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Development of Unity-Based Augmented Reality Science Learning Media for Seventh-Grade Students

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A B S T R A C T

Science instruction at MTsN 6 Lima Puluh Kota continues to rely primarily on lectures and textbooks, limiting students' understanding of abstract concepts. This study aimed to develop Unity-based Augmented Reality (AR) learning media and evaluate their validity, practicality, and effectiveness in science instruction. A research and development approach was employed using the ADDIE model, encompassing Analysis, Design, Development, Implementation, and Evaluation. The evaluation involved media experts, subject-matter specialists, teachers, and students. The application achieved reported scores of 0.89 for validity, 0.92 for practicality, and 0.90 for effectiveness, all within the highest assessment categories. These findings suggest that Unity-based AR learning media are suitable for science instruction and may help students understand abstract scientific concepts.

Abstrak

Pengajaran sains di MTsN 6 Lima Puluh Kota masih didominasi oleh ceramah dan buku teks, sehingga pemahaman siswa terhadap konsep-konsep sains yang abstrak masih terbatas. Penelitian ini bertujuan untuk mengembangkan media pembelajaran Augmented Reality (AR) berbasis Unity serta menguji validitas, kepraktisan, dan efektivitasnya dalam pembelajaran sains. Penelitian ini menggunakan metode Penelitian dan Pengembangan (R&D) dengan model ADDIE, yang terdiri dari tahap Analisis, Desain, Pengembangan, Implementasi, dan Evaluasi. Peserta yang terlibat meliputi pakar media, pakar bidang studi, guru, dan siswa. Hasil penelitian menunjukkan bahwa media yang dikembangkan memperoleh skor validitas sebesar 0,89, skor kepraktisan sebesar 0,92, dan skor efektivitas sebesar 0,90, yang semuanya dikategorikan sebagai sangat tinggi. Temuan ini menunjukkan bahwa media pembelajaran AR berbasis Unity layak digunakan dalam pengajaran sains dan berpotensi mendukung pemahaman siswa terhadap konsep-konsep abstrak.

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1. Introduction

Education plays a vital role in developing high-quality human resources. Technological advances have profoundly influenced education, including the adoption of Android-based learning platforms that offer teachers engaging ways to deliver instructional resources. Such technology can support students who struggle to understand course content by providing varied, interactive presentations that promote participation and creativity and, ultimately, improve learning outcomes [1].

Instructional media are essential to the communication of knowledge and contribute substantially to successful learning. Effective media should capture students' attention and facilitate their understanding of the material presented [2]. Appropriate media can improve instructional quality by encouraging active participation, increasing motivation, and fostering an enjoyable learning environment [3]. They also serve as communication tools that enable teachers to deliver information

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more effectively and efficiently. Images, videos, and digital simulations, for example, have been shown to enhance students' comprehension and retention of instructional content [4]. Furthermore, the use of instructional media is important for educational inclusion. Learning resources should be accessible to all students, including those with disabilities such as visual impairments. Related research has demonstrated that storybooks incorporating tactile illustrations and Braille can help students with visual impairments understand instructional material more effectively. These findings underscore the importance of educational media in ensuring equitable access to learning opportunities [5].

Augmented Reality (AR) can provide more interactive learning experiences by rendering abstract objects in a tangible visual form [6]. Previous studies have indicated that AR can enhance students' motivation and understanding during instruction [7]. AR integrates virtual objects into real-world environments in real time and enables users to interact directly with those objects [8]. In educational settings, it offers an innovative approach by embedding digital elements within physical surroundings, allowing students to observe and manipulate representations of abstract concepts in a contextualized and engaging manner [9]. Unlike Virtual Reality (VR), which replaces the physical environment entirely, AR enriches the real world with digital content displayed through devices such as smartphones or AR headsets [10]. Cameras and sensors are used to superimpose text, images, or three-dimensional models on the user's surroundings. Accordingly, AR can support learning by increasing interaction and helping students comprehend abstract concepts [11].

Unity is among the most widely used platforms for developing AR-based instructional media. Originally designed for game development, Unity is now extensively employed in educational AR applications [12]. Its visual features, animation capabilities, and integration with AR technologies [13], enable developers to create interactive three-dimensional simulations that make abstract concepts easier to visualize. Unity can also be combined with 3D modeling software, such as Blender or 3ds Max, to produce high-quality visual objects, animations, and touch-based interactions integrated with real-world environments [14]. As a cross-platform game engine, Unity supports application development for PCs, Android, iOS, the web, and AR/VR devices. Its C# programming environment, asset ecosystem, and plugins further streamline development [15]. Unity's flexibility, usability, and extensive developer community have contributed to its widespread international adoption [16].

Observations and interviews with science teachers at MTsN 6 Lima Puluh Kota indicated that science instruction remains largely conventional and makes limited use of technology-enhanced media. Teachers primarily rely on lectures and textbooks, with relatively little use of visual resources [17]. Consequently, students tend to be passive and show limited interest in classroom activities. They also struggle with abstract concepts involving living organisms, the solar system, and the motion of objects. Reliance on lectures and textbooks makes complex scientific phenomena, such as planetary motion, particularly difficult to grasp. This situation can hinder comprehension and reduce students' interest in science. Innovative instructional media are therefore needed to encourage active student engagement.

Augmented Reality represents a promising way to address these challenges. By enabling users to observe virtual objects interacting with the physical environment, AR can make instructional content more engaging and interactive. To enhance science instruction at MTsN 6 Lima Puluh Kota, this study aims to develop Unity-based AR learning media. Through realistic and interactive three-dimensional visualizations, the application is expected to facilitate students' understanding of science concepts, strengthen their motivation, and provide more enjoyable and meaningful learning experiences.

Previous studies have reported positive effects of AR-based instructional media on students' understanding of abstract concepts. A. H. Febrianti (2024) developed animated-video-based AR materials for integrated science and social studies in primary schools and reported a 40% improvement in conceptual understanding. J. Wadu, J. Enstein, and Y. A. Benufinit (2025) likewise

found that AR media for science instruction achieved a very high feasibility rating and increased students' interest in and understanding of visually oriented material. In addition, a study by Muhammad Ilyas in senior high school biology instruction found a significant positive effect of AR on cognitive learning outcomes, particularly comprehension and interpretation.

Nevertheless, most previous studies were conducted in primary or senior high schools and did not specifically develop Unity-based AR media for seventh-grade science instruction in Islamic junior secondary schools (MTs). Moreover, prior evaluations generally addressed only selected aspects of instructional media rather than comprehensively assessing validity, practicality, and effectiveness within a single developed product.

