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The Practicality of STEAM Based Augmented Reality (AR) Learning Media for Vocational High School Students in Robotic System Subject

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Abstract: This study aims to create and implement STEAM-based Augmented Reality (AR) learning media for the class XI robotics systems curriculum at SMK N 1 West Sumatra. The research follows a Research and Development (R&D) approach using the ADDIE development model. Participants included class XI students and robotics systems teachers. Data collection methods comprised questionnaires and interviews, with descriptive data analysis employed to assess the validity and practicality of the developed learning media. The findings indicate that the STEAM-based AR learning media is effective. According to media expert validation, the average score was 0.88 (≥ 0.66), categorizing it as valid. Material expert validation yielded an average score of 0.85 (≥ 0.66), also marking it as valid. The practicality assessment showed that teacher responses averaged 90.14%, and student responses averaged 92.03%, both rated as very practical. Consequently, the STEAM-based AR learning media is considered suitable for class XI robotics systems at SMK N 1 West Sumatra, based on the validity and practicality tests.

Keywords: Augmented Reality (AR); Learning Media; STEAM; Vocational High Schools

Introduction

Learning media can be defined as tools that facilitate communication between the sender and the receiver. These media act as a channel that conveys messages from the communicator to the audience (Sukma et al., 2022). In other words, learning is essentially a communication process. Specifically, in an educational context, media are often regarded as graphic, photographic, or electronic tools used to capture, process, and restructure visual or verbal information (Mustofa, 2020).

According to this opinion, learning media are physical tools such as objects, printed materials, audio, visual, multimedia, and others that are designed creatively to convey information to students. The aim is to build effective communication so that students can understand the material or information presented well (Jalinus & Ambiyar, 2016). Based on this opinion, it can be concluded that learning media functions as a means of conveying messages from learning sources, such as books or modules, to students in order to create a conducive, efficient and enjoyable learning environment.

Learning elements Robotic systems are learning elements that must be studied by Mechatronics Engineering skill concentration students. The learning elements of this robotic system have discussions in the form of theory and practice and hone the skills of reasoning, processing and presenting practically, creatively, productively, critically, independently, collaboratively, communicatively and solutions in the abstract realm related to the development of what they learn at school. and able to carry out specific tasks under direct supervision (Guna & Risfendra, 2022).

Augmented Reality (AR) is a technology that integrates two-dimensional and three-dimensional objects into a real environment, then projects these objects in real-time. These virtual objects provide information that humans cannot receive directly (Chen

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et al., 2020). This makes AR a useful tool for improving user perception and interaction. For example, when a television presenter delivers news, there is an animation or virtual object that appears with him, as if he were in that virtual world. In fact, this is a technique for combining the virtual world with the real world (Sabil et al., 2022).

From the explanation above, Augmented Reality (AR) can be simply defined as a real environment enhanced with virtual objects. This integration of real and virtual elements is facilitated through suitable display technology. The primary aim of AR is to create an immersive environment by blending activities from both the real and virtual worlds, making users perceive the combined environment as real (Nurfaizi et al., 2022). The elements displayed give a realistic impression to the objects used, thus making the use of AR popular in learning media (Ramadani et al., 2023).

STEAM (Science, Technology, Engineering, Art, and Mathematics) is a learning approach that combines five fields of science, which is a development of STEM (Science, Technology, Engineering, and Mathematics) education by adding art (Art) to the learning process (Guna & Risfendra, 2022). The STEAM-based learning approach is highly appreciated because it is able to develop students' potential in critical thinking, problem solving, and solving problems. Boring and uninteresting learning often causes a decrease in students' interest, creativity and involvement in the learning process (Fri & Risfendra, 2021).

