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The Effectiveness of Augmented Reality in Physical Sustainable Education on Learning Behaviour and Motivation

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Abstract: This research explores the integration of information technology into physical education and uses augmented reality (AR) as an auxiliary tool to explore the impact of this teaching mode on the learning motivation, knowledge, and learning behaviour of beginner runners. A pre- and post-test control group design is adopted in this study. The study participants were 56 students implemented into a 16-session football teaching course. Before the teaching was implemented, the Learning Motivation Scale, independent variables were different learning modes, while the dependent ones were the participants' learning performances, including their learning outcomes and motives, as well as their skill learning behaviours. The findings of this research are as follows: first, the experimental group (using AR) achieves better learning outcomes for motor skills than the control group. The experimental group also experiences stronger learning motives and better motor skill performances than the control one. Finally, the experimental group has a more positive attitude towards using the teaching materials, and the materials are more acceptable to them in comparison to the control one. This research contribution uses the advantages of AR to adopt an innovative teaching model, which can be highly appealing and motivating for learner behaviour. In practice, it also solves the deficiencies in the integration of information technology into physical education at this stage.

Keywords: learning motivation; augmented reality (AR); physical sustainable education; learning behaviour

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1. Introduction

In recent years, information technology (IT) and the Internet have developed rapidly and have gradually been implemented and applied in daily life and work. The integration of digital tools into classroom instruction has become a trend in modern teaching. The draft syllabus for the education program has included "Life Technology" and "Information Technology" to emphasise the use of computer-assisted learning tools in each key learning area to help students learn effectively. However, until now, many teaching materials and tools have been developed for application in traditional academic subjects, and relatively few methods of integrating information technology into teaching have been applied in technical ones. Sport is a field involving a variety of motor skills and techniques that require precision, coordination, and quick learning. Therefore, physical education teachers must undertake the explanation, technical demonstration, and even the practice of movement skills, and the current traditional physical education teaching mode can no longer meet the needs of learners. Physical education scholars are faced with a range of challenges, such as having to research or propose updated physical education strategies and constantly develop educational, innovative, and inspiring teaching content to enhance learning [1,2]. The motivation of this paper is to investigate how information technology is integrated into the sports field, for which the most common method is the "video learning mode". For example, when teaching tactics, games are recorded for tactical and action analysis so that players or learners can quickly understand response strategies; in competitions, video replays are used to assist judgements, which can help referees make more accurate decisions and fair assessments.

Action research conducted in the field of IT integration in health and physical education has pointed out that through the three aspects of teaching content, strategies, and information technology, the planning of a curriculum that integrates IT as well as the application of modern information technology and the Internet can make teaching more lively and a student's learning modes more diverse; if the teacher can present interesting and realistic visual images, they can retain a student's attention and enhance their learning motivation. In addition, some researchers believe that in the field of physical education, the use of audio-visual tools can produce more entertaining and vivid teaching content and also make the curriculum more varied, which can lead to greater learning interest. Incorporating information technology into physical education also has a significant effect on the performance of motor skills [3–5]. Using a specialized platform combined with an online learning mode, different sports and various tactics can be analysed in detail, and annotation and message functions, as well as other auxiliary information, can be added to make the discussion more systematic and logical. This can make the content of the video teaching material more exhaustive and diverse so that the learners can enter a situation and simulate the tactics more quickly, which can improve the probability of winning a game. The use of computer-based multimedia in education, combined with video and text explanations, can promote learning effectiveness and the development of teaching materials [3].

With the help of a 3D dynamic module, learners can interact with the teaching materials, which can be of assistance in the understanding and cognition of movements, and 3D visual images can generate interest in learners, thereby maintaining and enhancing their attention. With the development of digital technology, an increasing number of innovative studies on the application of information technology in teaching have been advanced. If different technologies can be integrated and applied within the physical education curriculum, they can effectively improve the disadvantages of the traditional form of teaching and enhance students' learning motivation and effectiveness. Using AR technology to combine virtual and real-world environments can introduce the effect of virtual and real integration as well as real-time interaction, allowing learners to visualize complex spatial relationships and abstract concepts, control and operate virtual objects in a 3D stereoscopic setting, and transform the original activity. Teaching materials can be superimposed with 2D or 3D images, effectively incorporating content for learning. Improving the authenticity and interactivity of the content presentation of digital teaching materials and combining paper and digital content can also effectively achieve an innovative and more appealing learning model [4–6].

Research on the integration of AR into the teaching of electrical machines also noted that learners assisted by AR were able to clearly explain their thoughts on teaching and achieve better evaluations in the use and understanding of teaching materials and confidently stated that after studying through AR aids, they learned more than with traditional learning models [7–10]. AR can help students concentrate on completing tasks, control their learning progress, and rewatch content they have not yet understood. When learners undertake tasks assigned by an instructor, their attention is also much higher than during traditional teaching, and their memory content after learning is also clearer and more solid, showing greater motivation and interest [11–13]. Therefore, this investigation explores the impact of different teaching materials (video action analysis and AR combined with 3D visual dynamic modules) using information technology on the teaching of motor skills and attitudes as well as cognition. AR combined with a 3D dynamic action skill module can solve the problem of the filming perspective, and it will not cause inconvenience in teaching or the greater load on learning generated by repeatedly shooting multiple angles. It is hoped that under the guidance of AR technology, the motivation and effectiveness of students studying motor skills can be improved.

It explores the influence of the integration of different information technology types into physical education teaching models on students' motor skills and attitudes, as well as their learning effectiveness and satisfaction; the teaching materials are divided into two categories [14,15]. The experimental group employs the AR teaching software for the physical education class developed with the Unity engine for learning; the control group uses video as the learning material. The contribution of this paper is the integration of information technology into physical education teaching using AR as a tool to assist the learning of running skills so as to establish the correct concepts for learners and to understand the movement process. It can overcome the shortcomings of traditional teaching and compared with the general information technology integrated into teaching materials, it can better assist physical education teaching and improve the attitude, motivation, and motor skills performance of scholars and learners. The specific objectives of the research are as follows: to explore the performance of learners' use of AR software on motor skills learning compared to video-based teaching materials; to explore the influence of learners' use of AR software on the motivation for motor skills learning compared with video-based teaching materials; to discuss the difference in learners' performance of motor skills using AR software compared with video-based teaching materials; and to discuss learners' use of AR software and video-based teaching materials and their attitudes towards and acceptance of them [16].