The present study therefore offers a distinct contribution by developing Unity-based AR learning media for several seventh-grade science topics. The application incorporates interactive marker-based 3D visualizations and audio narration, and its validity, practicality, and effectiveness are evaluated comprehensively with students at MTsN 6 Lima Puluh Kota.

2. Research Methodology

This study employed a research and development (R&D) approach based on the five-stage ADDIE model: Analysis, Design, Development, Implementation, and Evaluation. ADDIE was selected because it provides a systematic, coherent, and flexible development framework suited to instructional media design [18]. Its interconnected stages are implemented sequentially to ensure that the resulting product meets users' needs and instructional objectives [19]. The model also facilitates collaboration among subject-matter experts, media specialists, and educational practitioners. Continuous evaluation and revision throughout development are intended to improve product quality and support its validity, practicality, and reliability [20]. The research procedures are illustrated in the following figure.

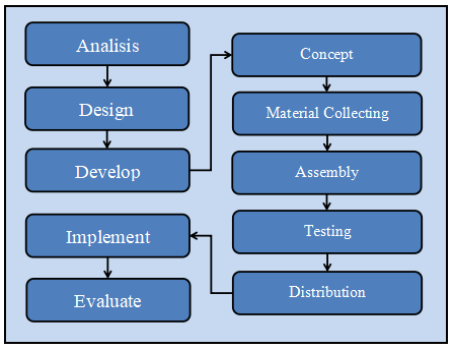


Figure 1. ADDIE development models [21], and Luther–Sutopo [22].

2.1. Analysis

Needs analysis was conducted at MTsN 6 Lima Puluh Kota through interviews with science teachers and observations of seventh-grade classroom instruction. The findings informed the development objective: to create AR-based learning media that help students understand science concepts involving motion, forces, the solar system, and the classification of living organisms.

2.2. Design

During the design stage, an overall application concept and its navigation system were developed. The AR learning application begins with a Main Menu scene containing three primary buttons: Start, Information, and Exit.

2.3. Development

Development constituted the central stage of the study, during which the learning application was created using Unity and Vuforia. This stage comprised the following activities.

a) Concept: Define the application objectives, select the science topics to be presented through AR, and determine the technologies required.

b) Design: Develop the navigation structure, storyboard, and user interface.

c) Material collection: Gather images, animations, 3D models, audio, and text needed to support the learning content.

d) Assembly: Integrate all collected assets into Unity. The Vuforia SDK enables the application to detect markers and display AR objects in real time, while C# scripts implement interactive functions.

e) Testing: Conduct preliminary tests to verify AR functionality, including the appearance of 3D objects on markers, user interactions, and application stability across devices.

f) Distribution: Following preliminary testing, package and prepare the application for use in school-based science learning trials.

2.4. Implementation

Following development, the AR learning media were implemented and tested in seventh-grade classes at MTsN 6 Lima Puluh Kota. Teachers also participated to assess whether the application facilitated the effective delivery of science content. Data were collected through observations, interviews, and questionnaires to examine students' and teachers' responses to the use of AR.

2.5. Evaluation

The learning media were evaluated for validity, practicality, and effectiveness. Pretests and posttests were administered to assess changes in student understanding, and revisions were made in response to evaluation findings before wider deployment.

Product assessment comprised three principal procedures:

a. Product Validity Assessment

Subject-matter and media experts evaluated the alignment of the science content, presentation quality, usability, and consistency with instructional objectives. Ratings were collected using a Likert scale and analyzed using Aiken's V.

$$V = \frac{\sum s}{n(c-1)} \quad \text{.....[Aiken's V]}$$

Where:

$\sum s$: r - lo

lo: The lowest possible rating on the assessment scale.

c: The highest possible rating on the assessment scale.

r: The score assigned by each evaluator.

n: The total number of evaluators.

Table 1. Criteria for Aiken's V Validity1

Percentage (%)	Criteria
0,6<	Tidak Valid
>=0,6	Valid

As shown in the table, a product was classified as valid when its score was at least 0.6 and invalid when the score was below 0.6 [23].

b. Product Practicality Assessment

A product is considered highly practical when it is easy to use and administer. Conversely, a product that is complicated and difficult to administer has low practicality.

The questionnaire ratings were analyzed using the kappa formula to obtain the kappa coefficient.

$$(k) = \frac{\mathbf{P - e(k)}}{\mathbf{1 - e(k)}}$$

Where:

K: The kappa coefficient indicating product validity or practicality.

p: The observed proportion, calculated by dividing the total score assigned by the evaluators by the maximum possible score.

e: The unrealized proportion, calculated as the difference between the maximum possible score and the evaluators' total score, divided by the maximum possible score [24].

Table 2. Criteria for Product Practicality

Score	Category
0,81 - 1,00	Very Practical
0,61 - 0,80	Practical
0,41 - 0,60	Moderately Practical
0,21 - 0,40	Not Very Practical
0,01 - 0,20	Impractical
≤0,00.	Invalid

c. Effectiveness Assessment

The effectiveness of the AR-based learning media was evaluated in terms of ease of use, potential to increase students' motivation, and time and effort efficiency. Direct observations were also conducted to determine how effectively the media supported classroom instruction.

Effectiveness was measured using Richard R. Hake's normalized gain statistic (G-score), as follows [25]:

$$G = \frac{Sf - Si}{100\% - Si}$$

Where:

G: Average improvement in learning outcomes (gain score).

Sf: Final score obtained by the student.

Si: Initial score before use of the learning media.

Table 3. Gain-Score Classification

Score	Category
G>0,7	High
0,7>G>0,3	Medium
G<0,3	Low

The categories were defined as follows:

High G: The learning media are classified as highly effective when G exceeds 0.7.

Medium G: The media are classified as moderately effective when G is between 0.3 and 0.7.

Low G: The media have low effectiveness when G is below 0.3.

3. Results and Discussion

3.1. Research Results

The AR-based learning media were developed through the ADDIE research and development process, encompassing analysis, design, development, implementation, and evaluation. The following sections describe the development of Unity-based AR learning media for seventh-grade science at MTsN 6 Lima Puluh Kota.

3.1.1. Analysis

3.1.1.1. Problem Analysis

At this stage, the principal challenges in science instruction at MTsN 6 Lima Puluh Kota were identified to inform the development of AR-based media. Classroom observations and teacher interviews revealed a reliance on lectures and basic instructional tools, including PowerPoint presentations and relatively unengaging two-dimensional images. Students consequently became bored and demonstrated limited motivation. AR-based instructional media had not previously been introduced at the school.

More interactive and contextually relevant media were therefore needed to help students visualize and understand scientific concepts.

