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Designing a Virtual Reality Storyboard for Basic Volleyball Skills Training for Athletes with Disabilities

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Abstract This research aims to create a Virtual Reality (VR)-based storyboard to support disabled athletes in understanding fundamental volleyball techniques. The foundation of this research stems from the need for adaptive, safe, and inclusive sports training tools to help physically disabled athletes improve their motor skills. VR technology was chosen due to its ability to generate realistic and interactive training environments, allowing participants to learn and repeat basic volleyball movements without the risk of physical injury. This research employs the Research and Development (R&D) method, referring to the ADDIE model (Analysis, Design, Development, Implementation, Evaluation). However, the focus is limited to the first two phases: analysis and design. In the analysis phase, the characteristics, needs, and challenges faced by disabled athletes during training in basic volleyball techniques were identified through interviews and observations. The analysis findings indicate that the required training tools must clearly display movements, be repeatable, and include accessibility features such as high color contrast, large-sized icons, and voice guidance. The design phase produced an organized storyboard, encompassing a training sequence starting from VR media introduction, virtual warm-up, demonstration of four main techniques (serving, passing, smashing, and blocking), to final assessment and motivation sessions. Every segment includes visual and auditory guides to help users grasp the exercises. The study produces a VR storyboard design as its output, which can act as a basis for developing customized sports training media for athletes with disabilities. However, the researcher recognizes the constraints of this work, since it does not encompass the complete stages of the ADDIE model, development, implementation, and evaluation. As a result, upcoming studies will focus on developing a working VR prototype, conducting trials with a broader set of disabled athletes, and evaluating how well the media enhances motor abilities and engagement in learning for the athletes.

Keywords Virtual Reality (VR), Storyboard Design, Volleyball Training, Fundamental Techniques, Athletes with Disabilities, Adaptive Sports Media

1. Introduction

The use of information technology in volleyball instruction is increasingly popular nowadays [1]. Advancements in digital tools within education and athletic coaching have created fresh possibilities for learning that are more engaging, personalized, and accessible to all. One notable innovation is the application of Virtual Reality (VR), which can create an immersive and realistic training environment, allowing users to interact with training scenarios safely without the risk of physical injury [2]. Virtual reality is a concept for exploring the virtual world. Virtual reality works by manipulating the human brain so

that it feels as though the virtual experiences are real [3], [4]. In the context of physical education and adaptive sports, VR serves not only as a learning tool but also as an effective means of motor rehabilitation [5]. In addition, various studies show that Virtual Reality (VR) has a significant contribution to physical education learning. Yusuf [6] explains that the use of VR in physical education can improve students' spatial perception and motor coordination, thereby positively impacting the development of motor skills. In line with these findings, Maulana et al. [7] state that VR as a medium for sports education provides an immersive learning experience, which not only helps students understand movement concepts but also improves motor skills in a tangible way. Furthermore, Fernández-Vázquez et al. [8], through an intervention study, found that the integration of VR with gamification in physical education has a positive impact on improving motor skills as well as the level of effort and engagement of students during the learning process.

Volleyball falls under the category of ball sports and enjoys widespread popularity among Indonesian students and the general public, thanks to its relative simplicity to learn and the ability to play it virtually anywhere without needing costly gear [9]. In addition, volleyball is a sport that requires fine and gross motor coordination, muscle strength, balance, and an understanding of game tactics. For athletes with disabilities, mastering basic techniques such as serving, passing, smashing, and blocking often poses challenges due to physical limitations or limited access to safe training facilities [10]. Therefore, an educational approach is needed that can clearly visualize movements, provide repeated guidance, and minimize the risk of injury. In this context, the virtual reality-based training system for basic volleyball techniques offers athletes with disabilities the opportunity to participate in training that avoids direct physical contact while still providing engaging gameplay and techniques [11].

In the development of learning media, storyboards serve as visual maps that describe the sequence of scenes, visual elements, and user interactions, making it easier for designers to ensure the integration of materials and the smooth flow of learning. In the context of interactive media, storyboards also serve as guidelines for planning and evaluation before entering the production stage, as well as visualizing the step-by-step navigation required by users [12]. A storyboard can be defined as a sequence or flow in the form of storyboards or sketch drawings that represents a story from beginning to end [13], [14]. Storyboard design can help teachers/prospective teachers to design virtual basic volleyball techniques more accurately, structurally, and efficiently [15]. This stage will help to understand the overall picture of the basic volleyball technique training system that will be displayed in virtual reality. In creating a storyboard, the illustrator is not required to be able to draw sketches well, but rather to ensure that others involved in the team can understand the images. The illustrator is required to provide a simple overview of the final result from the camera's perspective [16]. In the context of technology-based learning media, storyboards serve as technical documents that contain navigation flows, visual displays, and user interactions, thereby facilitating the evaluation and further development processes [17].