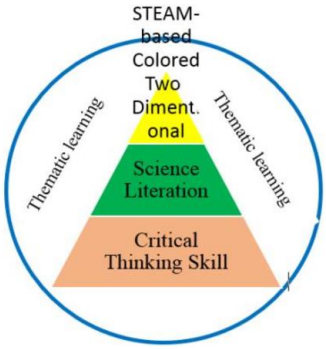

Figure 1. STEAM Learning Approach

Integrating STEAM-based learning media, students will get new opportunities to learn design directly and produce work with creativity and good problem solving skills (Daryanto et al., 2022). This is explained in the lesson as follows: Science includes unders tanding material concepts such as experiments, natural phenomena, social conditions, the environment, and changes in objects, Technology includes the use of tools, basic equipment, simple technology, as well as innovations, changes, or modifications from nature that are made to meet human needs, Engineering explains the techniques used by students in designing goods and the process of completing learning, Art includes culture, music, students' ability to express ideas, and generate creativity and Mathematics includes measurements, number concepts, calculation formulas, or shapes that students apply in the learning process.

The use of Augmented Reality (AR) in the STEAM learning approach has attracted the interest of researchers, educators and educational practitioners. Various studies and AR implementation projects have been carried out to measure its impact, and the results show extraordinary potential in increasing knowledge logically, critically, creatively and innovatively (Alkhabra et al., 2023).

When developing Augmented Reality (AR) experiences, the Vuforia SDK is essential. Vuforia SDK is an AR software that utilizes a mobile device's screen to display an AR environment where real and virtual elements coexist. Vuforia serves as a platform for storing and managing various AR assets and functionalities, enabling seamless integration of virtual objects into the real world (Febyola & Aswardi, 2021). Vuforia transforms standard 2D images or specific patterns into detectable markers that can be recognized by the camera. This allows the AR system to overlay virtual content onto these images or patterns when viewed through the device.

SketchUp is software that functions in graphic design of 3-dimensional models, designed for professionals in the fields of civil engineering, architecture, game creation, film, and various other related designs. This software allows the creation of realistic 3-dimensional designs, as well as related graphic design and animation. SketchUp is a 3D modeling tool designed for architects, civil engineers, filmmakers, game developers, applications and other professions working in the 3D field (Molina & Thamrin, 2021).

Unity 3D is a multiplatform game engine developed by Unity Technologies. Unity 3D includes a game engine and integrated development environment (IDE) in one package. Unity 3D can be used to create video games for websites, desktops, various types of consoles, and mobile devices (Hamdani & Sumbawati, 2021).

Android is an operating system utilized on smartphones and tablets, as well as some PCs. It encompasses not only the operating system but also middleware and key applications provided by Google. To develop applications for the Android platform, developers use the Android SDK (Software Development Kit), which includes tools and libraries. Additionally, the Android API (Application Programming Interface) is essential for creating apps, allowing programmers to utilize various programming languages to build and customize their applications (Febyola & Aswardi, 2021).

Method

This research is categorized as Research and Development (R&D) and employs the ADDIE development model. (Arikunto, 2012). The ADDIE model comprises five stages: Analysis, Design, Development, Implementation, and Evaluation (Sabil et al., 2022). In this research, the ADDIE development model is used to create Augmented Reality (AR)-based learning media integrated with STEAM, as illustrated in Figure 2.

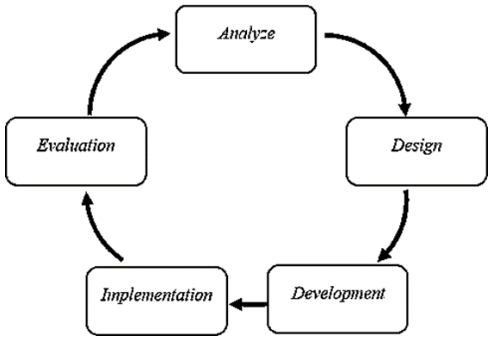

Figure 2. ADDIE Development Model

Table 1. Data collection technique

Data type	Method	Data source
Information learning resources	Guidelines interview	Teacher of robotic systems subject XI mechatronics engineering
Learning characteristics	Instrument questionnaire	Student xi mechatronics engineering at smkn 1 sumbar
Response User	Instrument questionnaire	Teachers and students in robotic systems subject XI Mechatronics Engineering.