This investigation explores the influence of different information technology types integrated into physical education teaching models on learners' motor skills, learning outcomes, attitudes, and satisfaction. Previous works on AR yielded three notable positive results. Firstly, regarding AR for skill learning, the AR to assist sketch learning developed a related teaching system to facilitate the application for learners. Secondly, regarding learning motivation, the natural science curriculum utilised an auxiliary tool to carry out action learning inquiry activities. Lastly, He developed an AR alphabet book using animation to maintain learners' attention and improve learning satisfaction [16]. Therefore, the following four research hypotheses are proposed: the experimental group (AR group) that integrates physical education with IT achieves a better performance in motor skills learning than the control group (video group); compared with the control group, the experimental group using IT during physical education teaching has a higher learning motivation than the control group; the experimental group that applies IT during physical education achieves a better performance in motor skills than the control group; and compared with the control group, the experimental group that uses IT during physical education has a more positive attitude and acceptance of the teaching materials [17].

2. Literature Review

2.1. Physical Education

Motor skills are a basic element in physical education teaching. Various special skills related to human movement are taught through demonstration, observation, imitation, and practice between teachers and students. Therefore, when physical education teachers are teaching, they must employ explanations and technical demonstrations of motor skills practices. Motor skills refer to the process in which the actor's body or limbs correctly achieve a series of target movements; students learning motor skills need to undergo a stage of cognitive comprehension and improve the correctness, coordination, and fluency of their movements by identifying incorrect actions during practice [18–20]. Learning a motor skill generally involves three stages, namely the cognitive, associative, and automation phases. The biggest difficulty in physical education is that it must take into account the physical complexity of the action, space, and precision, as well as the speed requirements. In sports teaching, for the movement flow, coherence, coordination, and integrity, the structure and fluency of the specific presentation of the movement are emphasised; the main concept is based on the movement analysis theory. The German dancer Rudolf Laban invented the Laban movement analysis system in order to strengthen the shortcomings of the traditional dance score, which only notes the time, steps, body, space, force, and relationship, recording body movements in a quantitative way. Actions are defined by three categories [21–25]. (1) Fundamental: actions must start from the deep layers and should not only imitate the appearance of the movements but focus on the deep muscles or joints as the starting point. (2) Integrity: intermittent or discontinuous movements should be connected in a series and integrated from the inside out, as well as from outside to inside, so as to achieve the coordination of the body in time and space. (3) The functions represented are varied, and the ways of expressing them are also different. The student learns which parts to use and when to perform a specific action, as well as how to utilize it to change the environment and make correct and coordinated motions within a period of time [26–30].

The theory of the spectrum of teaching styles in physical education is an important basis for the subject. The teaching spectrum is divided into 11 forms: (1) imperative, (2) practice, (3) reciprocal, (4) the self-testing formula, (5) inclusive formula, (6) guiding formula, (7) centralized formula, (8) diffusion formula, (9) design formula, (10) creation formula, and (11) self-teaching formula. Among them, the first five represent teacher-centred "replication-style" teaching, while the last six tend to involve the student-centred "production-style" form. Most teachers focus on the "copying" method, with the result that students have less experience in exploring the movement process independently, and physical education instructors also mostly use the "direct method" [31–33].

At present, the traditional one-to-one teaching method of physical education teachers relying solely on their own demonstration movements and guidance in the classroom to enhance the cognition of all student's motor skills and achieve the correctness of movements is somewhat challenging to implement. When there are 20 or 30 students, it is difficult to improve the cognition and knowledge of all their motor skills and achieve their correctness if they only rely on the traditional teaching method of demonstrating their own movements and guiding classes. Therefore, it is necessary to propose more efficient and innovative teaching procedures to solve the current problems in physical education teaching; in terms of movement skills, the coach needs to point out incorrect actions and provide a demonstration in a short time [34–38]. If two- or three-dimensional multimedia teaching materials can be provided in teaching, the disadvantages of traditional physical education can be solved by guiding learners to study without the limits of space and time. At present, the traditional physical education teaching mode can no longer meet the needs of learners. Physical education teachers are faced with multiple challenges, such as having to research or propose updated physical education teaching strategies and combine information technology to develop educational, innovative, and inspiring teaching content to enhance learning behaviour [39].

2.2. The Application of Information Technology in Physical Education

The advancement of information technology has generated a great leap forward in the development of the technology industry, making life more convenient as a result. In today's era of readily available information, the convenience of the Internet and the popularization of mobile devices have placed a great focus on food, clothing, housing, transportation, education, and entertainment. There have been many major changes, including among educational reforms; recently, information technology has also been incorporated into the development of the education sector, and digital learning has gradually become a new teaching model in many fields, such as the natural sciences and social humanities, while information technology integration is relatively rare in subjects such as physical education, music, and art [40–45]. The integration of IT into teaching could be applicable in 1. Abstract teaching materials, 2. The need to cultivate the experience of engaging in physical exercises, 3. An environment where the school cannot provide problem solving, and 4. Areas where for some subjects the school lacks teachers' ability development and social skills learning. Digital learning has transformed teaching modes, with tablet computers replacing books and electronic whiteboards supplanting blackboards; student learning has been changed accordingly, flipped classroom teaching has been introduced, and pupils now have control over their learning [46]. Mobile learning refers to the use of mobile devices to help students learn at any time and place and to employ convenient network technology to establish a personalised learning environment that is not limited by time or space [47–49].

In terms of meaningful learning and interaction [50], the integration of information technology into teaching, combined with visual and auditory multimedia, can reduce students' cognitive burden on oral text learning and make it easier to maintain learners' concentration and increase the learning effect. In a previous study, He used web-based multimedia courses as teaching materials to aid college students in learning to play basketball [51]. The experiment was divided into two groups: the multimedia one and the traditional teaching one. The investigation found that tablet computer-assisted action skills teaching is helpful for students to gain basketball skills [52–57].