3.1.1.2. Needs Analysis

3.1.1.2.1. User Requirements

3.1.1.2.1.1. Teachers

Teachers require learning media that capture students' interest and attention and help them remain focused. Such media can facilitate the delivery of instructional content and create a more conducive classroom environment for both teachers and students.

3.1.1.2.1.2. Students

Today's students tend to be attracted to visual content, including images, colors, and animated three-dimensional (3D) objects. They expect engaging instructional presentations, particularly interactive learning media incorporating 3D animation. Such media are expected to increase students' interest in lessons and make teacher-presented concepts easier to understand.

3.1.1.2.2. Media Requirements

The content and supporting software were selected in accordance with the instructional objectives to develop suitable three-dimensional AR learning media. The application was produced primarily using Unity3D, Blender, and CorelDRAW.

Unity3D served as the primary platform for developing the 3D application and integrating interactive AR objects in real time. Blender was used to create and modify the three-dimensional models displayed by the application, while CorelDRAW supported the design of markers, icons, and user-interface graphics. Together, these tools enabled the development of interactive and engaging media suited to the characteristics of MTsN 6 Lima Puluh Kota students.

3.1.1.2.3. Technology Requirements

Developing AR-based instructional media required both hardware and software resources. The hardware comprised a laptop for application design and development and Android smartphones for testing. The software included Windows, Unity3D as the primary AR development platform, Blender version 4.4 for 3D modeling, and CorelDRAW for creating supporting graphical elements such as icons and markers.

The three-dimensional AR learning application was developed for seventh-grade students at MTsN 6 Lima Puluh Kota, who tend to respond positively to visual, animated, and interactive media. Unity3D, Blender, and CorelDRAW were therefore used in combination to produce learning resources tailored to their characteristics.

3.1.2. Design

The design stage involved establishing the initial concept and structure of the proposed AR-based learning media. Activities included designing the system flow, navigation structure, storyboard, and user interface. These elements provided a clear representation of how users would interact with the application, from its main menu to the instructional content. The stage also determined how science topics—motion and forces, the solar system, and classification of living organisms—would be organized and presented systematically through interactive AR-based 3D objects. The resulting designs served as the foundation for subsequent application development.

3.1.2.1. Storyboard Design

The storyboard was prepared to map the learning application's sequence and guide its subsequent development. It outlined the menu pages and individual scenes, providing a concise description of the overall user experience. A summary of the storyboard for each scene is presented in the following table.

Table 4. Storyboard Design

NO	Scene Name
Scene 1	Scene Menu Utama
Scene 2	Displacement Scene
Scene 3	Scene Titik Acuan
Scene 4	Newton's First Law Scene
Scene 5	Scene Newton 2
Scene 6	Scene Newton 3
Scene 7	Scene Quiz Gerak Gaya
Scene 8	Scene Fase Bulan
Scene 9	Scene Planet
Scene 10	Scene Rotasi
Scene 11	Scene Tata Surya
Scene 12	Scene Quiz Tata Surya
Scene 13	Scene Kunci Dikotomi
Scene 14	Scene Lima Kingdom
Scene 15	Scene Quiz Klasifikasi

3.1.2.2. Navigation Structure Design

The science learning application uses a linear navigation structure that guides users sequentially from one frame to the next. This arrangement supports navigation and interaction as students explore on-screen objects using an Android smartphone.

The navigation diagrams below illustrate the relationships between the application's menu pages and scenes.

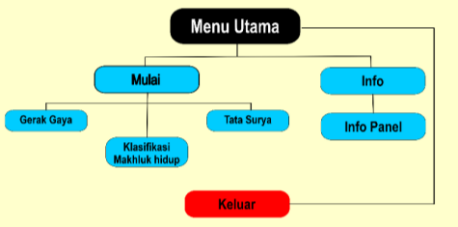


Figure 2. Main Menu Navigation



Figure 3. Motion and Forces Menu Navigation

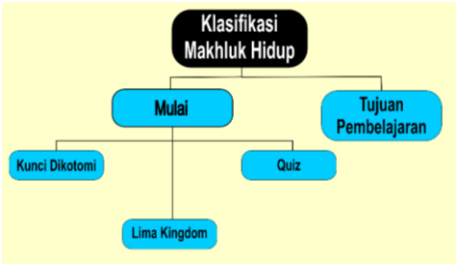


Figure 4. Living Organism Classification Menu Navigation

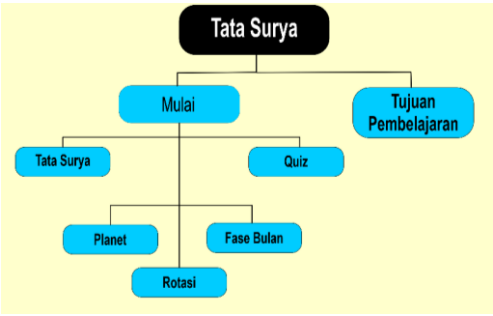


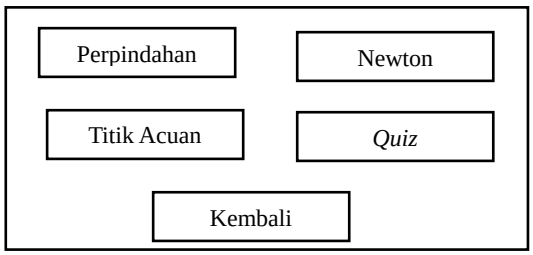
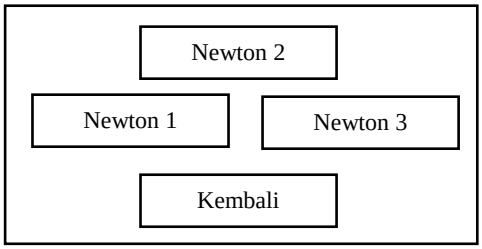
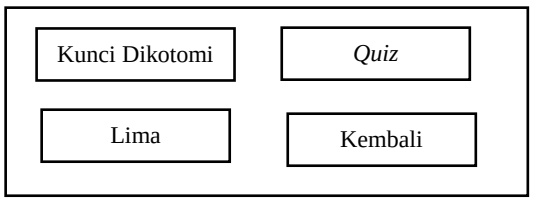
Figure 5. Solar System Menu Navigation