Table 2. Media and Material Validity Level Criteria

Achievement Level	Category
≤ 0.666	Tidak valid
> 0 .667	Valid

At the data analysis stage, researchers used a Likert scale with five alternative answers to provide meaning and support decision making regarding testing to ensure that the media used functions practically (Ahmad, 2023). This process includes validation and practicality testing. Validity testing is carried out using the Aiken's V statistical formula to determine the validity of media and learning materials, with validity categories which can be seen in Table 2.

The next phase is practicality testing, which involves assessing the media's usability through a questionnaire that gathers feedback from both teachers and students. The classification of media practicality can be observed in the results Table 3.

Table 3. Kriteria Tingkat Validitas Media dan Materi

Achievement Level (%)	Category
0.00 - 25.00	Very impractical
25.01 - 50.00	Impractical
50.01 - 75.00	Quite practical
75.01 - 100	Very practical

All research follows systematic steps to ensure that STEAM-based Augmented Reality (AR) learning media is a valid and practical media. This research was applied in learning robotic systems for class XI Electronics Engineering with a concentration in Mechatronics Engineering at SMK Negeri 1 West Sumatra.

Result and Discussion

Result

Analysis

During the Analysis stage of this research, two key aspects were examined: Curriculum Analysis and Needs Analysis. Curriculum Analysis was conducted through interviews with robotic systems subject teachers at SMKN 1 West Sumatra. Needs Analysis focused on developing media that incorporates learning materials, 3D images, assignments, games, and evaluations, with an emphasis on enhancing student creativity, which is deemed crucial for the learning process (Nurlaela et al., 2021).

Design

In the design stage of STEAM-based Augmented Reality (AR) learning media, the process is guided by Learning Outcomes (CP), Learning Objectives (TP), and the Flow of Learning Objectives (ATP). The media developed will feature learning materials, 3D images, assignments, educational games, and evaluations. Apart from that, at this stage a design is also carried out which includes designing the functional model of the software and designing the software. The design of the functional model is illustrated through use case diagrams and activity diagrams (Harta et al., 2021), as can be seen in Figure 3.

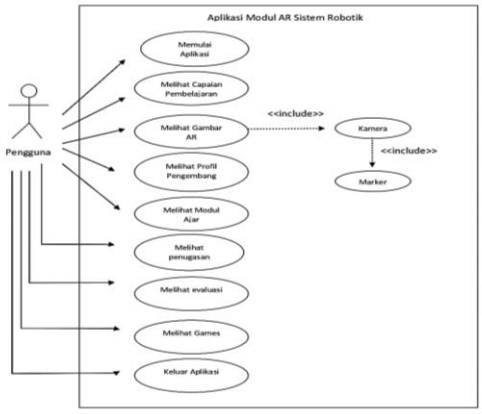

Figure 3. Use Case Diagram

Based on the activity diagram, the process starts with the user pressing the AR image menu button on the main page of the application. The application then displays menu options for input, process, and output components. Users will point their smartphone camera at the marker, namely the AR module. The application will detect the marker; If the marker detected matches the one in the application, the application will display a 3D object (Harta et al., 2021). After that, users can zoom in, zoom out and rotate the 3D object. The use of activity diagrams for AR Camera Media can be seen in Figure 4.