Action research in the field of health and physical education has also pointed out that the integration of information technology into the curriculum through the three aspects of teaching content, strategies, and information technology, as well as incorporating modern information technology, the Internet, and multimedia teaching materials, can also help students achieve meaningful learning. If the teacher can present interesting and vivid visual images, they can retain students' attention and enhance their motivation [58–62].

According to a study using an online teaching platform to assist Chinese students in learning billiards, the results demonstrate that students who use the online teaching platform to watch the demonstration video teaching materials find it more helpful than traditional methods, and it also improves students' skills, as well as the absorption of knowledge and the promotion of learning motivation. In addition, the application of multimedia tools in Taijiquan teaching can also effectively improve learning motivation. The multimedia teaching materials are divided into three groups, high, medium, and low: a traditional eight-style Taijiquan teaching group, a 2D eight-style film group, and a 3D animation group. In the eight-style Taijiquan animation group, the students completed questionnaires and interviews on conscious learning effects and practices after learning; the outcomes showed that in the 3D eight-style Taijiquan animation group, four movements were higher than the 2D eight-style Taijiquan film group, and compared with the traditional group, the 3D eight-style Taijiquan animation group was significantly better than the traditional teaching group; the results demonstrate that the 3D animation can be viewed from multiple angles, and the practice rhythm can be freely controlled, as well as being lively and interesting, so it is more effective than the traditional teaching format. The study group and the 2D film group had fewer problems and a higher interest in learning [63,64].

In addition to the improvement in learning effectiveness, the application of information technology in physical education can also produce better results than traditional teaching in terms of motivation. For example, in teaching badminton skills, after placing skill demonstration videos on a tablet computer, providing learners with the material, and finally conducting an evaluation test by professional teachers, both conscious questionnaires and subjective evaluations found better learning attitudes and results. At present, the most widely used form of integrating information technology into physical education is video learning. In traditionally taught physical education, learners cannot always fully comprehend correct movements due to their viewing angles or the brief demonstrations by teachers. In addition, the teacher is not able to give individual guidance because there are too many learners, so the beginners cannot understand the errors in their actions [57]. Combining it with 3D module technology and an action learning mode to assist physical education can improve the deficiencies and overcome students' limitations, as well as help them learn without being affected by the field. This can more effectively assist learners to understand motor skills and achieve the goal of incorporating information technology into physical education [65–69].

2.3. Applications of Augmented Reality

In augmented reality, real and virtual environments represent two ends of a continuum. The left side defines the environment as composed of real objects, while the area from the real environment to the virtual one is augmented reality, and from the virtual environment to the real one is augmented virtuality. Mixed reality represents the continuous interval between the real and the virtual. The part close to the real environment is augmented reality, and the one close to the virtual environment is augmented virtuality. The essence of AR is to start in the real environment and add virtual elements. AR uses ordinary digital technology equipment to project virtual objects, information, and scenes into the real world and integrates the real object information to generate an immersive feeling. When needed, users can easily obtain information that is relevant and useful in the real world [70–73]. During the operation of augmented reality, the user can still visit the scene in the real environment, where the image on the device will be superimposed, so both the real and the virtual can exist at the same time, and help the user to see, hear, and feel the situation in a new way [74,75].

The focus of AR is to provide two- and three-dimensional ways to combine virtual and real objects to enhance users' sensory perception and interaction with the real world [76–79]. It is possible to apply the information perceived by their own senses to assist users in more easily understanding the information they want to obtain or perform work in the real world. Through 3D modelling in teaching, 3D characteristics can help teaching become more efficient and appealing, such as through the ability to flip the angle of view at will, as well as the rich settings and interesting features, in addition to the compatibility with other media, so that learners can use it easily, resulting in a lively and interesting environment that achieves the effect of learning. The application of 3D images can aid teaching in increasing three-dimensional and spatial cognition, and students' interaction with 3D objects can enhance their ability to perform, as well as their self-learning. AR presents three features: (1) merging virtual and real objects into reality, (2) cooperation between virtual and real objects, and (3) instant interaction between the virtual world and reality [75].

AR can be broadly defined as the dynamic fusion of real-world and virtual images into an AR by using relevant positioning technology or virtual situational information. In this mixed real and virtual world, AR can provide users with an immersive experience, allowing learners to interact with the teaching content. Numerous studies on the interaction between students and learning content have shown that increasing students' cognitive and learning abilities, such as comprehension, memory, and imagination, can improve satisfaction and help students build knowledge to complete tasks. Educators and researchers can integrate emerging technologies, such as AR and multimedia tools, into teaching and learning activities, and the resulting sensory experience and interaction extend the concept of augmented reality. AR theory and applications were often used in medical simulations, such as in planning complex circuit devices and paths, etc., in the early days of their development, usually with special head-mounted displays to integrate virtual objects into real situations [58].

With the rapid development of information technology, as well as computers, tablets, and smartphones, the improvement of science and technology and the convenience of carrying the equipment required for AR have made its utilisation increasingly popular, and AR has gradually become an auxiliary tool in many fields. Many educational information systems in the form of AR and mobile devices have been proposed, such as mobile board vehicles, to simulate scenarios of nuclear power disasters. Scholars have found that through the presentation of augmented reality, learners' attitudes toward nuclear power issues are significantly correlated [77]. For the application of AR in education, a very wide range of studies have recently been proposed. For example, when assessing the application of AR to astronomical observations in elementary schools, combined with the G-sensor on mobile devices, the results found that using AR as an auxiliary tool helps to improve the effectiveness and motivation of learners and also solves the problem of difficult operation and implementation in astronomical observation learning [78]. In addition to improving learners' motivation and effectiveness, augmented reality-assisted teaching can improve academic performance and narrow the gap between high- and low-group learners [79]. The action learning inquiry-based activities used the natural science curriculum. The results show that this system can improve students' academic performance. Compared with traditional inquiry-based learning, an action learning system based on AR can result in higher levels of motivation, learning engagement, and confidence.

