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Development of Augmented Reality-Based Media for PJOK Learning Basketball Phase D

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Abstract

This research aims to develop and test the effectiveness of Augmented Reality (AR)-based learning media that focuses on phase D basketball dribbling techniques in the subject of Physical Education, Sports, and Health (PJOK). The method used is Research and Development (R&D) with the ADDIE model involving 15 students in small-scale trials and 30 students in large-scale trials. The learning materials are structured based on the Independent Curriculum and are presented through illustrative images and three-dimensional animations integrated into interactive AR video game applications. Media validation was carried out by material experts and programming experts with the results of the category of feasible and very feasible. Quantitative data in the form of pretest and posttest results were analyzed using the gain score formula, showing a significant increase in students' dribbling skills with an average gain score of 0.64. Qualitative data from questionnaires and observations showed positive student responses to AR media that increased motivation and learning engagement. The results of the study concluded that AR-based learning media was effectively used to improve basketball dribbling technique skills in PJOK students. This research contributes to the development of innovative learning media that combines AR technology with sports learning.

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INTRODUCTION

Education has a very significant role in the lives of students, and is expected to lead them to become better and dignified individuals. Learning is closely related to education, because it is basically an effort made by students to achieve behavior change that supports overall self-development. This is characterized by a transformation in the cognitive (science), psychomotor (ability), and affective (attitude) aspects which aim to create improvement in students (Maha et al., 2021). Education is a very vital aspect for every individual, because it has a great impact on students in improving the quality of learning as well as realizing their dreams and contributing to improving the intelligence of people's lives (Nuraini, 2023). The essence of education according to Ki Hadjar Dewantara is an effort adults to the younger generation with the intention of supporting progress in their lives, meaning that the function of education is to directs the growth and development, spiritual and physical strength that exists in the every child so that they can benefit their lives (Al-Mubarok Bandar Mataram Lampung Tengah, 2022). This eventually became an important moment for the development of sports in the country (Kogoya et al., 2022).

Physical education is an activity that involves physical movements, carried out based on understanding (cognition) and when this activity is carried out, individual attitudes will emerge that are related to traits or affective traits (such as discipline, honesty, confidence, resilience) and social behavior (such as collaboration, mutual support) (Isman et al., 2023). Physical Education is actually an important component of the overall education system that aims to improve health, physical fitness, critical thinking skills, emotional stability, social skills, and ethical reasoning and behavior through physical activities and sports. Physical education involves the process of learning, moving, and learning through movement activities (Resah Pratama & Marsiyem, 2019). The concept of Physical Education (Penjas) is a very significant element in the learning process. This means that Penjas are not just decorations or additions to school programs that serve to fill children's time. However, Penjas has a crucial role in education (Dermawansyah, 2023). Physical education is a teaching and learning activity that can be carried out by humans or members of society systematically through various forms of physical activities that aim to gain improvements in knowledge, skills, and obtain a fit soul that can form character in each human being (Aji, 2023).

Learning is a type of process to understand the knowledge conveyed by a teacher or expert in his field (Hodidjah, 2020) In this process, several elements are needed that can support the implementation of learning, including media or devices that have technology that can balance with the field being taught (Maritsa et al., 2021). Teaching media is a tool or facility that is used to convey information on teaching materials from teachers to students (Bashri et al., 2022).

The use of technology in education is one way to prepare the workforce in the future, because in this case it is considered an important field related to education. (Maritsa et al., 2021). PJOK learning is synonymous with physical activity, for this reason, in addition to the teacher's ability to choose the appropriate learning model, as a PJOK teacher must also know the dominant physical components needed in each learning material. After knowing the physical components needed, teachers must know the extent of students' abilities in the physical components (Wayan Tirtawati et al., 2024). The strategy for implementing the learning model can be said to have been successful if the implementation of the learning model has been done well and students can follow it happily and confidently in understanding the content of the subject matter that has been taught by the teacher (Aji, 2023).