Storyboard design consists of three main stages: Thumbnail, Rough Storyboard, and Clean-Up Storyboard [18]. The first stage, thumbnail, focuses on small and simple sketches to quickly explore basic ideas and the visual composition of each scene. Next, the rough storyboard stage develops the thumbnail by adding clearer details to characters, movements, expressions, and camera positions, often accompanied by annotations to explain important elements. Finally, the Clean-Up Storyboard is the finalization stage, where the images are made neater and more detailed, with clear lines, complete technical notes, and adjustments to proportions and perspective to ensure they are ready for use as a production guide. These three stages complement each other to create an effective and structured storyboard [19].

The role of technology in training athletes with disabilities emphasizes that technology, including Virtual Reality (VR), has become a breakthrough in disability sports training. VR enables safe simulation of competitive environments, provides real-time feedback, and reduces the risk of injury [20]. Athletes with disabilities are individuals with physical, sensory, intellectual, or a combination of such limitations who participate in competitive or recreational sports activities with certain adjustments to rules, equipment, or training methods. According to the International Paralympic Committee (IPC), disabled athletes can come from various impairment categories such as visual impairments, amputations, cerebral palsy, intellectual impairments, spinal cord injuries, and others [21].

Building on this context, the research centers on creating a VR storyboard aimed at teaching fundamental volleyball skills to disabled athletes. The primary goal is to develop training materials that prioritize safety, interactivity, and customization to the participants' physical requirements, thereby promoting inclusive sports education in Indonesia.

2. Materials and Methods

2.1. Research Design

This study employs the Research and Development (R&D) approach, drawing on the ADDIE model (Analysis, Design, Development, Implementation, Evaluation) as outlined by Branch [22]. The model was selected for its structured framework for creating educational media, guiding the process from initial needs assessment through thorough product assessment.

In this particular research, the development was limited to the Analysis and Design phases, which establish the core groundwork for VR training tools for athletes with

disabilities. These stages yielded a needs assessment map, a plan for training materials, and an interactive storyboard that acts as a guide for future development steps.

The subsequent stages in the ADDIE model will be the focus of future research. In the Development stage, the researcher plans to develop an interactive VR prototype based on the designed storyboard, using software such as Unity 3D and Blender to produce simulations of basic volleyball movement techniques (serving, passing, smashing, and blocking). The Implementation stage will involve limited trials (pilot testing) on a small group of disabled athletes to assess aspects of functionality, user engagement, and ease of use of the media.

The Evaluation phase will employ two methods: formative assessment and summative assessment. Formative assessment occurs throughout the development process to gather input from subject matter specialists and media professionals, whereas summative assessment takes place post-implementation to evaluate the VR media's impact on enhancing motor abilities and comprehension of fundamental volleyball skills. This strategy is consistent with the guidelines from Dick, Carey, & Carey [23], which highlight the value of ongoing feedback loops at every stage of educational media creation.

Thus, although this research only covers the first two stages of the ADDIE model, the resulting design has provided a strong conceptual and structural foundation to support prototype development and implementation in subsequent research. For an explanation of the ADDIE model steps, see **Figure 1**.

2.2. Research Subjects

The research subjects consisted of:

1) Athletes with Disabilities: 20 athletes with disabilities who are physically disabled and are members of an inclusive sports club in Palembang City.
2) Subject Matter Experts: two physical education lecturers with experience in coaching volleyball and adaptive learning.
3) Media Experts: one educational technology expert specializing in VR-based media development.

2.3. Research Instruments

The instruments used in this study include:

1) Observation Sheet: used to record the motor skills and challenges faced by disabled athletes during basic volleyball technique training.
2) Interview Guidelines: to explore the needs of coaches and athletes regarding adaptive training media.
3) Storyboard Feasibility Checklist: used by content experts and media experts to assess the quality of VR storyboard design.

These instruments were developed based on the principles of content validity and contextual appropriateness [24].