AR was also incorporated into Shuaier's education. During his research, Shuaier developed AR educational magic toys, combining AR with 3D images, which were highly appealing to learners. These provided a more authentic and novel feeling and enhanced students' interest in learning. The characteristics of 3D modelling can help teaching become more efficient and engaging, such as through the ability to flip the angle of view at will, as well as offering a rich environment, in addition to compatibility with other media, so that learners can use such applications easily, resulting in a lively and interesting setting for achieving the effect of learning. Compared with the integration of traditional information technology into physical education, AR can solve problems regarding the filming perspective, movement, and speed. Students' interaction with 3D objects can enhance their ability to perform in addition to their self-learning. The introduction of AR into teaching can effectively stimulate students' learning motivation and can also have a good effect on memory retention. In the visual arts curriculum, using AR as a teaching aid is more effective for students than traditional methods. Good performance in memory and satisfaction can have a positive impact on overall learning motivation [73]. In addition, when learning scaffolding in the field of mathematics, the process employs AR tools to build concrete representations of dimensional abstract concepts and geometric figures, which can also effectively improve learners' comprehension [76]. Previous investigations into the application of information technology to physical education found that it was rare to apply AR tools to physical education. Through the combination of AR and multimedia teaching materials in physical education, learners can compare the differences between their own movements and a 3D dynamic model and also use it to understand correct movements and learn motor skills. If an appropriate model simulation is provided, it offers a more effective learning mode. The student can observe and imitate the demonstration model during practice. Through the interaction of vision, memory, and action performance, they can achieve a more productive learning effect and assessment. Together with the professional knowledge of the on-site teachers, appropriate feedback on learning is given to students, so as to achieve the goal and learning effect of motor skills teaching [76].

The developments in AR help explain trends that influence the likelihood of mainstream adoption. The idea of AR drives the development of many other related technologies, including wearables, haptic technologies, and many others that have been featured in this column. Developers invest in the future based on the idea that widespread use of AR is just around the corner. Yet, in many ways, it still appears to be a technology eternally on the cusp of mainstream adoption [46]. Based on situated learning by combining mobile learning and augmented reality, students could not only access information content in a real environment but also obtain such information via augmented reality to support mobile learning. The research of an AR system combined with situational learning was used by students to learn about campus plants as part of the college life technology curriculum. Students took part in mobile learning, and an investigation was conducted into the computer learning behaviour of notebook users. It was found that learners who used mobile learning AR generally managed to browse all the contents of the textbook at each learning location without spending too much time looking for information, and learners could quickly integrate this into the learning situation. Learners who used MLAR had a strong motivation to study plants at the learning site [78]. The study focuses on AR and virtual reality in libraries and museums, as seen from the internet cybersphere, including blogs. It takes a look at the first quarter of 2018 and analyses the trending issues within the period, highlighting examples of some institutions that make use of VR and AR. The advantages of the use of VR, AR, and sometimes mixed reality are also pointed out. Libraries, archives, and museums are increasingly using AR/VR technologies in their service delivery because it is trending. Facebook is the largest investor in AR and VR, and because Facebook is also extremely popular, many are opportune to have a go at VR and AR through the use of the Facebook social media platform. VR "involves using 3D graphics and advanced interactions to immerse a real-world user in a simulated environment" [42]. This paper presents an AR application to aid the elderly in library reference searches. The application supports the elderly in searching books and videos in a large library when librarians have insufficient time to meet their needs. The Search AR application was an integrating library catalog, which provides AR and 3D graphics. The elderly can also use Search AR to see a library map and every library element via 3D graphics before they start searching in a wide area. This makes it easier for the elderly to navigate a library without using complicated online catalogs, and it reduces time spent on reading and searching [55]. This study presents a model for the use of AR in the libraries of universities of medical sciences. The goal was to introduce the applications, advantages, opportunities, and challenges of AR. This study adopted a qualitative approach, had an applied goal, and was based on data theory. The category of application consisted of strengthening education, promoting users' information literacy, finding resources, user guidance, gamification, educational justice, helping management, enriching resources, providing new services, and economic savings [78].

3. System Design and Architecture

This research involves the design of an action skill learning software, which integrates the virtual and real features of "augmented reality" and further adds a 3D action skill module to present a visual effect. The experimental group used the AR software developed by the Unity 3D game engine and AR as the teaching material for learning, while the control group employed an action skill teaching video.

3.1. AR System Design Procedure and Functions

The main feature of this system is augmented reality, which is combined with 3D action skill modules to present visual effects, improving the current form of traditional sports teaching and integrating information technology into action skills and sports. The shortcoming of the viewing angle of the film is overcome. The procedure of using AR system and the functions are as follows:

Step 1. Open the textbook;
Step 2. The teacher guides and explains the learning objectives;
Step 3. Learners read the text according to the teacher's instructions;
Step 4. The learner scans the text;
Step 5. Scan the key blocks of the text.
Step 6. Jump out of the 3D action skill module and guide interface;
Step 7. One teacher guides the learning of motor skills with text textbooks;
Step 8. Fill the ARCS questionnaires. (Appendix A)

1. Teachers' motor skill assessment test: 1. pull the legs forward, 2. tuck the knees forward, 3. kick the opposite side forward, 4. lunge forward, and 5. kick the buttocks and run. The most important movement evaluations are as follows: 1. the correctness of movements, 2. the fluency of movements, and 3. the completeness of movements. These three aspects should be considered to measure the following AR functions:The integration of virtual reality;
2. 3D dynamic module;
3. Zoom in and zoom out;
4. Rotate left and right;
5. Action essentials.

The use of AR should help with study questions as follows:
Improve learning motivation;

1. Deepen memory;
2. Visualize the real feeling;
3. Improve learning motivation.

Enhanced skill learning should include the following:

1. Local details;
2. Guidance strategy;
3. Action Demonstration Distance;
4. Solve the viewing angle problem.

AR system design procedure and system functions description: For the AR class textbook software developed, learners need to learn with capital textbooks. When the software is turned on, it will enter the AR space to scan the camera lens to the action skill pictures on the capital textbooks. After completion, a dynamic model will appear. The group and operation interface are classified according to the functional interface displayed after scanning. After pressing the action essentials, the next action button will appear, and learner need to follow the teacher's instructions to learn the next action skill. Learners need to instruct the teacher for the first time, after watching the model demonstrate the movement skills, fill in the multiple-choice questions on the learning sheet, and complete the learning of each movement skill in the classroom. The AR software developed in this study has the functions of guiding visualization, local action close-up, memory retention, and motivation improvement on the functional interface for learners to learn motor skills and presents the learning problems corresponding to the interface functions.

