# DESIGN AND CONSTRUCTION OF AUGMENTED REALITY X-RAY LEARNING MEDIA WITH DUBBING SYSTEM AT AVIATION POLYTECHNIC SURABAYA

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**ABSTRACT**

*In the world of vocational education, innovative learning media is essential to improve understanding of technical and complex materials. In the learning process of the Goods and Person Inspection Detection Equipment course at the Surabaya Aviation Polytechnic, there are limited interactive and safe learning media to learn the structure and workings of X-Ray machines, where the use of real tools has radiation risks and limited access. Therefore, this study aims to Design and build Augmented Reality (AR)-based learning media equipped with a Dubbing system and visualizes X-Ray machine components in three dimensions and provides explanatory audio narration. The Development method used is ADDIE (Analysis, Design, Development, Implementation, Evaluation). In the Analysis stage, learning needs are identified and data are collected. The Design stage includes system Design, starting from the X-Ray machine visualization concept to the integration of the DUBBING system as an audio narration. Next, in the Development stage, learning media is developed using supporting software and initial testing of system functionality is carried out. Implementation by applying the developed media in the learning environment. Finally, Evaluation, an assessment of the feasibility and effectiveness of the learning media was carried out with the results of validation tests from media experts and respondents, so that media that is suitable for use in the learning process was obtained. The results of the study showed that this AR X-Ray media can be operated via a smartphone device equipped with interactive features so that it supports the delivery of material accompanied by voice narration. Based on the validation results by users and media experts, this media was declared suitable for use in the learning process and was proven to improve cadets' understanding of the material and be a safer and more interesting alternative to conventional methods.*

***Keywords**: Augmented Reality, X-Ray, Learning Media, Dubbing, ADDIE**.*

## 1. INTRODUCTION

In the era of digital education, the use of cutting-edge technologies such as Augmented Reality (AR) has become an innovative strategy aimed at improving the effectiveness and quality of learning, particularly in vocational fields like aeronautical engineering. In vocational education settings like the Surabaya Aviation Polytechnic, material on Goods and Person Inspection Detection Equipment is included in the core courses required by Air Navigation Engineering students. Based on the applicable syllabus, learning outcomes include cadets being able to explain, demonstrate, and classify various types of goods and person inspection detection equipment. This reflects the importance of mastering technical concepts visually and procedurally.

Ideally, the learning process regarding X-ray machines should be supported by interactive media that can realistically, safely, and easily understood represent the internal structure of the equipment. However, actual conditions in the Surveillance laboratory environment demonstrate limited learning resources, particularly regarding X-ray equipment. Based on the laboratory equipment inventory list, X-ray equipment is not yet available for practice, or in some cases, is insufficient for all cadets to use interchangeably. As a result, the learning process relies solely on verbal presentation, two-dimensional images, or static illustrations without direct interaction, making it difficult for students to understand the physical form, internal components, and dynamic operation of the machine. In addition to the limitations of the equipment, direct use of X-ray equipment also carries the risk of radiation exposure if not properly controlled. Therefore, technical training using real equipment is not always possible in vocational education institutions due to safety and security considerations. This creates a gap between the competency requirements in the syllabus and the reality of practical work in the field.

One approach considered effective is the use of Augmented Reality (AR)-based learning media. AR technology allows for realistic visualization of three-dimensional objects through digital devices such as smartphones. This media can be developed to display virtual X-ray models that can be viewed from various angles and equipped with a voice-over system to narrate the function and operational procedures of the equipment. Using a voice-over system, or voice-over narration, allows cadets to receive explanations simultaneously in visual and audio formats, making complex technical material easier to understand (Ayub 2021).

To test the effectiveness of the developed media, a pre-assessment and assessment process was conducted, including administering pre- and post-tests to students. The pre-assessment was used to measure prior knowledge before using the media, while the post-test was conducted after AR learning to determine improvements in understanding. Improvement analysis was conducted using the N-Gain Score method, which is widely used to measure the effectiveness of technology-based learning media. Pre-test results showed an average score of 500, indicating that students still had low initial understanding. After using the AR X-Ray media with a dubbing system, post-test results improved significantly, with an average score of 840. This improvement was analyzed using the N-Gain formula and yielded a score of 0.68, categorized as moderate to high effectiveness. This data reinforces the urgency of developing innovative, technology-based learning media to enhance learning effectiveness in technical and applied vocational education environments.

Based on a previous study (Ashari, A, and Mappalotteng 2022), AR-based learning media has proven effective in improving cadets' understanding of engineering and radiology tools. Research (Azfar 2023) also shows that the integration of AR technology can increase the interactivity and involvement of students in understanding the technical components of aviation equipment. Therefore, this study aims to design and develop learning media based on Augmented Reality X-Ray equipped with a Dubbing system with the title of this research, namely "Design and Construction of Augmented Reality X-Ray learning media with a Dubbing system at the Surabaya Aviation Polytechnic". This media is expected to be an innovative alternative in the learning process of the Goods and People Detection Equipment course at Poltekbang Surabaya and is able to improve the quality of conceptual understanding of cadets, reduce direct risk management of X-Ray equipment, and support the achievement of learning outcomes according to the curriculum.