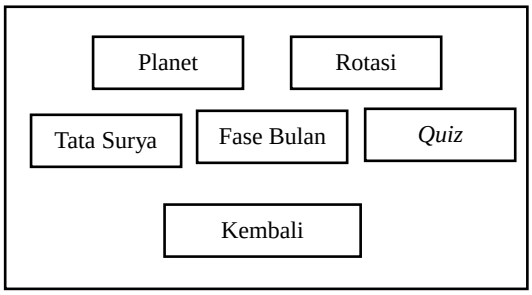
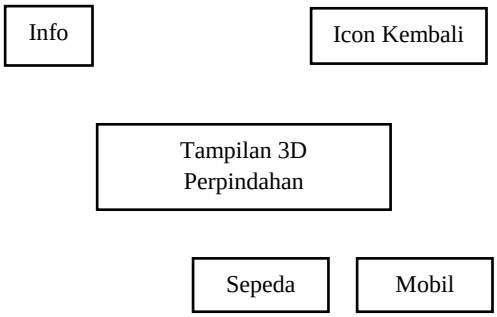
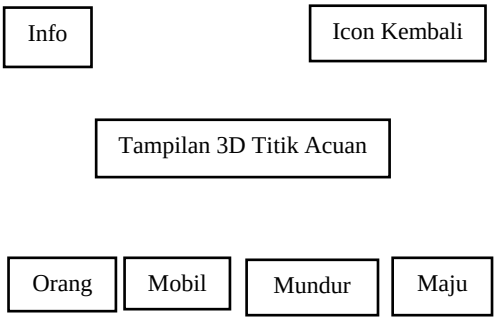
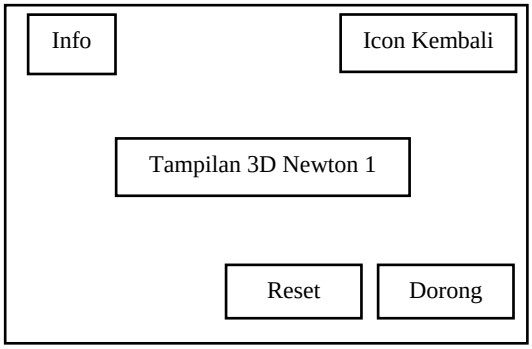
3.1.2.3. User Interface Design

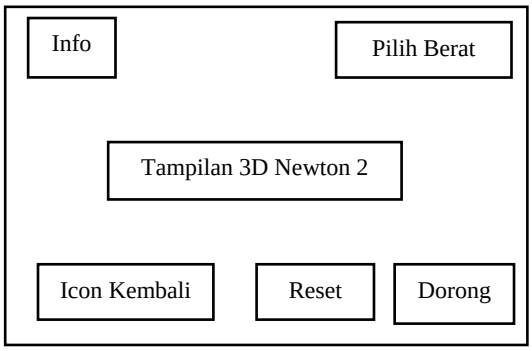
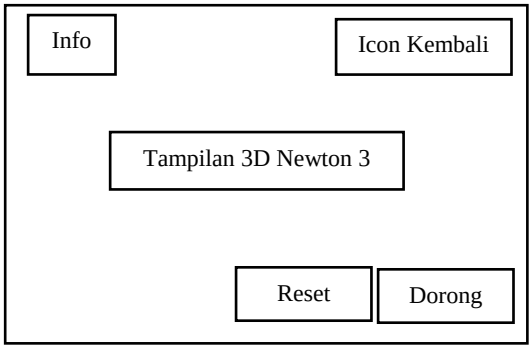
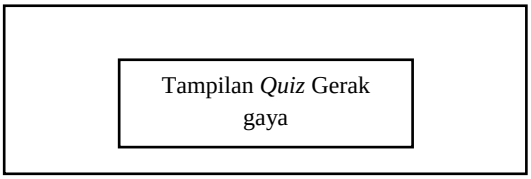
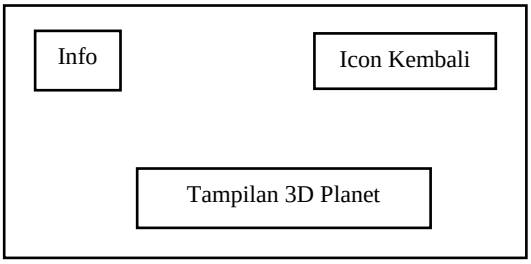
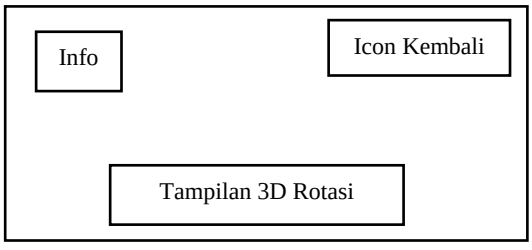
User interface (UI) design concerns the visual elements users see and interact with. The application was designed for students at MTsN 6 Lima Puluh Kota, with a simple, user-friendly interface tailored to their needs. The proposed screen designs are presented below.

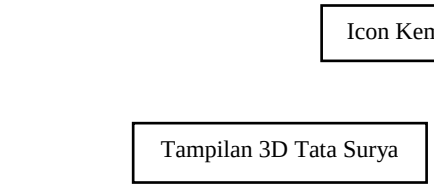
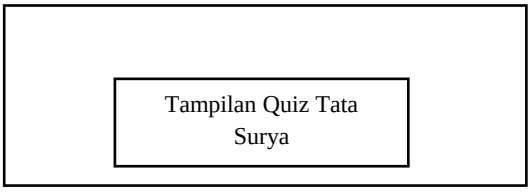
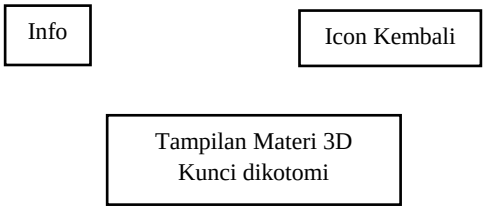
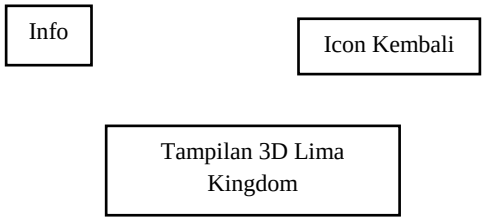
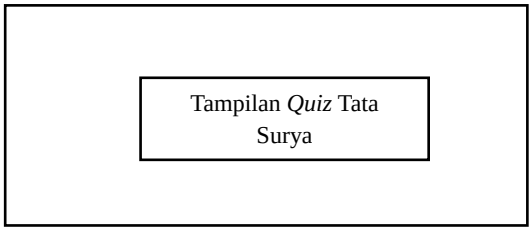
Table 5. User Interface Design

Scene	Visual	Button Navigation Description
1	Main Menu Mulai Info Keluar	Start: Opens the learning topics menu. Information: Displays a brief explanation. Exit: Closes the application.
	Main Learning Topics Menu Klasifikasi Gerak Tata Surya Kembali	Motion and Forces: Opens the Motion and Forces menu. Classification: Opens the Classification of Living Organisms menu. Solar System: Opens the Solar System menu. Back: Returns to the Main Menu.