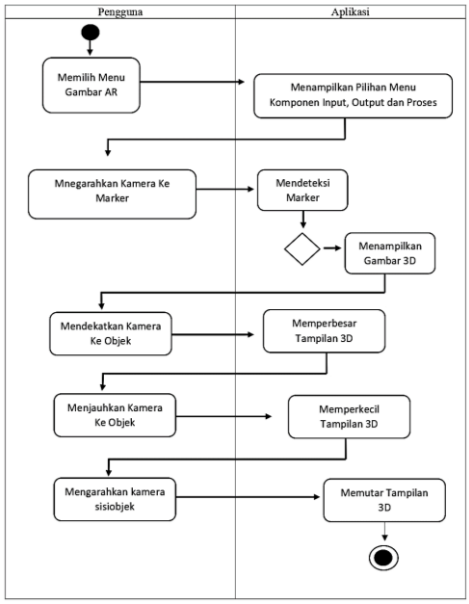

Figure 4. AR Camera Media Activity diagram

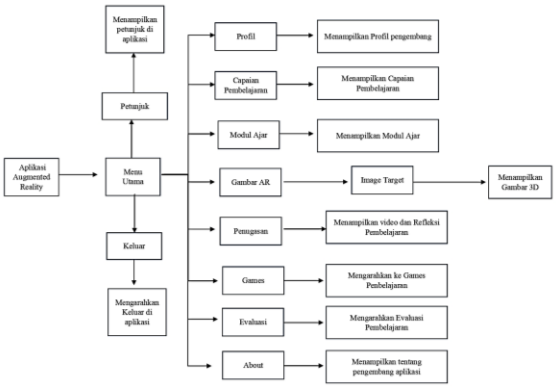

Figure 5. Structure Chart of Augmented Reality (AR) Application

The results of designing media designs include several elements such as Profiles, Learning Outcomes (CP), materials, AR images, assignments, learning evaluations, games, as well as about and out options. The media display that has been designed can be seen as follows: initial Appearance of Augmented Reality (AR) Media; and the home page displays a button that leads to the main view. This media can be seen in Figure 6.

Figure 6. Initial View

Main Display of Augmented Reality (AR) Media

The main view includes features such as Learning Outcomes (CP), modules, AR images, assignments, learning evaluations, games, information about the application, and instructions. This display can be seen in Figure 7.

Figure 7. Main View

Augmented Reality (AR) Media Profile Display

The Media Profile display provides information about the lecturers who guided the developers in this research. This display can be seen in Figure 8.

Figure 8. Profile View

Display of Augmented Reality (AR) Media Learning Achievements

The Learning Outcomes display provides details about learning outcomes, objectives, and the sequence of these objectives. This information is illustrated in Figure 9.

Figure 9. Display of Learning Achievements

Augmented Reality (AR) Media Module Display

The module display presents teaching material as well as symbol images that function as markers in Augmented Reality (AR) and also accompanied by project-based worksheets on learning. This display can be seen in Figure 10.

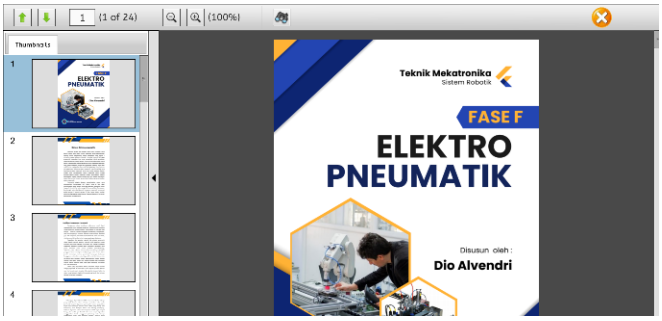

Figure 10. Media Module Display

AR Image Display Augmented Reality (AR) Media

Image Display includes input components, process components, and output components. This display can be seen in Figures 11 and 12.

Figure 11. Augmented Reality (AR) Image Display

Figure 12. 3D Image View

Augmented Reality (AR) Media Assignment Display

The assignment display consists of four parts, namely video 1, video 2, video 3, and reflection. This display can be seen in Figure 13.

Figure 13. Assignment display

Augmented Reality (AR) Media Games Display

The games display includes two learning games, namely maze chase and balloon pop. The appearance of this game can be seen in Figure 13 and 14.

Figure 14. Initial appearance of the game

Figure 15. Game Display

Augmented Reality (AR) Media Evaluation Display

The evaluation display presents evaluation tests in the form of interactive questions consisting of objective questions. This display can be seen in figure 16 and Figure 17.