Augmented Reality (AR) is a technology that unites virtual elements in the form of two-dimensional or three-dimensional to observe the real world, while simultaneously displaying certain objects in virtual form (Rizali Rachim & Salim, 2024). Augmented Reality aims to create a technology that allows for the direct merging of computer-generated digital content with the physical world (Nuraini, 2023). When viewed from a practical point of view, Augmented Reality (AR) learning media is more efficient because it is easy to carry and allows users to see 3D objects. This technology is designed to meet the needs of teachers who are less interested in reading as well as students who have an active nature (Dwi Mukti, 2019). Some of the reasons for using augmented reality media in learning are to increase students' intrinsic motivation, build a constructivist approach, and collaboration as a student experience (Bashri, Puspitawati, & Sri, 2022). Augmented Reality is a different thing from Virtual Reality and Mixed Reality. This difference lies in the way the technology works. In Virtual Reality technology, users enter a completely virtual world and cannot interact or see the real world. Meanwhile, Augmented Reality and Mixed Reality allow users to keep seeing and interacting with the real world (Pranata et al., 2021). Development and progress can be found out by how to participate in sports events between students, because nowadays often sports events between students were held including, championships of basketball, volleyball, soccer, and the Currently popular is the futsal championship (Mahputra et al., 2020).

Technology is also included in a field science to study a system contained in a computer or laptop and create a tool or application that is installed in a network to help or facilitate humans in daily activities (Maritsa et al., 2021). Educational technology requires teachers to formulate clear goals thinking about the method he considers most effective to achieve that goal (Satya et al., 2020). Learning media cannot be separated from the learning process, because the media Learning is an intermediary between teachers and students in transferring science (Anantiwi, 2021). Analysis of the evidence shows that Physical Education and School Sport has the potential to give contribution at developments in each domain namely physical, social, affective and cognitive(Raibowo & Nopiyanto, 2020).

An innovative and creative attitude is needed so that science and technology become solutions to the problems of human life (Waruwu, 2024). The media is Media that can help in the needs of and activities, which can be makes it easier for Anyone who take advantage of it (Luthfi et al., 2020). Learning media is a channel or intermediaries used to convey message or teaching materials (Marufah et al., 2023). Principles Learning is an important part that needs to be known by a teacher, with Understanding the principles of learning, A teacher can create a reference in learning (Sahbudin et al., 2021). Device Learning Putting things together who must prepared by the teacher before Implement Learning (MBoleng et al., 2018).

A basketball game is a type of sports game that involves a large ball, played in teams of two groups of five players each. The two teams compete for points by throwing the ball into the hoop (Maha et al., 2021). The application of basketball materials has the recommendations of its applicator as a characteristic of schools that have special courts and basketball facilities (Devidson et al., 2021). The game of basketball is a type of team sport that involves two groups, each consisting of five members, which aims to score points by putting the ball in the opponent's basket and blocking the ball from entering the team's own basket (Wayan Tirtawati et al., 2024). The sport of basketball can be played by all ages, from children to adults. In the school environment, lessons about basketball are attended by students at the elementary school, junior high school, high school, and college levels (Dermawansyah, 2023). Basketball is a highly demanding team sport, requiring players to adequately develop various physical fitness attributes for successful on-court performance (Sánchez-Díaz et al., 2021).

METHODS

This research uses a research and development approach with the ADDIE development model, which consists of five main stages, namely Analysis, Design, Development, Implementation, and Evaluation. The selection of this model is based on its systematic and flexible goal of developing technology-based learning media, especially Augmented Reality (AR), to support Physical Education, Sports, and Health (PJOK) learning in phase D basketball materials.