## 2. METHODS

This research is a research and development (R&D) project. This research aims to create Augmented Reality learning media with X-Ray objects using the Branch method. This development method has five stages: Analysis, Design, Development, Implementation, and Evaluation, commonly referred to as ADDIE (Allen, 2006).

The development flow in the ADDIE model consists of five stages:

1. Analysis: This stage involves analyzing and identifying problems to define needs in the learning process.

2. Design: This stage involves designing the concept and content of the learning media.

3. Development: This stage involves creating a product ready for validation testing.

4. Implementation: This stage involves testing the product.

5. Evaluation: This stage marks the successful development of the product.

The data analysis technique in this research and development uses a Likert scale. The Likert scale is a type of scale used to measure a person's perception. The answers to this test are divided into 5 choices, namely: “Very Good” is worth 5, “Good” is worth 4, “Neutral” is worth 3, “Less” is worth 2, and “Very Less” is worth 1.

2.1 Analysis

The learning needs were analyzed by interviewing lecturers and cadets to identify the difficulties they faced in understanding X-Ray material, including limited access to tools and the associated radiation risks. In addition, a curriculum analysis was conducted by reviewing the material in the course on Equipment for Inspecting Goods and People to determine the scope of Augmented Reality (AR) simulation required in learning. The researcher also conducted a literature review to examine previous research on the use of AR in vocational education, including the works of Ashari and Mappalotteng (2022) and Azfar (2023), which served as the basis for developing more effective and interactive learning media. Through this analysis, the researchers were able to understand the context and challenges faced by cadets and design appropriate solutions to improve their understanding of X-Ray material.

2.2 Design

At this stage, the researcher installed supporting software and began designing the website using PHP, HTML, C++, and Visual Studio Code as the code editor.During the design phase, researchers designed the learning media concept by creating an interaction scheme between Augmented Reality (AR) and the Dubbing system, which includes 3D visualization flows and voice narration that will accompany the model. This process is important to ensure that users can interact with the media intuitively and have an engaging learning experience. Additionally, researchers create storyboards and wireframes to design the user interface, including the admin dashboard and AR application, to facilitate navigation and information access. In the technical design phase, researchers selected appropriate development tools, such as SketchUp for 3D modeling, PHP and HTML for web dashboard development, and the Vuforia SDK as the AR engine. The selection of these tools aims to ensure that the developed media is not only functional but also engaging and user-friendly for cadets..

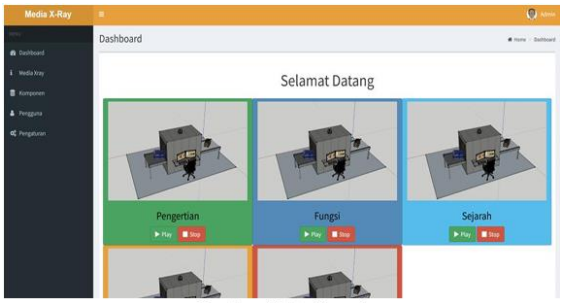


**Figure1** Dashboard display design

2.3 Development

In the Development stage, development is carried out based on the results of the design explanation of starting the application of the button function from the home screen of the Augmented Reality learning media application. There are 5 features in the AR application, these five features are carried out to ensure the feature runs well.

**Figure2** Login view

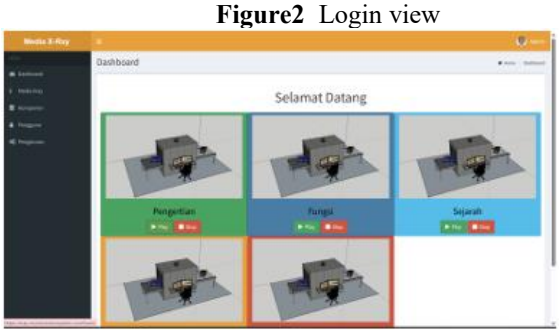


**Figure3** Dashboard view

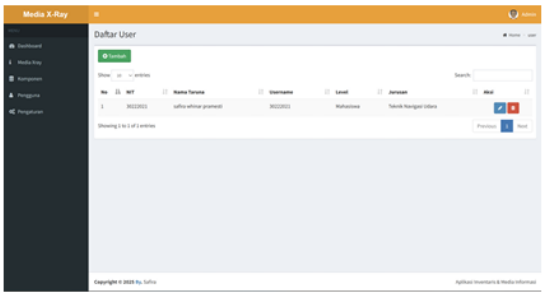


**Figure4** User view


**Figure5** Component view

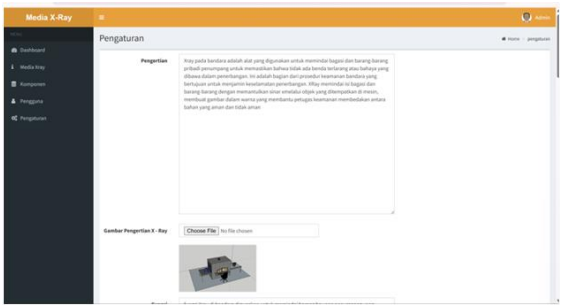


**Figure6** Settings view

2.4 Implementation

The assessment was carried out by validators consisting of lecturers, cadets from the Surabaya Aviation Polytechnic, and media experts.