2.4. Research Procedure

1) Analysis Stage
   a) Direct observation of training sessions to identify physical limitations and learning needs of athletes with disabilities.
   b) Interviews with coaches and athletes to identify priority basic techniques (serve, pass, smash, block) and accessibility features required.
   c) Analysis of the suitability of the material for potential integration of VR in basic volleyball technique learning.
2) Design Stage
   a) Development of a VR storyboard as a media blueprint, including scenario flow, 3D movement visualization, audio instructions, and interactive features.
   b) Scenario design begins with the VR media introduction, virtual warm-up session, basic technique demonstration, and concludes with automatic evaluation and motivational closing.
   c) Determination of accessibility elements such as high color contrast, large icon size, and clear audio guidance, in accordance with the principles of Universal Design for Learning [25].

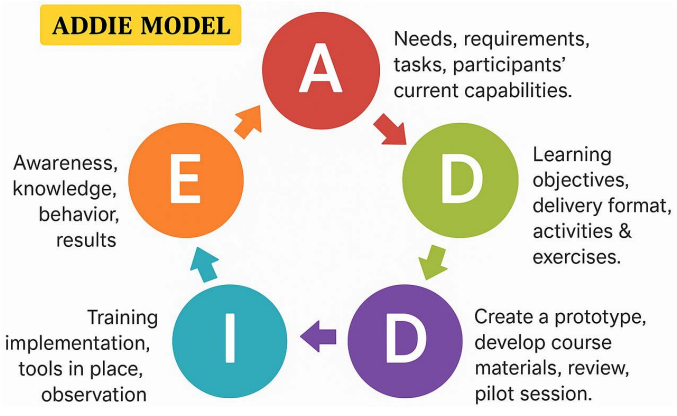


Figure 1. Analysis-Design-Development-Implementation-Evaluation (ADDIE) Model (Source: Adapted from (Branch, 2009))

2.5. Data Analysis

Data from observations and interviews were analyzed using descriptive qualitative methods to identify training media needs. Data from storyboard evaluations by subject matter experts and media experts were analyzed using feasibility percentages [26] to determine design quality prior to the production stage.

3. Results

The development of a Virtual Reality (VR) storyboard for basic volleyball training for athletes with disabilities was carried out with reference to the ADDIE model. In this study, the development process has only reached the Analysis and Design stages, both of which provide an important foundation for the preparation of effective, adaptive training media that are tailored to the needs of athletes with disabilities.

3.1. Analysis Stage

The analysis stage began with direct observation of inclusive sports club training sessions in Palembang City, followed by in-depth interviews with coaches and athletes with disabilities (blind and physically disabled). The results of field data collection revealed several key points:

1) Mobility Limitations and Risk of Injury

Athletes with disabilities face significant movement limitations, which can increase the risk of injury during full-intensity field training. According to Kitchin & Howe [27], accessibility in sports training must prioritize safety considerations for athletes with disabilities.

2) Need for Clear, Repetitive, and Interactive Visual Media

Coaches desire training media that can visualize basic volleyball techniques in detail, with the option to repeat material at the athlete's learning pace.

3) Priority Techniques in Training

Based on discussions with coaches, the four basic techniques that are the main focus are serving, passing, smashing, and blocking. These techniques were chosen because they form the foundation of volleyball and can be modified for the motor skills of athletes with disabilities [28].

4) Special Needs Related to Media Accessibility

Athletes with disabilities require special features such as high color contrast, large text and icons, and clear audio instructions.

The findings at this stage of analysis are consistent with the study by Al-Azawei et al., [29] which shows that adaptive learning media tailored to the needs of individual students with special needs can improve material comprehension and learning effectiveness, while reducing cognitive load.

3.2. Design Stage

In the Design phase, a Virtual Reality (VR) storyboard is crafted to act as a blueprint for creating a VR system that teaches fundamental volleyball skills. This storyboard systematically depicts the sequence of training scenarios, movement visualizations, audio instructions, and forms of user interaction during the training process. In line with the opinion of Hsin and Cigas [30], the storyboard plays a crucial role in helping developers design content flow, maintain narrative consistency, and anticipate potential usage barriers before the media production stage begins.

3.2.1. Training Scenario Structure

1) The session begins with a VR media intro containing an introduction to the training objectives, safety guidelines, and technical explanations for using VR devices.
2) It continues to a virtual warm-up session, where the instructor avatar demonstrates static and dynamic stretching movements to prevent injury [31].
3) After that, users are directed to a basic technique training session arranged gradually according to difficulty level.