3.2. System Architecture

The software part of this system combines 3D action skill modules and an AR interface, and students learn action skills according to its guidance. When the teaching material is scanned with the camera lens of the mobile device, the device screen will display the effect of integrating virtual and real elements, as shown in Figure 1.

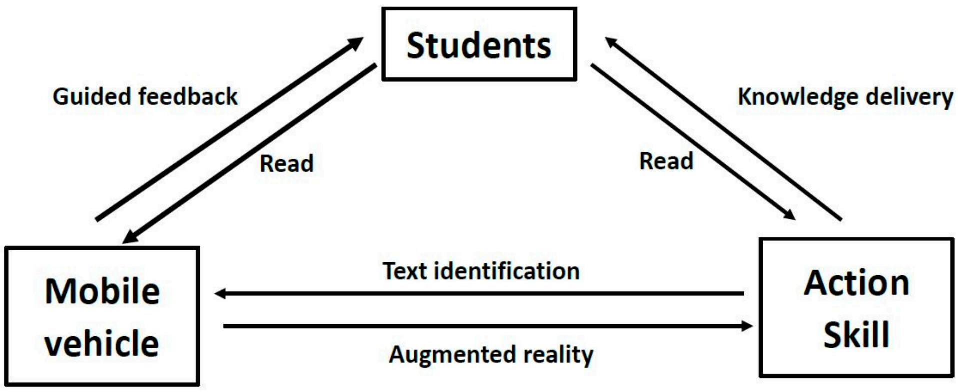

Figure 1. System architecture diagram.

3.3. System Development Tools

This research uses the software development kit (SDK) of "Vuforia", a free AR package released by Qualcomm, and the Unity 3D game engine for development. For 3D presentations, the Xsen MVN motion capture system equipment has been rented from the manufacturer for recording, and the modules have been imported into the Unity 3D game engine for system development. Xsen MVN motion capture system software include MTi series: MT Software Suite; DOT: Xsen DOT SDK, Xsen DOT App; and MVN: MVN Analyze, MVN Animate. Unity 3D provides designers with the ability to design the game environment, write the program script themselves, and integrate the script content with the 3D module to complete the AR software system tool, as shown in Figure 2.

Figure 2. 3D module to complete by AR software system.

3.4. System Functions Interface

According to Figure 3, the AR functions interface of AR display is divided into four modules. First, zoom in and zoom out; the main purpose is to change the size of the 3D dynamic module. Second, rotate the module left to right; the most important thing is to change the 3D dynamic module viewing angle. Third, the direction key; the most important thing is to adjust the position of the 3D dynamic module in the picture. Fourth, action essentials; give learners key guidance on action skills. 3d model is divided into three modules: virtual reality; improve learning motivation; uniformity of action demonstration.

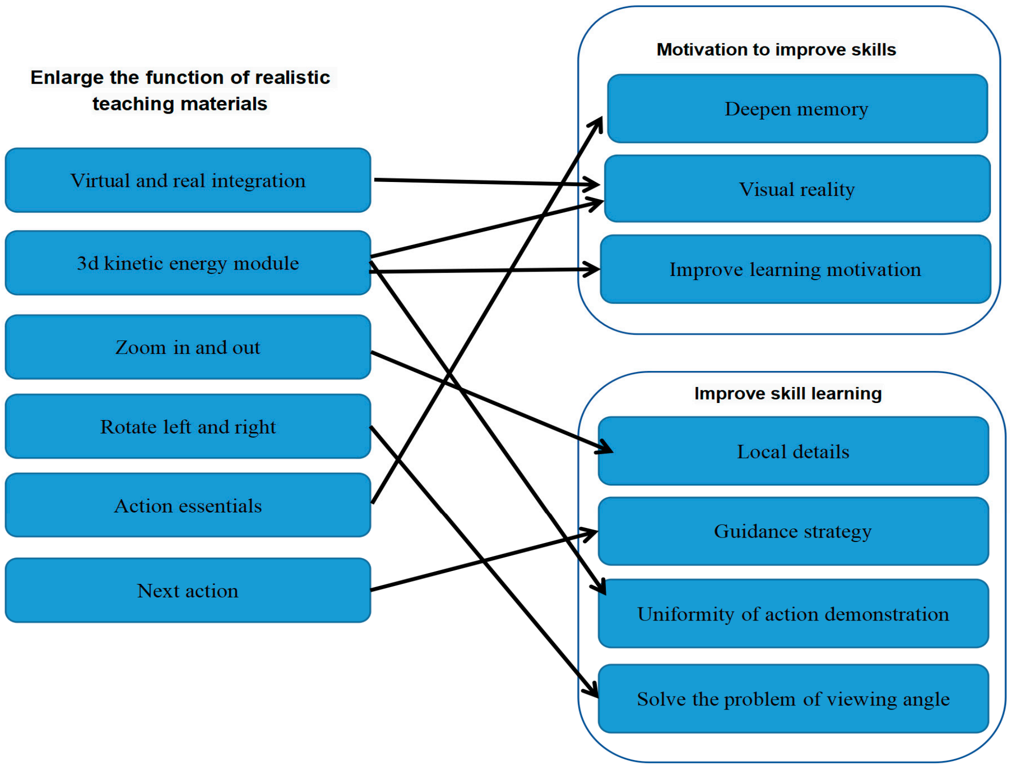

Figure 3. AR teaching material functions interface mapping motivation to improve skills and skill learning.