**Table1** validation test results

| No | Aspect | Analysis | Validator |
|---|---|---|---|
| 1 | Satisfaction | Score | 6 |
| | | Persentage | 75% |
| | | Criteria | Eligible |
| 2 | Suitability | Score | 6 |
| | | Persentage | 75% |
| | | Criteria | Eligible |
| 3 | Accessibility | Skor | 6 |
| | | Persentage | 75% |
| | | Criteria | Eligible |

Based on the validation above, the assessment category obtained from the validation results shows a Very Feasible category with a user feasibility percentage value of 75%.

2.5 Evaluation

In the evaluation stage, the developed Augmented Reality (AR) application was tested to assess its functionality and obtain feedback from users. The instrument used was a 10-item multiple-choice question that measured 10 students' understanding of the X-Ray machine structure, working principles, main part functions, usage procedures, and safety aspects in using the tool. Based on the results of data processing, the average Pre-Test score was 500, and the average post-test score was 840 out of a maximum total score of 1,000. The average N-Gain value was 0.68, indicating that the developed learning media was in the medium to high effectiveness category.

## 3. RESULTS AND DISCUSSION

The results of this research successfully designed and developed an Augmented Reality (AR) X-Ray-based learning medium with a dubbing system, which visualizes a three-dimensional model of an X-Ray machine and is equipped with audio narration. The development process followed the ADDIE model, starting with a needs analysis that identified the lack of interactive and safe media for X-Ray learning at the Surabaya Aviation Polytechnic. The design phase involved the creation of a web interface and a 3D model of the X-Ray machine, as well as the integration of the Dubbing system. During the development phase, the application was implemented using PHP, HTML, C++, Visual Studio Code, SketchUp, and 3D Warehouse, resulting in an interactive AR interface and a content management dashboard.

The implementation of the media showed good performance, with validation results from media experts and users categorizing this media as “very feasible” (75%). This indicates that the media meets quality standards and learning needs, both in terms of 3D visualization, clarity of material, voice narration, and ease of use. These findings align with previous studies by Ashari, A, and Mappalotteng (2022) as well as Azfar (2023), which demonstrate the success of AR in enhancing understanding and interactivity in technical content

Furthermore, evaluation of the effectiveness of the media through pre-tests and post-tests showed a significant increase in student understanding. The average pre-test score of 500 increased to 840 on the post-test. N-Gain analysis resulted in a score of 0.68, which falls into the moderate to high effectiveness category. This figure strongly indicates that the AR X-Ray learning media with the Dubbing system is effective in helping students understand the structure and functioning of X-Ray machines. This improvement can be attributed to the media's ability to present complex technical information visually in 3D and auditorily simultaneously, overcoming the limitations of conventional methods that rely solely on 2D images and verbal explanations. The integration of AR visualization allows students to “see” the internal components of the machine, which were previously difficult to observe directly due to radiation risks and equipment limitations. The voice dubbing feature enhances understanding by providing clear narrative context.

Academically, these results reinforce the argument that AR technology, especially with the addition of dubbing features, has great potential as an effective vocational learning tool. The contribution of this research is to provide empirical evidence of the effectiveness of Augmented Reality media in the context of high-risk materials such as X-Ray, as well as offering practical solutions to improve the quality of education in the aviation field. This medium not only enhances conceptual understanding but also minimizes the risk of direct exposure to equipment, thereby supporting the achievement of safer and more comprehensive learning outcomes.

## 4. CONCLUSION

` This study successfully designed and developed an Augmented Reality (AR) X-Ray-based learning medium with an interactive dubbing system, addressing the first research question. This media visualizes a 3D model of an X-Ray machine and is equipped with audio narration, developed through the ADDIE stages. Feasibility tests conducted by subject matter experts and media experts indicate that this media is “highly feasible” for use as a learning aid, indicating suitability in terms of content, presentation, and ease of use.

Regarding the second research question, the effectiveness of the media in enhancing students' understanding was found to be significant. The increase in post-test scores compared to pre-test scores, with an N-Gain value of 0.68, places this media in the moderate to high effectiveness category. The practical implication is that this media can serve as a safer and more engaging learning alternative for high-risk technical content, reducing reliance on physical tools and enhancing the quality of understanding among students at Surabaya Aviation Polytechnic. For future research, it is recommended to develop a comprehensive simulation of X-Ray machine operation and maintenance procedures, as well as add evaluation features or interactive quizzes to the application. Testing on a larger group of students could also be conducted to obtain broader analysis results.

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