3.2.2. Visualization of Basic Technique Movements

1) Each basic technique (serving, passing, smashing, and blocking) is visualized using interactive 3D animations that can be viewed from various angles.
2) Movements are accompanied by visual indicators, such as motion paths, highlighted ball contact areas, and slow-motion replays to make it easier for athletes to understand the technique stages.
3) This visualization feature is developed based on the cognitive load theory [32], which emphasizes the gradual presentation of information to facilitate the motor learning process.

3.2.3. Interaction and Feedback

1) The VR system is equipped with motion tracking sensors to detect the athlete's position and movement accuracy.
2) Real-time feedback is provided audibly, such as instructions like “Straighten your arm” or “Stabilize your foot position,” to support direct correction during training [33].
3) Additionally, the system can provide score-based feedback based on the level of accuracy and consistency of the movements performed by disabled athletes.

3.2.4. Accessibility and Inclusivity

To ensure that this media can be used by various categories of athletes with disabilities, the storyboard design stage was developed with consideration of the principles of Universal Design for Learning (UDL) [34], along with the Web Content Accessibility Guidelines (WCAG) [35]. Several practical accessibility options added include:

1) Multilingual audio guides, so that the media can be used by users with different native languages.
2) Adjustable training difficulty levels, allowing athletes to adapt the pace and complexity of training according to their motor abilities.
3) Compatibility with assistive devices, such as wheelchairs, haptic gloves, or VR controllers that can be adjusted to the user's physical condition.
4) Avatar personalization, where users can customize their virtual characters (gender, body shape, skin color, and assistive devices) to enhance the sense of presence and motivation to train [36].
5) Disability-friendly interface, with high contrast, large icon sizes, and clear voice narration.

3.2.5. Storyboard Flow Diagram

The storyboard flow diagram in Figure 2 illustrates the sequential learning flow, starting from introduction, warm-up session, basic technique training, automatic evaluation based on movement detection, to the closing motivation session. This design helps athletes follow the training path independently and gradually in a safe virtual training environment.

Table 1 outlines the storyboard design stages that were created, featuring multiple phases that structure the progression of fundamental volleyball skill instruction. This design adheres to cognitive load theory, which advocates for the incremental delivery of information to facilitate easier comprehension for users [37].

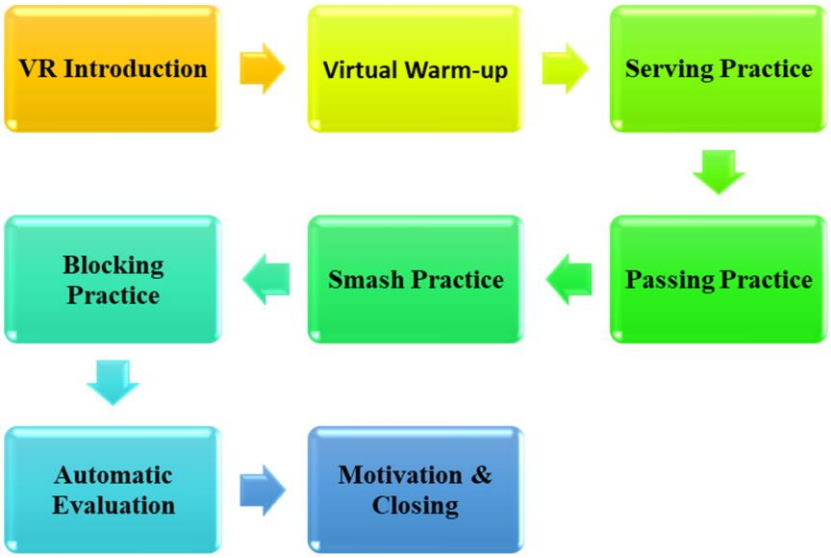


Figure 2. Storyboard Flow Diagram

Table 1. Design Storyboard Stage

No	Training Flow Steps	Visualization	Description
1	VR Media Introduction		Explanation of training objectives and how to use VR devices
2	Warm-up		Light movements to reduce the risk of injury before performing basic volleyball techniques