Participants

Participants in this study were divided into 2 scales. The small scale is 15 students from SMP Negeri 1 Tegalsiwalan, and the large scale is 30 students from MTS Negeri 2 Probolinggo. The selection of participants was carried out purposively by considering their involvement in PJOK learning that is relevant to basketball materials in accordance with the learning outcomes in the Independent Curriculum. A total of 45 students were involved in the implementation stage of Augmented Reality-based learning media. These numbers are considered representative to test the acceptability and effectiveness of the media developed at each scale. Participants consisted of men and women with an age range between 13 and 14

years, all of whom had participated in regular PJOK learning.

Materials and Apparatus

In this study, the materials used include basketball teaching materials in phase D which were compiled referring to learning outcomes in the Independent Curriculum and web-based game application codes. The teaching material is focused on the basic technical concepts of the game of basketball, especially dribbling skills, which are one of the important competencies in learning Physical Education, Sports, and Health (PJOK).

1. Teaching Materials
   PJOK Basketball Phase D

Teaching Materials Topic: Basic Dribbling Techniques
Grade: Junior High School/MTs (Phase D)
Time Allocation: 2 × 40 minutes

Learning Outcomes (CP): Students are able to understand the basic concepts, principles, and techniques of basketball dribbling, as well as practice them correctly in simple game situations.

A. Learning Objectives

After participating in learning, students are expected to:
1. Explain the meaning and purpose of dribbling in the game of basketball.
2. Identify various dribbling techniques.
3. Practice basic dribbling techniques (low dribble, speed dribble, crossover) correctly.
4. Showing sportsmanship, discipline, and cooperation when practicing.

B. Subject matter

1. Definition of Dribbling Dribbling is a technique of carrying the ball by bouncing it off the floor using one hand in turn, to move the ball from one place to another in the game.
2. Dribbling Purpose
   1) Move the ball to approach the opponent's hoop.
   2) Set the tempo of the game.
   3) Avoiding opponents (defenders).
   4) Opening up opportunities for attack.
3. Basic Principles of Dribbling
   1) The ball is reflected with the fingertips, not the palm.
   2) The body position is slightly bent, the knees are slightly bent.
   3) Foresight to read the game situation.
   4) Use dominant or non-dominant hands alternately.
4. Types of Dribbling
   1) Low Dribble: Low dribble to protect the ball from opponents (used when guarded).
   2) Speed Dribble: A quick dribble to move towards the opponent's hoop over long distances.
   3) Crossover Dribble: Cross-dribble to outwit opponents and change the direction of movement.
5. Frequent Mistakes
   1) Bounce the ball too high or too low.
   2) Looking at the ball too often, so as not to pay attention to the opponent/team.
   3) Not keeping the ball away from the body when dribbling.

C. Learning Media and Resources

1. Standard basketball size 5 (junior high school).
2. Basketball court/practice area.
3. AR/Video 3D app to display dribbling movements.
4. PJOK Independent Curriculum Junior High School Book.

D. Learning Steps Introduction (10 minutes)

1. The teacher conveys the learning objectives.
2. Dynamic warm-up and muscle stretching.
3. Motivation by showing a short video of dribbling techniques.

Core Activities (60 minutes)

1. Observation and Discussion
   1) Students observe dribbling movements through teacher demonstrations/AR animations.
   2) Discussion about the purpose and principles of dribbling.
2. Guided Training
   1) Practice low dribble on the spot.
   2) Speed dribble practice while running on cones lanes.
   3) Crossover dribble practice to outwit opponents.
3. Applicative Exercises
   1) Simple 3-on-3 game with a focus on dribbling.

Closing (10 minutes)

1. Learning reflection: students convey impressions and difficulties.
2. Cooling.
3. Teacher provides feedback and homework: looking for dribbling technique videos from professional players.