Figure 16. Learning Evaluation Display

Figure 17. Display of Learning Evaluation results

Display About/About Augmented Reality (AR) Media

The About display contains information about the learning media application developer. This display can be seen in Figure 18.

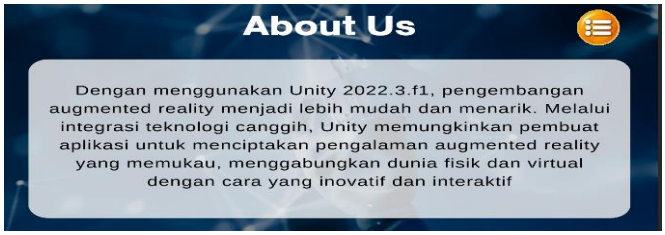

Figure 18. About display

The following is a paraphrase of the sentence:

The instructions display presents a guide to using the learning media being developed. This display can be seen in Figure 19 and 20.

Figure 19. Instructions for Media Use

Figure 20. Instructions for Media Use

Development

Validity Testing

The results of the validity test carried out by media experts show a validity value of 0.887, which exceeds the minimum limit set at 0.667. Thus, STEAM-based Augmented Reality (AR) learning media can be categorized as valid.

Table 4. Media Expert Validation Results

Assessment aspects	Mark validation	Category
Media design	0.90	Valid
Software	0.93	Valid
Benefit	0.81	Valid
Average	0.88	Valid

Apart from that, the validity test by material experts produced a validity value of 0.893, which also exceeds the minimum limit set, so it can be categorized as valid. These findings confirm that the material in STEAM-based Augmented Reality (AR) learning media is also feasible and valid. The results of media and material validity tests can be seen in Table 4 and Table 5.

Table 5. Material Expert Validation Results

Assessment Aspects	Mark Validation	Category
Material quality	0.88	Valid
Quality of learning	0.85	Valid
Quality of Interaction	0.83	Valid
Learning design	0.85	Valid
Average	0.85	Valid

Practicality Testing

Based on the assessment results, the practicality of the STEAM-based Augmented Reality (AR) learning media received an average rating of [insert average rating here 90.14% from teachers, categorizing it as very practical. Additionally, students' reactions to the media yielded an average rating of 92.03%, also classified as very practical. Overall, these results indicate that the developed media effectively aids teachers in their instruction and enhances students' understanding of the learning material. This information is detailed in Table 6 and Table 7.

Table 6. Teacher Practicality Data Results

Assessment Aspects	Mark validation	Category
Ease of ase aspect	88.89	Very practical
Aspects of Effectiveness of Learning Time	88.33	Very practical
Aspects of media Use	90.00	Very practical
Benefit aspect	93.33	Very practical
Average percentage (%)	90.14	Very practical

Table 7. Student Practicality Data Results

Assessment Aspects	Mark validation	Category
Ease of use aspect	92.58	Very practical
Aspects of effectiveness of Learning Time	91.35	Very practical
Aspects of Media Use	93.23	Very practical
Benefit aspect	92.03	Very practical
Average percentage (%)	92.58	Very practical

Implementation

The implementation phase, the fourth stage in the ADDIE development model, focuses on applying the STEAM-based Augmented Reality (AR) learning media developed in the previous stage. During this phase, researchers evaluated the practicality of the AR learning media, specifically assessing its ease of use and functionality (Sabil et al., 2022). The practicality of learning media is assessed to determine how effectively and efficiently it can be used in educational settings.

Evaluation

The final stage in the ADDIE development model is the evaluation phase, which represents the concluding step in the development process of STEAM-based Augmented Reality (AR) learning media for robotic systems subjects (Harta et al., 2021). At this stage, researchers evaluate how practical the learning media is. Evaluation is carried out after implementing the media through a questionnaire with a Likert scale. Using the collected data, researchers analyzed the level of practicality in developing learning media.

