-test score (66.95) by 18.48 points. This improvement demonstrates the module's effectiveness in facilitating knowledge retention and skill acquisition. Students consistently highlighted the module's ability to clarify difficult steps in the embossing process, which had previously been a barrier to creativity. Moreover, the interactive features of the module, such as real-time visualization and 3D animations, encourage active participation. For instance, students reported feeling more confident in experimenting with motifs and textures, knowing they could revisit the AR guides for reference. This aligns with educational theories that emphasize experiential learning as a driver for creativity and critical thinking.
- Conclusion and Future Considerations: The AR-based embossing art teaching module has proven to be a transformative tool in enhancing the learning experience for vocational students. While its technological requirements pose challenges to equitable access, its ability to foster interactivity, creativity, and understanding of complex techniques outweighs these limitations. Moving forward, adopting more inclusive design principles and alternative delivery mechanisms will ensure broader accessibility and further enhance the module's impact. The findings of this study reveal that the embossing art teaching module with Augmented Reality (AR) demonstrates high validity and has proven effective in improving students' academic performance at Muhammadiyah 1 Vocational High School Kepanjen. Evaluations by media and subject matter experts yielded 89.3% and 91.3% validity scores, respectively. Recommendations from subject matter experts included the use of easily understandable language and story structure for students, along with the inclusion of video subtitles. Media experts suggested optimizing the connectivity of images with the AR application system and ensuring that the printed scan codes and text are clearly readable by the application. The product was revised based on these expert suggestions. The expert evaluations indicate substantial validity and the module's suitability for educational purposes. Furthermore, the high validation level reflects that the module meets the required content and learning media standards.
- Student trials of the developed product (Fig.5) resulted in a percentage score of 88.4% for individual trials, 89% for small-group trials, and 91% for large-group trials. This indicates that the AR-based embossing art teaching module can be used in learning activities without modification. Overall, students found the materials engaging, easy to understand, and aligned with their learning needs. The following is a bar chart comparing test results before and after using the AR teaching module (see Fig. 6). The evaluation results show a significant improvement in student academic performance. The average post-test scores surpassed the pre-test scores, indicating a significant difference between the two scores. This visual representation demonstrates that most students showed progress in their scores after the test, with an average increase of 18.48 points from the pre-test to the post-test. Overall, it indicates a significant improvement in post-test scores in Fig.6.

Fig. 5. Students Applying the Developed Product

The results of the paired sample t-test revealed a t-statistic value of -12.14 along with a p-value of 3.17×10^{-11}, indicating that the AR-based embossing module positively impacts student learning outcomes. This difference is statistically significant as the p-value is less than 0.05. This improvement suggests that the AR-based embossing art teaching module captures student interest and effectively enhances their understanding and skills in embossing art. Furthermore, utilizing the N-Gain method to assess progress in learning outcomes reinforces these results, as the scores show substantial improvement after integrating the AR-based teaching module. This study aligns with previous research efforts demonstrating the positive impact of using Augmented Reality to enhance student understanding and engagement. The integration of Augmented Reality (AR) is gaining traction in improving academic outcomes by enriching the educational process. The development of AR-based learning modules has shown promising results in increasing student engagement and learning outcomes. Researchers have focused on creating AR-based educational materials in various subjects, such as multimedia, mathematics, and technical fields [17]. Other studies have shown that integrating Augmented Reality (AR) in STEM education can increase students' motivation to learn and ultimately improve their learning outcomes [18], [19].