Scene	Visual	Button Navigation Description
	Motion and Forces Menu 	Start: Opens Motion and Forces content. Learning Objectives: Displays the instructional objectives. Back: Returns to the learning topics menu.
	Motion and Forces Content 	Displacement: Opens the 3D displacement scene. Reference Point: Opens the 3D reference point scene. Newton: Opens Newton's laws content. Quiz: Opens the Motion and Forces quiz. Back: Returns to the Motion and Forces menu.
	Materi Newton Motion and Forces 	Newton 1: Opens Newton's First Law. Newton 2: Opens Newton's Second Law. Newton 3: Opens Newton's Third Law. Back: Returns to the Motion and Forces content.
	Menu Classification of Living Organisms 	Start: Opens Classification of Living Organisms content. Learning Objectives: Displays the instructional objectives. Back: Returns to the learning topics menu.
	Materi Classification of Living Organisms 	Dichotomous Key: Opens the 3D dichotomous key scene. Five Kingdoms: Opens the 3D Five Kingdoms scene. Quiz: Opens the classification quiz. Back: Returns to the classification menu.
	Solar System Menu 	Start: Opens the Solar System content. Learning Objectives: Displays the instructional objectives. Back: Returns to the learning topics menu.

Scene	Visual	Button Navigation Description
	Solar System Content 	Solar System: Opens the 3D Solar System scene. Planet: Opens the 3D planets scene. Moon Phases: Opens the 3D moon phases scene. Rotation: Opens the 3D rotation scene. Quiz: Opens the Solar System quiz. Back: Returns to the Solar System menu.
2	Displacement 	Information: Explains displacement. Bicycle: Centers the camera on the bicycle. Car: Centers the camera on the car. Back: Returns to Motion and Forces content.
3	Reference Point 	Information: Explains reference points. Person: Centers the camera on the person. Car: Centers the camera on the car. Forward: Moves the car forward. Backward: Moves the car backward. Back: Returns to Motion and Forces content.
4	Newton 1 	Information: Explains Newton's First Law. Push: Moves the car. Reset: Restores the car's original position. Back: Returns to Newton's laws content.

Scene	Visual	Button Navigation Description
5	Newton 2 	Information: Explains Newton's Second Law. Select Weight: Changes the car's mass. Push: Moves the car. Reset: Restores its initial position. Back: Returns to Newton's laws content.
6	Newton 3 	Information: Explains Newton's Third Law. Push: Moves the cars. Reset: Restores their initial positions. Back: Returns to Newton's laws content.
7	*Quiz Motion and Forces* 	*Quiz: Presents multiple-choice questions with Replay and Back buttons. Back returns to Motion and Forces content.*
8	Planet 	Information: Displays information about planets. Back: Returns to the Solar System content.
9	Rotasi 	Information: Displays information about rotation. Back: Returns to the Solar System content.

Scene	Visual	Button Navigation Description
10	Solar System 	Back: Returns to the Solar System content.
11	Quiz Solar System 	*Quiz: Presents Solar System questions and provides Replay and Back buttons.*
12	Dichotomous Key 	Information: Explains dichotomous keys. Back: Returns to Classification of Living Organisms content.
13	Five Kingdoms 	Information: Explains the five-kingdom classification. Back: Returns to Classification of Living Organisms content.
14	Quiz Classification of Living Organisms 	*Quiz: Presents classification questions and provides Replay and Back buttons.*

3.1.3. Development

3.1.3.1. Concept

The development stage translated the proposed designs into a functional AR-based instructional application for seventh-grade science. The media were intended to support teachers' classroom activities while serving as interactive learning resources for Islamic junior secondary school students.

Their development aimed to increase students' interest and attention, making science topics, including the human digestive system and other concepts, easier and more enjoyable to learn.

The resulting product was an Android-based application distributed as an APK file. It enables users to view, read, and listen to interactive explanations of science content aligned with the applicable curriculum.

Unity3D was used as the main AR development platform, supported by Blender for creating 3D models and CorelDRAW and Canva for designing graphics and other visual elements. This stage produced an interactive 3D learning application ready for subsequent testing.

3.1.3.2. Material Collection

Material collection involved gathering science content from printed textbooks and images, as well as backgrounds and 3D objects relevant to the topics addressed by the application. In practice, material collection could be undertaken concurrently with assembly.

3.1.3.3. Assembly

The assembly stage involved producing and integrating the multimedia components specified during the preceding design stage.

3.1.3.3.1. 3D Object Development

The three-dimensional objects used in the application were created in Blender.

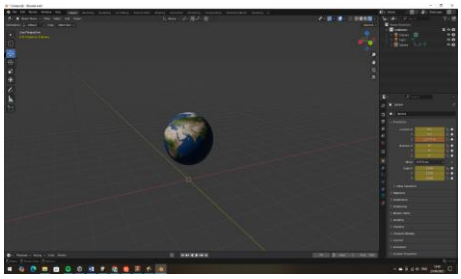


Figure 6. 3D Object Creation Process

3.1.3.3.2. Navigation Button Development

Navigation buttons were created by importing button graphics into Unity3D and converting them into interactive controls using scripts developed with MonoDevelop.



Figure 7. Main Menu Development Process

3.1.3.3.3. Programming

The AR application was programmed in C# (C-Sharp), an object-oriented language developed by Microsoft and adopted by Unity as its primary scripting language for games and interactive applications. In Unity, C# controls the behavior of 3D objects, including motion, click interactions, distance calculations, camera management, and interface elements such as buttons, panels, and text. Instructions are stored in .cs script files and attached to the relevant objects within individual scenes.

3.1.3.3.4. Application Testing

After development, the application was tested to determine whether its features operated as intended. Any identified errors or shortcomings were corrected until satisfactory functionality was achieved. The tested application was packaged as an APK file.

3.1.3.3.5. The final AR-based science learning application is presented in the following figures.

3.1.3.3.5.1. Main Menu Screen



Figure 8. Main Menu Screen

The Main Menu screen contains buttons used to navigate to subsequent scenes. Start opens the available learning topics, Information displays details about the application and its purpose, and Exit closes the application.



Figure 9. Information Screen

The Information screen explains the purpose of the application and includes a Back button for returning to the Main Menu.



Figure 10. Learning Topics Screen

The Learning Topics screen provides buttons leading to the content areas covered by the application: Motion and Forces opens the corresponding topic menu, Classification of Living Organisms opens the classification menu, and Solar System opens the solar system menu.

3.1.3.3.5.2. Motion and Forces Menu and Learning Content



Figure 11. Motion and Forces Menu

The Motion and Forces menu provides navigation buttons. Start opens the available subtopics, Learning Objectives displays the objectives for the topic, and Back returns to the main learning topics menu.