4. Research Methods and Steps

This research integrates information technology into the teaching of physical education. Based on the teaching objectives, as well as the content and implementation progress, the essentials of motor skills, related decomposition and application, and demonstration of movements, etc., were employed to create 3D dynamic motor skills modules with augmented reality. The software was given to the students in the experimental group to learn motor skills. For the control group's motor skills instruction, self-recorded and designed teaching videos of about one to two minutes were provided for the learners to learn motor skills. The researchers referred to school health, physical education textbooks, and motor skills teaching videos and employed the Unity 3D engine to develop a 3D dynamic motor skills information module application, as well as action teaching videos, utilising textbooks as reference materials to develop paper teaching aids as auxiliary tools. In order to verify the effectiveness of the software system, this study adopts a quasi-experimental method as well as statistical methods for analysis. Next, to explore the influence on learners' motor skills, the learning effectiveness, attitude, and satisfaction generated by the integration of different types of information technology into physical education teaching are assessed. The control group used the self-recorded and designed action skills teaching video as the learning material. The experiments process is as follows: 1. start the video teaching material, 2. instruct the teacher to explain the learning objectives, 3. the teacher guides learner to watch the movement skill video, 4. the learner watches the movement skill video to learn, 5. the learner reads the reading text according to the teacher's instruction, and 6. fill in the classroom study sheet. The study sheet contained the question, "Explain: The movement skills, study in two classes, and complete six learning target movement skills in each class". When learning for the first time, learners need to follow the teacher's progress to complete the learning objectives of classroom movement skills.

This evaluation examines the integration of information technology into physical education, combining tools such as pictures, images, texts, and sounds for 3D dynamic motor skills information modules and video teaching materials to assist teachers and help students through digital materials. The information and teaching content provided by the AR and video teaching materials are the same, but the learning modes and operations are slightly different. Both use the same paper teaching materials for learning, with the distinction made only in digital textbooks. Finally, the achieved differences in motor skills, as well as the knowledge, attitude, and performance of the two groups of learners are examined. The following sections provide detailed descriptions of the study participants, procedures and tools, as well as the research design, data collection, and analysis.

4.1. Study Participants

The participants in this investigation were students from two classes who formed the experimental subjects. The content of the course was health and physical education. The participants were divided into a control group of 28 as a film study group, and an experimental group of 28 as an AR group. Participants came from a region in South China. The participants were normally divided into classes and had not received professional training in sports skills performance.

4.2. Study Design

This investigation adopted the "experimental group and control group before and after design" of quasi-experimental design. The experimental group used the AR software developed by the Unity 3D game engine and AR as the teaching material. The control group employed the action skills teaching video as the learning material. This study explored the impact of the integration of information technology into physical education on running skills, as well as the knowledge, attitude, and satisfaction achieved under different learning material modes. The variables were as follows:

(1). Independent variable: Digital technology-assisted physical education teaching methods divided into two presentation types, AR and video-based teaching materials.

(2). Dependent variable:

- Learning effect: The cumulative improvement assessed through pre- and post-tests.
- Learning motivation: An attitude motivation questionnaire (attention, relevance, confidence, and satisfaction (ARCS) questionnaire) on learning motivation.
- Attitude to learning: The teaching material satisfaction questionnaire measured the student's attitude towards teaching and satisfaction with the use of materials.
- Learning motor skills performance: After testing, the student's performance in motor skills correctness, fluency, and completeness were assessed.

(3). Control variables:

- Learning content: The teaching content and paper textbooks of the two groups were the same.
- Participants: Both groups were composed of participant students.

In addition to the above-mentioned main experimental variables, this study also collected the following data as reference materials for the qualitative analysis of the experiment: textbook satisfaction questionnaires, opinion surveys, and interviews.

4.3. Research Tools

In this study, the AR software, combined with AR, in addition to the motor skills teaching video were used as the digital teaching materials, and the smart tablet mobile phone was employed as the hardware device. The table shows the data collection tools. The following is a detailed description of the tools applied in this research:

(1). Digital tools: During the experiment, we provided the learners with a smart tablet phone, the Sony Xperia Ultra C6800 with the Android operating system, as a course mobile device, and with Unity to develop digital teaching materials and action skill videos for the experimental group. Data transmission was carried out through the built-in Wi-Fi, and the built-in 8-megapixel main camera was used for AR scanning. In the control group, the recorded action skills teaching videos were employed as teaching materials, and they were played and studied through smart tablet mobile phones. During the testing process, both groups recorded the classroom teaching process and the teachers' motor skills evaluations by video and collected qualitative data for the researchers to undertake analysis and comparison.

(2). Action skills module development tool: The researchers used AR as a teaching aid to present the motor skills in a 3D stereoscopic visualization mode, providing manipulation and key prompts for 3D movements. For 3D presentations, the Xsen MVN motion capture system equipment was rented with Edith Technology for recording, and then the Unity 3D game engine was employed for the development of the teaching materials.

(3). Learning materials: The information for the classroom study sheets was selected using the primary and secondary school health and physical education textbooks and the materials on the physical education website as references, and the content of the running and sports chapters was employed to develop the study sheet. The content of the study sheet was divided into two lessons. The learning content of both included movement skills related to running. The difference was that the second lesson, the mark exercise, involved the deconstruction of running movements.

(4). Action skills: The experiment used a pen-and-paper pre- and post-test tool to find out whether learners can improve their knowledge and performance of motor skills after teachers guide students to watch different learning methods, such as 3D action models and action skill videos, and then learn about the two types. The learning effect of the students, assessed through the test paper, was tested by the physical education teacher in advance.

(5). Action skills rating scale: The movement skills scale included dynamic warm-up movement skills and Mark Cao movement skills, which were divided into the correctness, fluency, and completeness of movements, and were scored by three teachers out of equal points.

(6). Learning motivation scale: The purpose of this scale was to evaluate the learning process of students using the teaching materials in this study and to understand the motivation of learners who use different materials in motor skills learning. It involved a learning motivation questionnaire, including the design of attention, relevance, confidence, and satisfaction models. There were a total of 24 questions in four dimensions which were assessed using a five-point Likert scale [34]; that is, learning activities had to be designed to maintain student's attention, and learning activities and materials had to be relevant to them. They needed to complete the learning activities to be satisfied. The reliability analysis results are shown in Table 1.