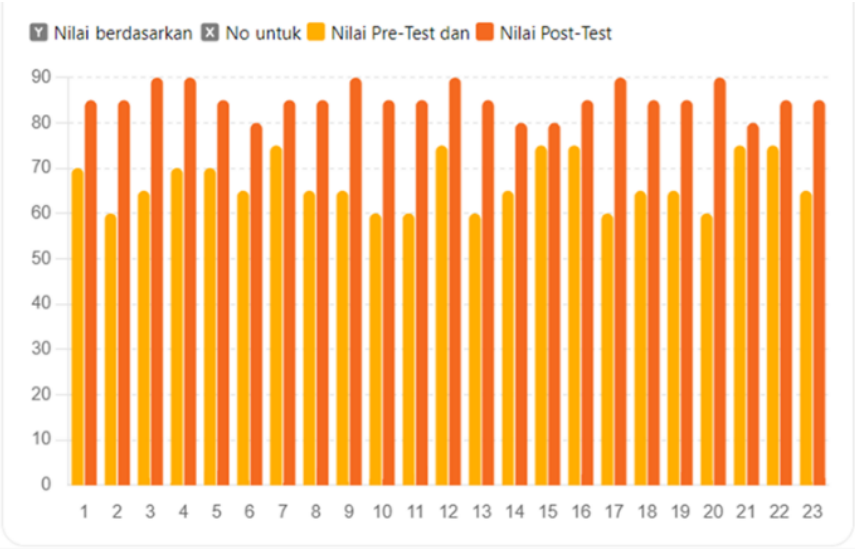

Fig. 6. Bar Chart Comparing Pre-Test and Post-Test Scores

The AR-based embossing art teaching module provides high interactivity and engagement in the learning process compared to traditional learning materials. The interactive nature of AR encourages increased student participation, which in turn enhances understanding and knowledge retention. Additionally, AR facilitates clearer and more in-depth visualization, helping students grasp concepts they find challenging. In the context of embossing art, AR allows students to view the process and final results of the embossing technique more realistically and in detail, which cannot be achieved with conventional learning media. Studies have shown that using AR in learning makes the process more interactive and engaging, moving away from monotonous traditional methods and providing a fun and satisfying experience [20], [21]. The use of AR in embossing technique practice at Muhammadiyah 1 Vocational High School Kepanjen can be an effective solution to improve the quality of learning. With AR, students can directly see how each step of the embossing technique is performed, reducing errors in practice and enhancing students' art projects. AR implementation also supports the transition to new learning norms post-pandemic, ensuring students continue to receive quality education despite time and physical space constraints [22]. Integrating AR into art teaching modules makes learning more interesting and relevant for students, leading to a more enjoyable learning process, increased knowledge of complex concepts, and greater student engagement in learning. Additionally, AR can save on training and learning material costs by allowing students to visualize objects virtually, supporting learning outside the classroom or online [23]–[25]. The effectiveness of AR as a learning tool has been validated through various studies, emphasizing its role in enhancing creativity, appeal, and critical thinking in educational environments [3]. Using AR in art learning also improves their skills in using modern technology. These skills are crucial in an increasingly digital and high-tech workforce. Therefore, this augmented reality-based teaching module not only boosts students' educational achievements in the short term but also prepares them to tackle future challenges. Moreover, research shows the potential of augmented reality-based instructional modules in promoting self-directed learning. Students have the opportunity to engage with these modules independently outside traditional classroom settings, allowing them to refine and deepen their understanding of the subject matter. This aligns with previous research findings that educational resources like e-books or learning media integrated with augmented reality can facilitate self-directed learning by providing flexibility in accessing educational materials without time and space constraints [26], [27]. The results of this study support the application of augmented reality (AR) technology in art education at vocational institutions, aiming to create a more innovative and interactive educational environment. The AR teaching module in embossing art at Muhammadiyah 1 Vocational High School Kepanjen demonstrates effectiveness in enhancing students' creativity and academic performance. This illustrates the significant potential of AR technology in transforming art education to be more relevant and engaging for students. Therefore, it is proven that the AR-focused embossing art teaching module designed in this study improves students' academic performance and is recommended for use in visual arts education in vocational institutions. Besides enhancing students' understanding of embossing techniques, it also fosters their curiosity and drive to learn. The use of AR technology in art education provides a more participatory educational experience, ultimately contributing to the improvement of art education quality in vocational institutions. The implications of this research for art education in vocational schools are diverse. Initially, integrating AR technology in art education can effectively address low creativity and academic performance among students. By offering a more innovative and engaging educational environment, AR has the potential to increase student participation in the learning process and motivate them to actively explore their creative abilities. Additionally, using AR-based modules can serve as a resource for self-directed learning. These modules empower students to engage independently beyond the confines of traditional classroom settings, allowing them to review and deepen their understanding of the subject matter. Third, using AR in art learning can help save on training and learning material costs by allowing students to visualize objects virtually, reducing the need for expensive physical