Table 1 continued

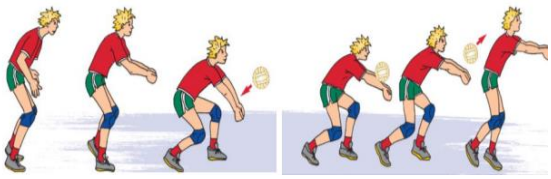
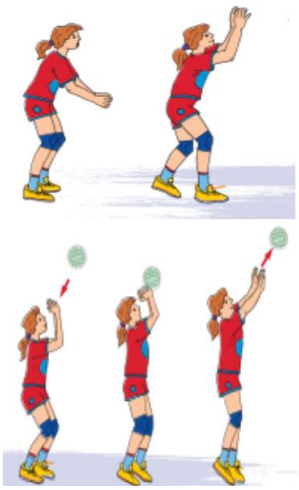
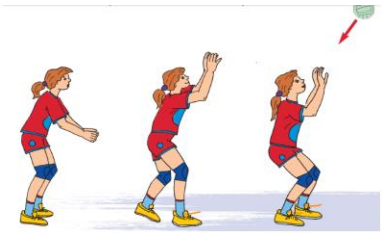
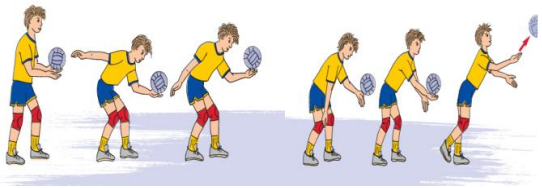
3	Underhand Passing Demonstration		Front and side angle views
4	Underhand Passing Practice		Interactive simulation
5	Overhand Passing Demonstration		Front and side views
6	Overhand Passing Practice		Interactive simulation
7	Underhand Serve Demonstration		Slow-motion movements with different view angles
8	Underhand Serve Practice		Immediate feedback on hand position

Table 1 continued

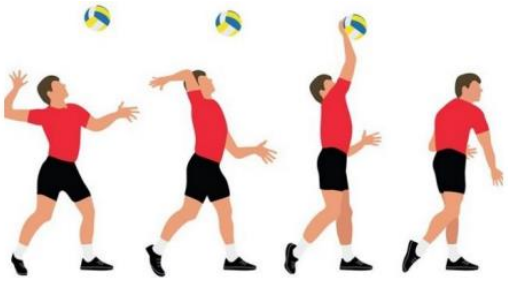
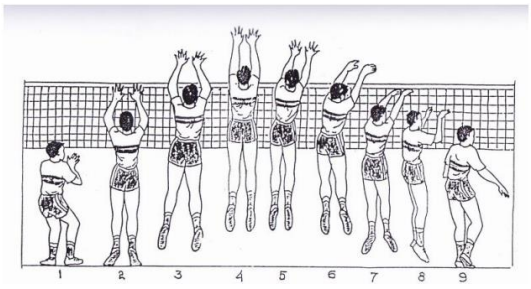
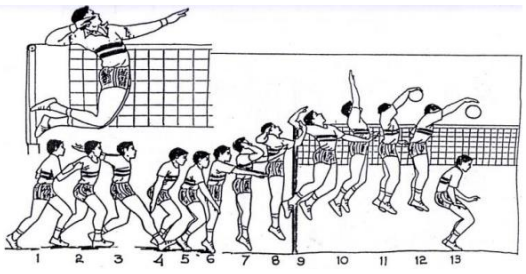
9	Overhand Serve Demonstration		Slow-motion movements with different view angles
10	Overhand Serve Practice		Immediate feedback on hand position
11	Blocking Demonstration		Movements starting from the initial stance, follow-through, and final position
12	Blocking Practice		Attempting complex movements
13	Smash Demonstration		Focus on hand-eye coordination
14	Smash Practice		Gradual attempts from slow to fast

Table 1 continued

15	Practice Evaluation		Automatic assessment based on movement detection
16	Closing and Motivation		Coach's message to provide encouragement and suggestions for independent practice

4. Discussion

Virtual Reality (VR) technology offers a safe and controlled simulation space, allowing individuals to practice intensively without the risk of injury [38]. Various previous studies have demonstrated the success of VR in education and training. For instance, Permana et al., [39] discussed the creation of a storyboard for virtual reality simulation (VRS) to facilitate nursing care learning in a respiratory system disorders course. Subsequently, Dongxu [40] emphasized VR's contribution to improving the efficiency of interactive teaching systems in science education, while Endrayanto et al. [41] explored the use of VR videos to enhance vocational teachers' knowledge and ability to implement the Merdeka Curriculum.

The effectiveness of this training tool heavily depends on the storyboard, which serves as a visual guide for designing the sequence of exercises. The storyboard facilitates the structured organization of materials, ensures smooth transitions between scenes, and helps developers visualize the user experience before the realization stage. In this study, the storyboard functions as the foundational design that directs the development of 3D content, audio insertion, and interactive elements tailored to the needs of athletes with disabilities.