Figure 12. Motion and Forces Learning Objectives

The Learning Objectives screen presents the objectives of the Motion and Forces topic and includes a Back button to return to its menu.



Figure 13. Motion and Forces Subtopics

The Motion and Forces subtopic screen contains buttons for Displacement, Reference Points, Newton's First, Second, and Third Laws, and a topic quiz. A Back button returns users to the Motion and Forces menu.

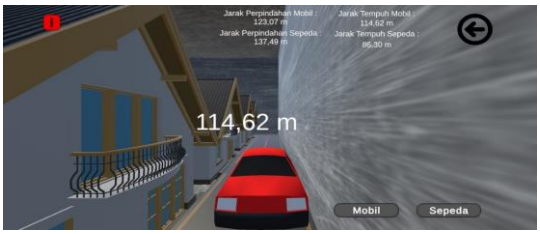


Figure 14. Displacement Learning Scene

The Displacement scene depicts a car and bicycle traveling to school along different routes and distances. Their displacement and distance traveled are displayed. Users can select the Car or Bicycle button to focus the camera on the corresponding vehicle, select the Information button for an explanation of displacement and distance, or use the Back arrow to return to the Motion and Forces subtopics.



Figure 15. Reference Point Learning Scene

The Reference Point scene presents a person beside a road and a car on the road. Camera buttons allow users to view the scene from the car's or the person's perspective. Up and Down controls move the car forward and backward, the Information button explains reference points, and the Back arrow returns to the Motion and Forces subtopics.



Figure 16. Newton's First Law Learning Scene

The Newton's First Law scene depicts a car on a road. The Push button moves the car, Reset restores its initial position, the Information button explains Newton's First Law, and the Back arrow returns to the Motion and Forces subtopics.



Figure 17. Newton's Second Law Learning Scene

The Newton's Second Law scene presents a car and several interactive controls. Push moves the car, the Weight control adjusts its mass, Reset restores its original position, the Information button displays an explanation of Newton's Second Law, and the Back arrow returns to the Motion and Forces subtopics.



Figure 18. Newton's Third Law Learning Scene

The Newton's Third Law scene depicts two cars facing one another. The Push button sets the vehicles in motion, causing them to push against each other; Reset returns them to their initial positions. The Information button displays the corresponding explanatory content, and the Back arrow returns to the Motion and Forces subtopics.

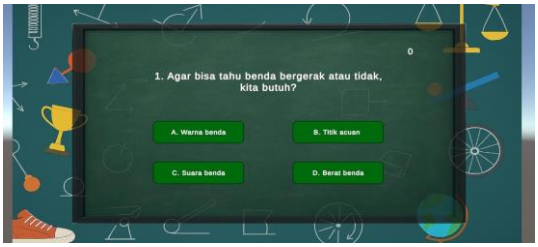


Figure 19. Motion and Forces Quiz Screen

The quiz presents multiple-choice questions on motion and forces. Correct responses earn points, whereas incorrect responses do not. Final scores are displayed at the end, and students may repeat the quiz to reinforce their understanding.

3.1.3.3.5.3. Classification of Living Organisms Menu and Learning Content



Figure 20. Classification of Living Organisms Menu

The Classification of Living Organisms menu includes Start, which opens the available subtopics; Learning Objectives, which presents the objectives for this topic; and Back, which returns to the main learning topics menu.



Figure 21. Classification of Living Organisms Subtopics

The classification subtopic menu links to the Five Kingdoms and Dichotomous Key lessons, an interactive quiz, and a Back button that returns users to the Classification of Living Organisms menu.



Figure 22. Classification of Living Organisms Learning Objectives

This screen presents the learning objectives for the Classification of Living Organisms topic and provides a Back button for returning to the topic menu.



Figure 23. Dichotomous Key Learning Scene

The Dichotomous Key scene provides Information buttons that explain the classification procedure. Two central selection buttons direct users to a particular plant or animal, and the Back arrow returns to the classification subtopics.



Figure 24. Classification of Living Organisms Quiz Screen

The quiz screen presents multiple-choice questions, awards points for correct answers, and displays the final score. Students can repeat the quiz to strengthen their understanding.

3.1.3.3.5.4. Solar System Menu and Learning Content



Figure 25. Solar System Menu

The Solar System menu includes a Start button linking to the topic's subtopics, a Learning Objectives button presenting the topic objectives, and a Back button returning to the main learning topics menu.

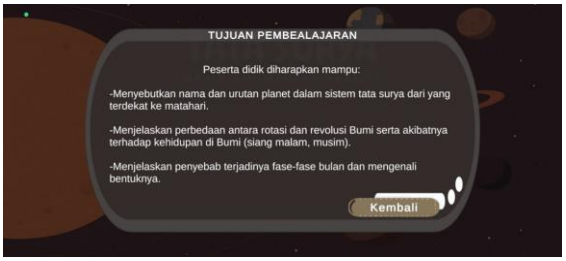


Figure 26. Solar System Learning Objectives

The Solar System Learning Objectives screen displays the relevant objectives and includes a Back button to return to the Solar System menu.



Figure 27. Solar System Subtopics

The Solar System subtopic screen offers navigation to Solar System, Planets, Moon Phases, Rotation, and Quiz scenes. The Back button returns users to the Solar System menu.

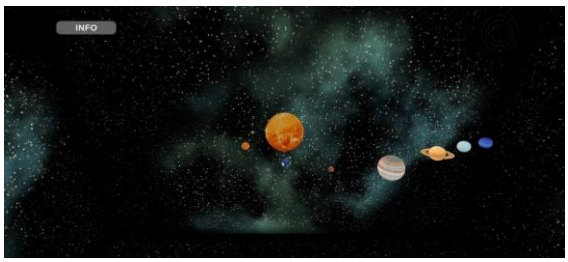


Figure 28. Solar System Learning Scene

The Solar System scene depicts planets orbiting the Sun. An Information button displays explanatory content, while the Back arrow returns users to the Solar System subtopics.



Figure 29. Moon Phases Learning Scene

The Moon Phases scene displays the Sun, Earth, and representations of the Moon at different phases, including their names and the days on which they occur. An Information button explains lunar phases, and the Back arrow returns to the Solar System subtopics.



Figure 30. Rotation Learning Scene

The Rotation scene displays the Sun, Earth, and Moon, illustrating the Moon orbiting Earth and Earth orbiting the Sun. Selecting any of these celestial bodies activates audio narration and explanatory information about the selected object.