E. Assessment

1. Knowledge
   1) Oral/written test regarding the definition, purpose, and type of dribbling.
   2) Skills

Table 1. Dribbling Technique Assessment Rubric:

Aspect	**Score 4**	**Score 3**	**Score 2**	**Score 1**
Body position	Stable, bent knees, forward-looking	Knees slightly bent, occasional gaze at the ball	Rigid position, often looking at the ball	Completely wrong position
Ball control	Consistent, waist-high bounce ball	Sometimes too high/low	Often uncontrolled	Balls often miss
Variasi dribble	Capable of all types of dribbles	2 types of dribbles are good, 1 less	1 good type, 2 less	Unable to perform the technique correctly

3. Attitude • Sportsmanship, discipline, cooperation in training.

Figure 1. Dribbling Illustration

Gen-4 Turbo 4153332663.mp4

Procedures

This research uses code where this code is part of the user interface (UI) structure for a web-based game application titled "Basketball Dribble Challenge". The app appears to use cameras to detect and count the number of basketball dribbles in real-time, likely in the context of augmented reality (AR).

This code is the user interface of a web-based game with camera and AR technology to count the number of times a player dribbles a basketball in a given time. Users can start the game, view tutorials, perform camera calibrations, and see the final result with their scores. All these elements are arranged in a variety that represents the different screens and controls in the game.

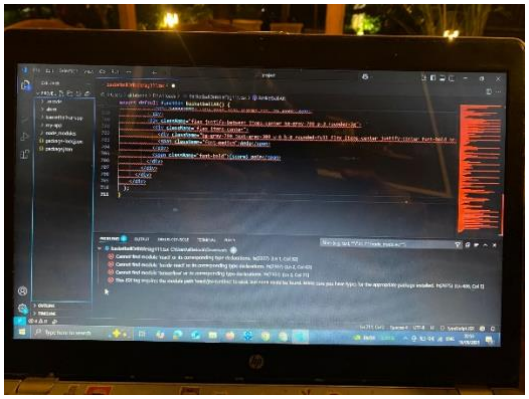

Figure 2. Coding Usage

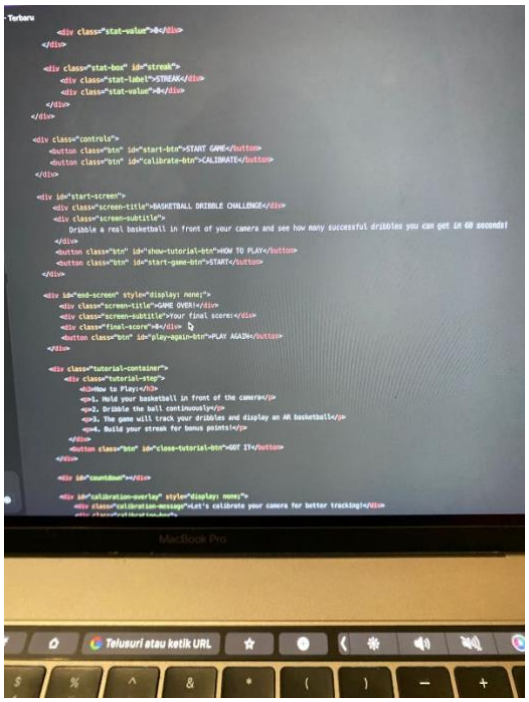

Figure 3. Application Usage Coding

Explanation per section:

1. Game Statistics (Streak and Score)
    1) This section displays the statistical value of the game, such as score or streak (the number of consecutive dribbles successful).
    2) Stat-Value contains numbers that will be updated as the game progresses.

2. Game Controls

1) There are two buttons: one to start the game (START GAME) and another to calibrate the camera (CALIBRATE), for more accurate dribble tracking.

3. Start Screen
   1) This section is the initial view when the app is opened.
   2) Explain the objective of the game: dribble a basketball in front of the camera and count the number of dribbles for 60 seconds.
   3) There is a button to open the tutorial and start the game.

4. End Screen
   1) This is the view after the game is over.
   2) Displays the player's final score.
   3) There is a button to play again.
   4) By default, this element is hidden (display: none;) and only appears when the game is over.