The use of VR in adaptive sports learning is also in line with the principles of Universal Design for Learning (UDL), which emphasize the ability of media to adapt to the various needs of participants. The use of virtual coach avatars and audio-visual guides helps address participants' sensory barriers. A study by Riva, G et al., [42] shows that emotionally adaptive avatars in VR increase motivation, exercise compliance, and motor rehabilitation outcomes.

Furthermore, the findings of this research align with global studies in the field of adaptive sports. For example, Albiol-Pérez et al. [43] developed a VR system for soccer training for visually impaired athletes, utilizing haptic feedback and spatial audio to improve spatial orientation and movement coordination. Another study by Laver et al. [44] highlighted the benefits of VR-based rehabilitation for patients with spinal cord injuries, showing significant progress in fine motor functions and exercise motivation. These findings strengthen the position of this study in an international context, affirming that VR is not merely an interactive educational tool but also an instrument for rehabilitation and social integration for individuals with physical limitations.

In general, this research indicates that VR built with a structured storyboard can enhance the efficiency of adaptive sports training. Practically, this method can be applied to other sports branches such as badminton, table tennis, or adaptive swimming, with content and technique modifications based on each sport's characteristics. Moreover, these results open opportunities for interdisciplinary collaboration between physical education, digital technology, and medical rehabilitation to promote inclusivity in the world of sports.

5. Conclusions

This study demonstrates that the design of a Virtual Reality (VR)-based storyboard, systematically structured using the ADDIE development model, proves feasible for progression to the subsequent stages: Development, Implementation, and Evaluation. The storyboard serves as a visual guide that helps organize the training flow in a structured manner, ensuring that the sequence of basic volleyball techniques (serving, passing, smashing, and blocking) is presented clearly, interactively, and in accordance with the needs of athletes with disabilities. This design also shows significant potential in enhancing the accessibility and effectiveness of adaptive sports training in Indonesia.

As a follow-up, this research outlines a roadmap for developing storyboard-based media toward a VR product ready for field testing, with three main stages as follows:

1) Development Stage (VR Prototype Development)
   a) At this stage, the designed storyboard will be developed into an interactive VR prototype using software such as Unity 3D and Blender.

b) Each basic volleyball technique will be visualized in the form of 3D animations with a motion tracking system to detect user movements.
c) Interactive features such as real-time feedback, audio guidance, and personalized avatars will be added to ensure an adaptive and inclusive learning experience.

2) Implementation Stage (Initial Testing / Pilot Testing)

a) The prototype will be tested on a limited scale with a small group of athletes with disabilities (10–20 participants) at inclusive sports clubs to assess functionality and user engagement levels.
b) The testing will also involve coaches and sports therapy experts as external evaluators to ensure content suitability with user needs.
c) Direct observations and interviews will be used to obtain feedback on ease of use, accessibility, and user comfort in operating the VR system.

3) Evaluation Stage (Effectiveness and User Satisfaction Evaluation)

a) Evaluation is conducted through two approaches: 1) Formative Evaluation to assess media quality during the development process, covering aspects of visuals, technical elements, and interactivity. 2) Summative Evaluation to measure media effectiveness in improving motor skills, user satisfaction levels, and injury risk prevention.
b) Evaluation instruments include basic motor ability tests, user satisfaction questionnaires, and training safety observation sheets.
c) Evaluation data will be analyzed quantitatively (percentage of motor performance improvement) and qualitatively (user and coach feedback).

Figure 3 below is the roadmap for developing storyboard-based media toward a VR product ready for field testing.

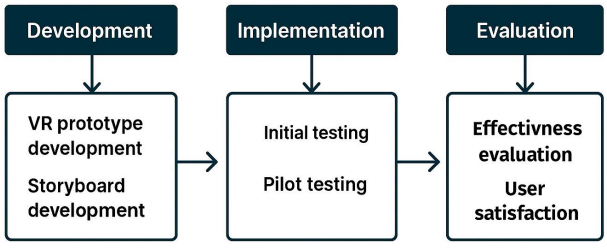


Figure 3. Roadmap for Storyboard-Based Media Development

With this roadmap, this research not only produces a conceptual storyboard design but also establishes a strong foundation for the development of adaptive VR media that can be applied to various other sports branches such as badminton, table tennis, or adaptive swimming. In the future, the results of this research are expected to contribute to the development of technology-based inclusive physical education in Indonesia, while also strengthening the position of this research in the global context of adaptive sports.

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