(7). Textbook satisfaction scale: The purpose of the textbook satisfaction scale was to understand learners' feelings about using the learning materials designed in this study. The scale contained two aspects: "perceived usefulness" and "perceived ease of use". The ease of use, font, key size, and screen arrangement satisfaction as well as the various tools and media included elements such as texts, pictures, sounds, and animations [76].

(8). Opinion survey and interview: After the whole experiment, feedback surveys and interviews were conducted to understand the learners' thoughts and suggestions on the activities. The items of the feedback survey were attached to the textbook satisfaction scale, and there were open-ended feedback questions to check their willingness to participate in the future, allowing learners to express their feelings and suggestions. The interviews were conducted in a sampling manner, and the interviewers maintained a neutral discourse during the process, with the principle of not interfering with the interviewees' thoughts.

Table 1. Reliability of learning motivation scale.

Orientation	Topic Number	Cronbach's Alpha	Number of Projects
Attention	1, 6, 9, 18, 22, 23	0.83	6
Relevance	3, 8, 11, 15, 19, 21	0.86	6
Confidence	5, 7, 10, 12, 14, 17	0.84	6
Satisfaction	2, 4, 13, 16, 20, 24	0.86	6

4.4. Research Procedures and Instructional Design

This investigation was carried out with experimental and control groups. The research process structure is shown in Figure 4. The subjects in the two groups had to take the motor skills achievement test before the experiment, while the subjects in the experimental group had to take the motor skills achievement test before the experiment. In addition, they received training in the operation of the mobile device equipment to ensure that the impact of technological obstacles was greatly reduced. They then performed the teaching activity, which involved integrating information technology into physical education. The difference between the experimental group and the control one lay in the learning materials. The experimental group used the AR application software developed and produced by the Unity 3D engine as the learning material. The students were freely able to operate the 3D motor skills module, while the control group employed motor skills teaching videos. The experimental and control groups followed the same process, but the substance of the digital teaching materials provided by the researchers was different. Both groups had the same learning content and teaching objectives.

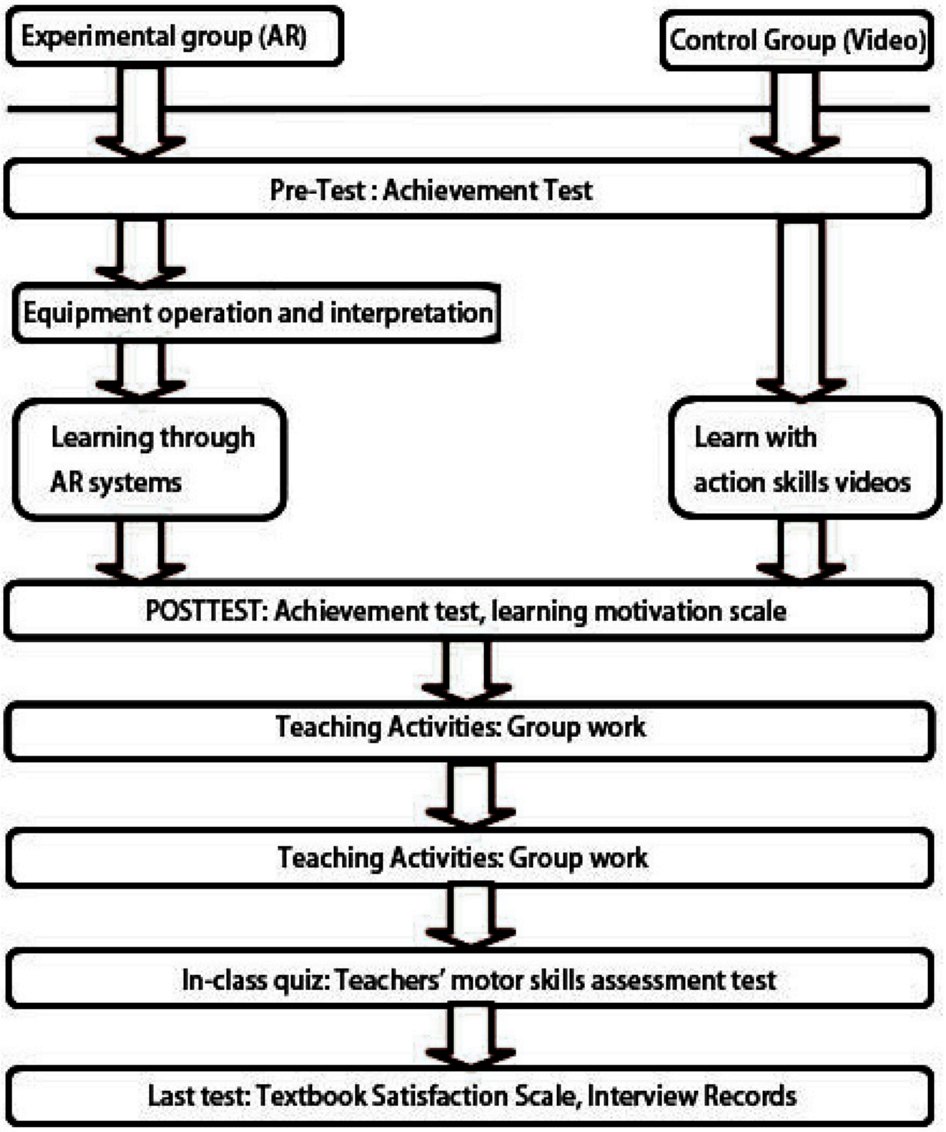

Figure 4. Research process architecture.