5. Play Guide
   1) Shows steps on how to play the game.
   2) Explains that the user must hold the basketball in front of the camera and dribble constantly.
   3) The system will track the dribble using AR technology.
   4) There is a button to close the tutorial.

6. Countdown and Calibration
   1) Countdown will likely display a countdown of time when the game starts.
   2) Calibration-overlay is an overlay that appears during camera calibration, helping the user to keep track of the ball properly.

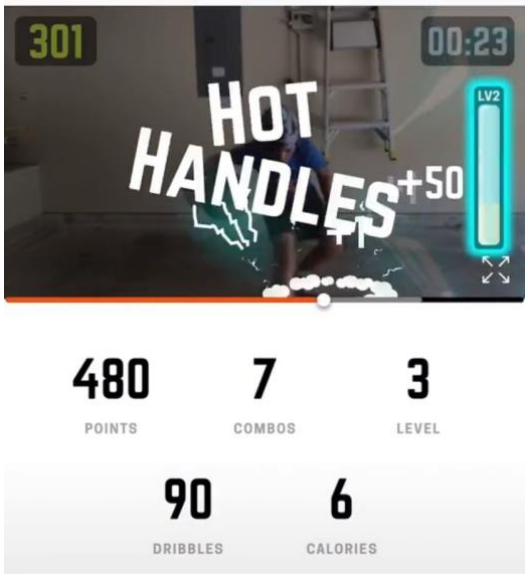

Figure 4. Examples of Dribbling Test Results

Explanation of Figure 4. As follows:

Metode	Nilai	Keterangan
Points (Poin)	480	Total scores collected from dribble, combo, speed, and accuracy combinations.
Combos	7	The total combination or variation of dribble movements performed in this session. Combinations can include crossovers, behind the back, double dribble, etc.
Level	3	The overall user level in this app.
Dribbles (Dribel)	90	The total amount of dribbling done during the session.
Calories (Kalori)	6	Estimated calories burned based on physical activity during dribbling.

Timer (Waktu)	00:23 detik	Time that has passed in this training session. It can be seen that the new session lasted for 23 seconds.

Dribbling practice now no longer has to be done on the field with the presence of a coach. Thanks to Augmented Reality (AR) technology, anyone can now practice basketball skills independently, anytime and anywhere. One of the obvious examples is the results of the training sessions shown in the picture.

In the 23-second session, users managed to record 480 points, with 90 dribbles, 7 movement combinations, and burned 6 calories. The app automatically recognizes the user's movements and provides real-time assessments, including bonuses such as "Hot Handles" when the user demonstrates fast and complex dribbling skills.

More than just counting scores, the app also monitors the user's progress through a level system. In the image it can be seen that the user is at Level 3, indicating that he has gone through several stages of training before.

This technology combines technical training, fitness tracking, and game elements (gamification), making training feel more interactive and fun. For anyone who wants to improve their ball handling skills in a modern, effective, and flexible way, this AR-based dribbling app is a smart and inspiring training solution.

Design or Data Analysis

Designing and analyzing data follows the stages of media development with the ADDIE model, specifically the development, implementation, and evaluation stages, with details:

1. Media Development: Media editing and programming is carried out with collaboration between researchers and programming experts, namely Rui Alfadel Saputra, S.T. AR video game media has been revised based on the input of programming experts to ensure that technical functions run optimally.
2. Material Validation: The dribbling learning material is validated by a basketball material expert, namely Anang Wahyu Widodo, S.Pd, to ensure the suitability of the material with the learning standards and the correctness of the techniques presented.
3. Small Scale Trial: The media was tested on 15 students of SMPN 1 Tegalsiwalan. Before and after the use of media, measurements were taken to determine feasibility and technical constraints.
4. Media Revision: Based on the results of small-scale trials and expert input, programming revisions and material improvements are carried out.
5. Large-Scale Trial: The media was tested on 30 MTsN 2 Probolinggo students to measure the effectiveness of the media in improving dribbling skills.
6. Data Collection: Through dribbling practice tests before and after the use of media, observation of student activities, and user response questionnaires.