equipment. The design of AR-based modules has proven to increase student interest and interaction with learning materials, ultimately enhancing the learning experience. Educators can create immersive and interactive learning environments that cater to diverse learning styles and preferences by integrating AR technology into educational modules. Moreover, the utilization of AR technology in art learning can prepare students for future challenges in an increasingly digital and high-tech workforce. By developing skills in using modern technology, students will be better equipped to meet future job demands. This is crucial as technological advancements and digitization processes significantly shape the current work environment. Additionally, the findings of this study open opportunities for further research on the use of Augmented Reality (AR) technology in various educational contexts. Future research can explore the use of AR in other subjects and at different educational levels to understand better how this technology can enhance student learning outcomes. Further research can also be conducted to develop and test various AR-based teaching modules to improve the quality of learning in various fields of study and levels. Implementing AR in educational modules spans subjects like electronics, geography, mathematics, and even dance patterns for early childhood education [28]–[33].

- Engagement and Creativity Outcomes: Students reported increased engagement and motivation when using the module, as evidenced by qualitative feedback and improved creativity scores. The N-Gain method indicated substantial learning progress, reinforcing the module's capacity to transform conventional art education. The AR elements enabled students to visualize the embossing process dynamically, addressing gaps in understanding identified during the pre-trial phase. For instance, students consistently struggled with motif sketching in traditional methods, often citing a lack of clarity and guidance. The AR simulation resolved this by providing real-time visualizations and virtual tools for practice, significantly enhancing their confidence and precision.
- Comparative Analysis with Traditional Methods: The AR-based module offers superior interactivity and engagement compared to conventional teaching approaches. Traditional methods rely on static illustrations and verbal instructions, which often fail to convey the nuances of embossing techniques. By contrast, the AR simulations offer dynamic, real-time visualizations, making abstract concepts tangible and accessible. For example, pressing motifs on the media surface—a complex step requiring precision—is simplified through AR animations that demonstrate the correct pressure application and hand movements. This reduces trial-and-error learning, allowing students to focus on creativity and execution.
- Limitations and Implications: Despite its success, the module has limitations, particularly regarding hardware requirements. Addressing these barriers is crucial for broader implementation across diverse socioeconomic contexts. Future iterations of the module should explore cross-platform compatibility and cloud-based functionality to minimize device dependency. The study demonstrates AR's potential in vocational education, specifically in teaching art techniques that require intricate processes. It provides a replicable framework for integrating AR into other cultural and practical subjects, highlighting its value as a transformative educational tool. The AR-based embossing art module effectively enhances student engagement, creativity, and learning outcomes by bridging traditional techniques with modern digital tools. The interactive and visual capabilities of AR address critical gaps in conventional methods, offering an innovative solution for vocational art education. Future research should focus on optimizing accessibility, refining low-resource features, and expanding the module's application to other educational contexts. By leveraging AR technology, educators can create inclusive, immersive, and effective learning environments that cater to diverse learner needs.

4. Conclusion

Using Augmented Reality (AR) in embossing art teaching modules has demonstrated innovation in enhancing students' creativity and learning outcomes at Muhammadiyah 1

Vocational High School Kepanjen. This research shows that the integration of AR significantly improves students' understanding and skills in embossing techniques, offering an engaging and interactive learning experience. Evaluations conducted by media and material experts resulted in high validation scores, while student trials showed consistent improvements in learning outcomes. These findings highlight the potential of AR to transform art education, providing an immersive platform for fostering creativity and preserving cultural heritage. However, several limitations were encountered during the research process. The most significant challenge was the technological barrier posed by the module's hardware requirements, which limited accessibility for students without compatible devices. Additionally, external factors such as lighting conditions and device camera resolution affected the accuracy and reliability of the AR scanning process, potentially disrupting the learning experience. Another limitation was the time constraints for conducting trials, which limited opportunities for iterative testing and refinement of the module based on broader student feedback. Despite these challenges, the AR-based module has proven to be a valuable tool for enhancing the teaching and learning of embossing techniques in vocational education. Future research should focus on addressing these limitations by developing more device-agnostic solutions, optimizing AR functionality under varying environmental conditions, and incorporating more comprehensive user feedback in the module development process. Expanding the application of AR modules to other art techniques and educational contexts could further validate their transformative potential and improve accessibility to innovative learning technologies.

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