Figure 31. Solar System Quiz Screen

The Solar System quiz presents multiple-choice questions. Correct answers earn points, whereas incorrect answers do not. The final score appears at the end, and students can repeat the quiz as often as needed.

3.1.3.4. Testing

This stage assessed the completed AR learning application using black-box testing, which evaluates the output of each function without examining the internal program structure. The purpose

was to verify that the features, buttons, and navigation operated according to the design specifications.

The application was tested by supplying inputs through its interactive buttons. Three functional areas were assessed: navigation between menus, AR simulations for each learning topic, and interactive quizzes. Testing covered all scenes, including the Main Menu, Motion and Forces, Solar System, and Classification of Living Organisms.

The results indicated that the application functions operated as intended and produced the expected outputs. Menu navigation functioned without errors, AR simulations displayed their 3D objects correctly, and all quizzes were accessible and provided feedback based on users' selections. These findings indicate that the AR learning application met the specified functional requirements and was suitable for instructional use.

3.1.3.5. Distribution

After the application was built as an APK file, it could be installed and run on Android smartphones with the following specifications:

a) Application name: Augmented Reality for Science Learning

b) Version: 0.1

c) Android operating system:

Minimum: Android Nougat 7.1

Recommended: Android Oreo 8.1 or later

d) Minimum RAM: 2 GB

e) Minimum screen size: 5 inches

f) Required installation space: 248 MB

The application requires 15 markers designed to correspond to the physical objects used to trigger and display the three-dimensional augmented objects.

3.1.4. Implementation

3.1.4.1. Product Validity Assessment

The validity of the Unity-based AR learning media developed for seventh-grade science at MTsN 6 Lima Puluh Kota was evaluated by two university lecturers with expertise in informatics.

Table 6. Validator 1

Item	Score/r	S	N(c-1)	V
Item 1	5	4	4	1
Item 2	4	3	4	0,75
Item 3	4	3	4	0,75
Item 4	4	3	4	0,75
Item 5	5	4	4	1
Item 6	5	4	4	1
Item 7	4	3	4	0,75
Item 8	4	3	4	0,75
Item 9	4	3	4	0,75
Item 10	4	3	4	0,75
Item 11	4	3	4	0,75
Item 12	4	3	4	0,75
Item 13	4	3	4	0,75
Item 14	4	3	4	0,75

Item	Score/r	S	N(c-1)	V
Item 15	4	3	4	0,75
Item 16	4	3	4	0,75
Item 17	4	3	4	0,75
Item 18	4	3	4	0,75
	Jumlah			14,25
	Rata-rata			0,79

Table 7. Validator 2

Item	Score/r	S	N(c-1)	V
Item 1	5	4	4	1
Item 2	5	4	4	1
Item 3	5	4	4	1
Item 4	5	4	4	1
Item 5	4	3	4	0,75
Item 6	4	3	4	0,75
Item 7	5	4	4	1
Item 8	5	4	4	1
Item 9	5	4	4	1
Item 10	5	4	4	1
Item 11	5	4	4	1
Item 12	5	4	4	1
Item 13	5	4	4	1
Item 14	5	4	4	1
Item 15	5	4	4	1
Item 16	5	4	4	1
Item 17	5	4	4	1
Item 18	5	4	4	1
	Jumlah			15.5
	Rata-rata			0,86

Table 8. Mean Validation Results

No	Name	Validator	Nilai
1.	Efmi Maiyana, M.Kom	I	0,79
2.	Rohaniatul Husna, M.Kom	II	0,97
	Mean		0,89

Two media experts completed the validation questionnaire. The first evaluator, Efmi Maiyana, M.Kom., assigned a validity score of 0.79, while the second evaluator, Rohaniatul Husna, M.Kom., assigned a score of 0.97. The reported mean based on Aiken's V was 0.89. The learning media were therefore classified as valid and suitable for use.

3.1.4.2. Product Practicality Assessment

Practicality testing aimed to assess the ease of use and operational feasibility of the developed AR learning media. The questionnaire results were analyzed using Cohen's kappa coefficient, as presented below.

Table 9. Practicality Assessment Results

NO	CRITERIA	Angie Mapanta, S.Si	Dede Irwanda, S.Pd.I
A	EASE OF USE		
1	Teachers and students can use the AR learning media without specialized training.	4	5

NO	CRITERIA	Angie Mapanta, S.Si	Dede Irwanda, S.Pd.I
2	Teachers can operate the AR learning media without difficulty.	5	5
3	The AR media interface is easy for users to understand.	5	5
4	Navigation in the AR media is clear and intuitive.	5	5
5.	Instructions for using the AR media are clear and easy to follow.	4	5
6.	Teachers can easily explain science content using the AR media.	5	5
7.	The media can be used independently without technical assistance.	5	5
B	TIME EFFICIENCY		
8	AR media help accelerate the delivery of instructional content.	4	5
9	Preparing lessons with the AR media requires relatively little time.	5	4
10	AR media help teachers communicate science concepts more efficiently.	4	5
11	AR media reduce the time required to explain science topics.	5	5
12	Teachers can quickly understand how to operate the AR media.	5	5
13	The media enable effective instruction in a shorter period.	5	5
C	FEATURE AVAILABILITY		
14	The AR media display 3D objects and animations aligned with science topics.	5	4
15	Interactive features help students understand science content.	4	4
16	AR media allow students to interact directly with the learning content.	5	4
17	The AR media provide visualization features unavailable in conventional media.	4	4
18	The AR features effectively support seventh-grade science instruction.	4	5
	TOTAL	83	85

The practicality assessment yielded the following calculations:

$$K = \frac{P-Pe}{1-Pe}$$

$$P = \frac{83+85}{180}$$

$$= \frac{166}{180}=0,92$$

$$Pe = \frac{180-166}{180}$$

$$= \frac{14}{180}=0,07$$

$$K = \frac{0,92-0,07}{1-0,07} = \frac{0,85}{0,92} = 0,92$$

Two science teachers at MTsN 6 Lima Puluh Kota, Angie Mapanta, S.Si., and Dede Yunanda, S.Pd.I., participated in the practicality test. After the responses had been collected, the mean score was calculated to assess the practicality of the application. The reported final value was 0.92, corresponding to the "very practical" category.

3.1.4.3. Product Effectiveness Assessment

The effectiveness assessment involved 22 students and employed the normalized gain (G-score) formula. The calculation is presented below.