Data Analysis

1. Media Validation: Validation data by material and programming experts is analyzed by percentage descriptive

method to determine the level of media eligibility.

2. Pretest and Posttest: The data from the dribbling skills test results are analyzed using the Gain Score formula to determine the improvement of students' abilities after using AR media.

3. Qualitative Analysis: Observation data and student response questionnaires are analyzed descriptively to evaluate students' motivation, ease of use, and level of involvement during learning.

RESULT

1. Media and Material Validation Results

a. Material Validation by Basketball Material Experts

The material expert, Anang Wahyu Widodo, S.Pd, gave an assessment on the aspects of the suitability of dribbling material with the Independent Curriculum, the clarity of the presentation of techniques, and the quality of illustrations and 3D animations. From the validation instrument containing 10 questions, an average score of 4.6 was obtained on a scale of 5, or 92% in the very feasible category.

Expert comments stated that the material was in accordance with competency standards and learning outcomes and illustrations made it easier for students to understand dribbling techniques. However, experts recommend adding animation variations to make dribbling moves look more realistic.

b. Programming Validation by Programming

Experts Programming expert, Rui Alfadel Saputra, S.T, assessed technical aspects such as media interactivity, control button responsiveness, smooth animation, and user interface. Of the 10 assessment items, the media obtained an average score of 4.4 or 88%, in the feasible category.

Suggestions for improvements are given to dribbling animation responses to make them smoother and application loading optimization so that they don't lag when running on mid-spec devices.

2. Small-Scale Trial Results

The trial on 15 students of SMPN 1 Tegalsiwalan was carried out to determine the feasibility and initial function of the media. The following are the results of the dribbling skill measurement:

Table 1. Results of small-scale trials

IndiCator	Pretest Rata-rata	Posttest Rata-rata	Gain Score
Technical Dribbling	55	75	0.45

1) Analysis: A gain score of 0.45 indicates an improvement in the ability of students in the medium category. This indicates that the media is quite effective in improving the understanding and practice of dribbling techniques.

2) Student Response: The response questionnaire showed that 86% of students found the media easy to use and engaging.

3) Constraints: Some students complain about the unresponsive control buttons, especially during dribbling animations.

3. Media Revision Results

Based on the input of programming experts and the results of small-scale trials, technical improvements were made such as improving dribbling animations to make them smoother and improving control responsiveness.

4. Large-Scale Trial Results

The follow-up trial on 30 MTsN 2 Probolinggo students aimed to test the effectiveness of the revised media:

Indicator	Pretest Rata-rata	Posttest Rata-rata	Gain Score
Technical Dribbling	58	85	0.64

1) Analysis: A gain score of 0.64 belongs to the medium to high category, indicating that the media is effective in improving dribbling skills.
2) Student Response: 90% of students responded positively to the media, stating that learning was more interesting and easy to understand.
3) Observation: Students are more active and motivated during learning, as seen from practical participation and discussion.

DISCUSSION

1. Media Eligibility Based on Expert Validation

The results of validation by material experts (Anang Wahyu Widodo, S.Pd) showed a feasibility percentage of 92% with a very feasible category. This score indicates that the dribbling material prepared is in accordance with the learning outcomes in the Independent Curriculum and in accordance with the basic technical standards of basketball phase D. Visualization in the form of illustrative images and 3D animations is considered to help students understand technical details such as hand position, eye coordination, and the rhythm of ball bounce.

Meanwhile, the validation results by a programming expert (Rui Alfadel Saputra, S.T) obtained a score of 88% or a decent category. The assessment is focused on the smoothness of animations, interactivity, responsiveness of the control buttons, and ease of navigation. The suggestions provided, such as the improvement of the frame rate of dribbling animations and the reduction of lag on mid-range devices, were immediately implemented before large-scale trials.