Discussion

The research produces valid and practical STEAM-based Augmented Reality (AR) learning media through the application of the ADDIE development model. (Harta et al., 2021). The first stage is Analysis, where needs in the learning process are analyzed to identify relevant problems, solutions and student competencies. The second stage is Design, which includes determining specific competencies, learning methods, teaching materials and teaching strategies. The third stage is Development, where programs and teaching materials are produced. The fourth stage is Implementation, where the learning program is implemented in accordance with the design or specifications that have been determined. The final stage is Evaluation, where the learning program is evaluated and learning outcomes are assessed.

The validity of the STEAM-based Augmented Reality (AR) learning media is assessed by media and material experts. According to the validation results, the media achieves a validity score of [insert validity score here 0.90 (≥ 0.667) in the Media Design aspect, 0.93 (≥ 0.667) in the Media Software aspect, and 0.81 (≥ 0.667) in the Media Benefits aspect. All these scores place each aspect in the valid category. The overall average validity score for the media is 0.88(≥ 0.667), which also falls into the valid category.

Meanwhile, validation results from material experts show that the media has a validity value in the Material Quality aspect of 0.88 (≥ 0.667), in the Learning Quality aspect of 0.85 (≥ 0.667), in the Interaction Quality aspect of 0.83 (≥ 0.667), and in the Learning Design Quality aspect is 0.85 (≥ 0.667). The results of this assessment place each aspect in the valid category. The average validity value in material validation is 0.85 (≥ 0.667), which is also included in the valid category.

The practicality of STEAM-based Augmented Reality (AR) learning media was measured through trials at SMKN 1 West Sumatra. The results show that the media has a practicality value in the Ease of Use aspect of 88.89%, in the Learning Time Effectiveness aspect of 88.33%, in the Media Use aspect of 90.00%, and in the Benefits aspect of 93.33%. The results of this assessment place each aspect in the very practical category. The average practicality value of teacher responses was 90.14%, which is also included in the very practical category.

The practicality of the media based on student responses shows that the media has a practicality value in the Ease of Use aspect of 90.97%, in the Learning Time Effectiveness aspect of 92.58%, in the Media Use aspect of 91.35%, and in the Benefits aspect of 93. 23%. The results of this assessment place each aspect in the very practical category, with an average score of 92.03%. Thus, the use of STEAM-based Augmented Reality (AR) media provides significant benefits in terms of validity and practicality, as well as offering innovative and interesting learning experiences for students. AR media integrates real-world environments with virtual elements, making the learning experience both engaging and enjoyable for students. By using AR, students can participate in direct experiences and virtual practicums, which actively involve them in the learning process and help them grasp concepts more concretely.

In addition, AR media helps students understand abstract concepts in a more concrete and visual way, and increases their involvement in learning (Daryanto et al., 2022). AR media also enables better personalization of learning according to students' individual needs and preferences, as well as supporting collaborative learning where students can work together in groups to complete learning assignments or projects (Chen et al., 2020). Thus, the use of STEAM-based Augmented Reality (AR) media in robotic systems subjects has met the quality criteria of validity and practicality. It has also garnered positive feedback from students, contributing to an innovative, engaging, and student-centered learning experience.

Conclusion

Based on the research and discussions regarding the development of STEAM-based Augmented Reality (AR) media for Robotic Systems Subjects at SMKN 1 West Sumatra, the validation results from experts indicate that the media is both valid and suitable for educational use. Media experts provided an average validity score of 0.88, while material experts gave an average score of 0.89, both of which are categorized as valid.The practicality assessment by teachers showed an average score of 90.14%, categorized as very practical. Similarly, student feedback indicated an average score of 92.03%, also classified as very practical. Overall, the development of this media is viewed positively, with validation and practicality assessments suggesting that it is engaging, effective, and user-friendly for learning. However, there are several aspects that need further attention and improvement. The development of STEAM-based Augmented Reality (AR) media still requires several improvements, considering the rapid development of science and technology. Therefore, it is important to continuously update the materials and technology used. For future developers, it is recommended to pay more attention to the appearance of 3D objects that are more attractive and more interactive in order to support the level of student interaction in the learning process.

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Conflicts of Interest
No conflict interest.

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