Table 10. Effectiveness Assessment Results

No.	Respondent Name	Before						After						
		1	2	3	4	5	6	1	2	3	4	5	6	7
1	Nayra Maulidal Fitri	60	80	60	100	80	60	80	100	100	100	100	80	100
2	Ramadhan Putra	80	100	80	100	100	80	80	80	100	80	100	80	100
3	M.Fari	100	80	100	80	100	80	80	80	100	100	80	80	80
4	Dian Fazki	20	40	40	100	40	80	40	80	60	40	80	40	20
5	Rizky Febrian Jaya	100	60	40	80	20	60	20	60	60	40	100	60	20
6	Lailatul Marsyanda	80	60	60	80	80	60	80	100	100	80	80	100	80
7	Nadjwa Latira	80	60	60	80	80	100	80	100	100	80	80	100	80
8	Latifa Melani Putri	60	40	20	40	80	20	80	100	80	100	80	100	100
9	M.Divo Pratama	80	100	60	80	100	80	80	100	100	80	80	100	80
10	Gathfan*	20	20	40	20	40	40	100	100	80	100	80	100	100
11	Michael	20	40	60	80	60	60	60	80	100	60	40	60	80
12	M.Fajri	40	80	60	60	60	40	80	60	60	80	60	60	60
13	Rendra*	60	40	80	20	80	40	20	60	20	80	40	80	60
14	Ahsanul Khahsan	60	80	60	60	60	40	80	60	100	60	60	60	60
15	Kinkan Naraya	20	20	20	40	20	60	80	100	80	100	80	100	80
16	Alvina Azmi Azizah	60	80	80	80	80	80	100	80	100	100	80	100	100
17	Safira Melviana Yahya	60	80	80	80	80	80	100	100	100	100	100	100	100
18	Keysa Indah Putri	80	60	80	40	80	60	100	80	80	100	100	100	100
19	Naysa Aqila	40	60	60	60	80	40	80	100	80	100	80	100	80
20	Zahratul Nelfia	20	40	20	20	40	40	100	80	100	80	100	100	100
21	Ulya Azizah	20	20	20	20	40	40	80	80	80	100	100	100	80
22	Ayvel Putri	60	100	40	20	80	100	80	100	80	100	80	100	80
	Jumlah	1220	1340	1220	1340	1480	1340	1680	1880	1860	1860	1780	1900	1740
	Total				7940						12700			
	rata rata				60,15						96,21			

$$g = \frac{Sf-Si}{100\%-Sf} = \frac{96,21-60,15}{100-60,15} = \frac{36,06}{39,85} = 0,90$$

The analysis of student-completed effectiveness assessment forms yielded a final score of 0.90, indicating a high level of effectiveness for the developed AR learning media.

3.1.5. Evaluation

Evaluation examined the extent to which the AR-based science learning media stimulated students' enthusiasm and identified product limitations based on expert testing. During validity assessment, the first evaluator recommended adding interactive quizzes and improving the explanations to make the learning content more complete and comprehensible. The second evaluator suggested incorporating background music or voice narration to enhance engagement and clarify the material. Practicality testing also revealed a technical issue with the Back button, which was addressed by revising the navigation system. All feedback from the media experts was incorporated into subsequent revisions to improve the application's suitability for instructional use.

3.2. Discussion

This study developed an Android learning application distributed as an APK file. The application uses Augmented Reality (AR) to support seventh-grade science instruction at MTsN 6 Lima Puluh Kota. Blender was used to model 3D objects, Unity3D served as the principal AR development platform, and CorelDRAW was used to design interface graphics and other visual components.

The developed media contain 15 interactive scenes organized into four main menus: a home menu and three science content menus. These address three major seventh-grade science topics: Motion and Forces, Classification of Living Organisms, and the Solar System. Each topic is divided into subtopics to provide a more systematic and comprehensive presentation. A distinctive feature is a dedicated marker book that can be scanned with an Android camera to display animated 3D objects associated with each lesson. This feature is intended to provide a more engaging, realistic, and interactive learning experience.

The application was also assessed for validity, practicality, and effectiveness by experts and users. The questionnaire-based evaluations yielded scores of 0.89 for validity, 0.92 for practicality, and 0.90 for effectiveness, all reported in the highest assessment categories. Thus, the application was considered both visually engaging and suitable for supporting seventh-grade science instruction at MTsN 6 Lima Puluh Kota.

Previous studies have likewise shown that AR can improve students' understanding of science. However, the present application differs from earlier developments in several important respects.

A relevant study by A. H. Febrianti (2024) at UIN Malang developed AR animated-video learning materials for integrated science and social studies at SDN Bunulrejo 1 Malang. The application focused on the water cycle and ecosystems and reportedly improved primary school students' conceptual understanding by 40%. However, its content was primarily passive rather than interactive. In contrast, the present application allows students to explore 3D objects directly using a marker book.

Similarly, J. Wadu, J. Enstein, and Y. A. Benufinit (2025) developed AR media for science instruction at SD Negeri Kelapa Lima using Unity and Vuforia. Although the technologies were comparable, that application addressed a narrower range of topics, including cell structure and the solar system. The present study covers three science chapters and their associated subtopics, with content tailored to the more complex learning needs of MTs students.

Another study by M. Jahi (2024) employed a ready-made platform, Assemblr Edu, in a quasi-experimental design. Although it reported positive effects on learning outcomes and student motivation, the media were not developed from the ground up. By contrast, this study involved 3D modeling, visual design, and interactive programming tailored to the needs of MTs students.

Research by Muhammad Ilyas at SMAN 3 Teladan Bukittinggi also reported that AR benefited students' learning outcomes in biology. However, it focused on a single subject area and a senior high

school population, whose characteristics differ from those of MTs students. The present study integrates three content areas for the junior secondary level.

Finally, A. A. Mahfudh and S. Nur'aini (2022) developed marker-based AR media for classifying vertebrate animals using Unity and Vuforia. Although their media improved students' understanding, they addressed only one subtopic. The present application provides a broader menu structure and content that can support continued use across several science topics.

Taken together, the principal strengths of the developed AR media are their coverage of three seventh-grade science chapters, interactive 3D objects accessed through markers, and integration of educational audio narration. The media were designed not only to visualize abstract concepts but also to provide an engaging and interactive experience suited to MTs students.

4. Conclusion

This study produced Unity-based augmented reality learning media for seventh-grade science at MTsN 6 Lima Puluh Kota. The media were rated valid, practical, and effective, with scores of 0.89, 0.92, and 0.90, respectively. The application was found to support students' motivation and understanding of abstract topics such as motion and forces, the solar system, and classification of living organisms. Its main strengths lie in the integration of three science chapters with interactive 3D objects and educational narration. These results suggest that AR can offer an innovative, visually engaging approach to science instruction in Islamic junior secondary schools. However, the evaluation was limited to one class and a relatively small sample, restricting the generalizability of the findings. The media also covered only selected science topics. Future research should therefore evaluate the application across more classes and develop additional instructional content to support wider use.

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