These findings show that the involvement of experts across fields (sports materials and technology) plays an important role in ensuring that learning media is valid both in terms of content and technicality.

2. Effectiveness of Trial-Based Media

a. Small-Scale Trials

The trial on 15 students of SMPN 1 Tegalsiwalan provided an initial overview of the effectiveness of the media. The average pretest score was 55 and increased to 75 on the posttest, resulting in a gain score of 0.45 (medium category). Student response to the media

reached 86% with indicators of ease of use, interest, and understanding of the material.

However, an obstacle was found in the form of less responsive control buttons in dribbling animations, especially when run on low-spec devices. This input is the basis for technical revisions before large-scale trials.

b. Large-Scale Trials

At this stage, the media was tested on 30 MTsN 2 Probolinggo students after repair. The average pretest score increased from 58 to 85 in the posttest, with a gain score of 0.64 (medium-high category). The positive response of students also increased to 90%.

Field observations show that students are more enthusiastic, active, and motivated to try dribbling exercises over and over again because of the game-based learning approach. Interaction with 3D visualization allows them to independently correct motion errors, such as the height of the ball's bounce or improper hand position.

3. Relevance of Results to Learning Theory

The results of this study are in line with the multimodal learning theory (Nasution et al., 2022) which states that the combination of visual, audio, and kinesthetic can improve conceptual understanding and practical skills. AR media allows students to see a simulation of dribbling in the form of realistic 3D animations, while also practicing them directly.

From the perspective of motor learning, accurate motion visualization helps the observational learning process (Bandura, 1986) in which students imitate the movements displayed by the virtual model. This speeds up the skill formation process as students can repeat the exercises without the limitations of space and time.

4. Advantages of AR Media in PJOK Learning

Based on field findings, some of the advantages of this media include:

1) Interactive and Engaging: Turn learning dribbling techniques that are usually repetitive into an experience like playing a video game.

2) Clear Motion Visualization: 3D animation helps students understand technical details that are difficult to explain verbally.

3) Independent Learning: Students can use the media in person outside of class hours to deepen their skills.

4) Time Efficiency: Teachers don't need to repeat the explanation of the movements many times because students can learn them from the app.

5. Obstacles and Challenges

Although the media has been shown to be effective, the study found several challenges:

1) Technical Constraints: On devices with low RAM, animations sometimes lag, interfering with the smooth running of the exercise.

2) Device Dependency: Students must have an AR-compatible smartphone or tablet.

3) Material Limitations: This media only focuses on dribbling techniques; Other

techniques such as passing and shooting have not yet been developed.

6. Research Implications

The use of AR in PJOK learning opens up great opportunities to:
1) Integrate digital technology in sports learning effectively.
2) Provide learning media that can be used at school or at home.
3) Adapting learning according to the learning style of the native digital generation.

CONCLUSION

Based on the results of the research and discussion, it can be concluded that:

1. Media Eligibility: Augmented Reality (AR)-based learning media developed for basketball dribbling material phase D is declared feasible to use. Validation by material experts obtained a feasibility percentage of 92% (very feasible), while validation by programming experts obtained a feasibility percentage of 88% (feasible).

2. Media Effectiveness: The use of AR media is able to significantly improve students' dribbling skills. In the small-scale trial (15 students of SMPN 1 Tegalsiwalan), the average gain score was 0.45 (medium category), while in the large-scale trial (30 MTsN 2 Probolinggo students) the gain score increased to 0.64 (medium-high category).

3. User Response: The majority of students give a positive response to the developed media. The percentage of positive responses increased from 86% in small-scale trials to 90% in large-scale trials. The media is considered interactive, interesting, and makes it easier for students to understand dribbling techniques visually and practically.

4. Learning Contribution: This media is able to combine elements of 3D visualization, interactivity, and game-based learning approaches so that it can increase student motivation, engagement, and learning outcomes. Thus, this AR-based learning media is suitable for PJOK learning, especially the basic techniques of basketball dribbling phase D.

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