In this study, the experimental and control groups were administered a total of two tests. Each time the test site was in the same field, and the exact same learning device was used. The activity was introduced before the first test, so that the tested students knew the content and learning objectives of the activity. The purpose was to understand the differences between the experimental participants before and after the intervention of research and teaching. Therefore, before the intervention, the students in both groups were given a motor skills course achievement test to compare whether the students in the two groups had previously participated in similar experimental teaching. After confirming that all students had completed their answers, they retrieved the pre-test papers and distributed the learning tools, including the textbook and mobile device. Ahead of the teaching activities, they demonstrated the operating methods and precautions to the learners. Before the experiment, it was necessary to receive training in the operation of the mobile device to ensure that the probability of technological obstacles was minimized and that the learners could clearly understand the learning objectives and procedures. Next, research on the integration of information technology into physical education was carried out. The experiment continued for two weeks, with two classes per week, each lasting approximately 40 min. The teaching content design mainly focused on basic movement skills, such as improving running foundations, dynamic warm-ups, and mark exercise skills, and establishing correct movement concepts as the main learning goals; the AR application and action skills teaching video developed and produced by the Unity 3D engine were intended to integrate information technology as a teaching material into physical education. The teaching and testing time was 15 min. When learning for the first time, the subject had to follow the teacher's progress to consider and answer the study sheet questions and follow the researcher's instructions.

Following the teaching and testing, the teacher retrieved the study sheet and conducted the motor skills course achievement and the learning motivation scale tests, which lasted for 10 min. After completing the classroom learning and testing, students could freely watch the 3D dynamic movement skill modules and teaching videos for the practical routine and group practice and review the previous class in the next one. For a period of 10 min, the students could freely operate and examine the action skills textbooks and conduct group exercises for the first lesson content. Group exercises help learners to become proficient in the operation of movement skills and achieve the learning goals of classroom physical education teaching. Following the group practice, the teachers' motor skills were compared. After the students had practised each motor skill, professional teachers evaluated and assigned points to test the student's learning effect on the movement performance on the spot. Scores were given by three teachers based on the correctness, fluency, and completeness of learners' movements. If the test was the second teachers' motor skill evaluation, the subjects were additionally asked to complete the teaching material satisfaction scale and feedback questionnaire, and randomly selected learners were interviewed for 8 min.

The motor skills were divided into two teaching courses, and in the next class, after the teaching and testing, the group exercises of the motor skills and the teachers' motor skill evaluations were conducted. There were four classes in total involved in teaching and practising movement skills, as shown in Figure 5.

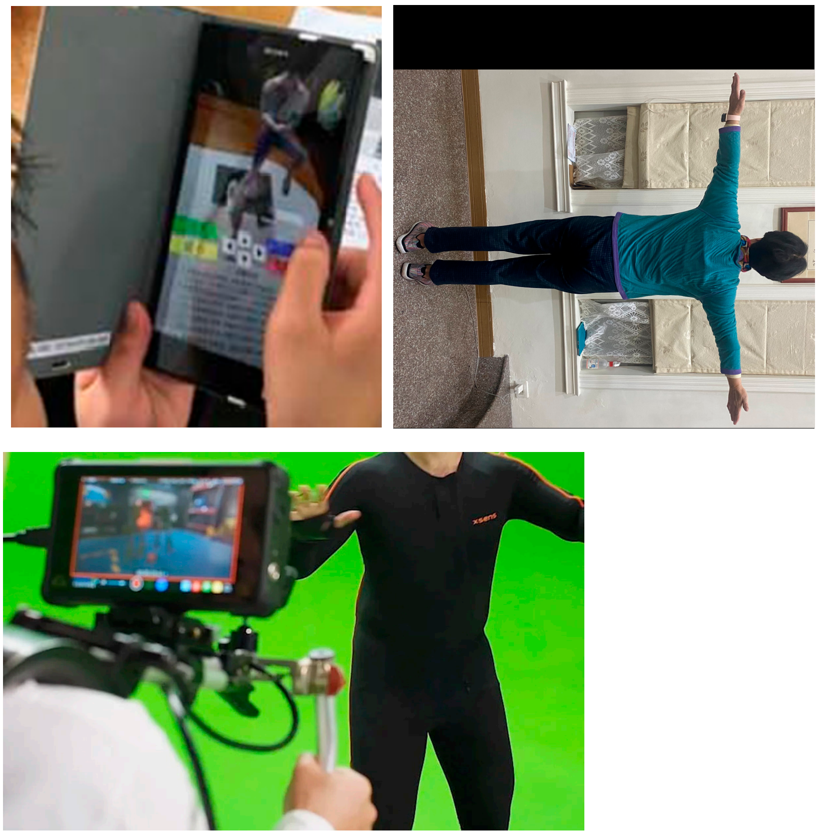

Figure 5. AR operation picture and action motion capture.

Lesson 1

(1). Pre-test of the first lesson of motor skills, knowledge and concepts;
(2). Grouping: Experiment group and control group;
(3). Uniform distribution of teaching equipment and inspection;
(4). Demonstrate the methods and explain the items to learn the first lesson in motor skills;
(5). Post-test of the first lesson on motor skills, knowledge, and concepts;
(6). Fill out the learning motivation scale;
(7). Movement skills practice;
(8). Review of movement skills from the first lesson;
(9). Movement skills practice;
(10). Teachers' motor skills assessment test.

Lesson 2

(1). Pre-test of motor skills, knowledge and concepts;
(2). Grouping: Experiment group and control group;
(3). Uniform distribution of teaching equipment and inspection;
(4). Demonstrate the methods and explain the items for the second lesson in motor skills learning;
(5). Post-test of the second lesson on motor skills, knowledge, and concepts;
(6). Fill out the learning motivation scale;
(7). Movement skills practice;
(8). Review of movement skills from the second lesson;
(9). Movement skills practice;
(10). Teachers' motor skills assessment-test. After experiment, fill in the teaching material satisfaction scale;
(11). Conduct sample interview records.

According to Figure 3, the AR functions interface of AR display is divided into four modules. First, zoom in and zoom out; the main purpose is to change the size of the 3D dynamic module. Second, rotate the module left to right; the most important thing is to change the 3D dynamic module viewing angle. Third, the direction key; the most important thing is to adjust the position of the 3D dynamic module in the picture. Fourth, action essentials; give learners key guidance on action skills.

4.5. Data Collection and Analysis

The data collected in this study include the results of the motor skills achievement test before and after the lesson, in addition to the results of the learning motivation and textbook satisfaction scales, as well as the teachers' motor skills evaluations, and the opinion surveys and interviews. The quantitative data will be analysed, and the qualitative data will be part of the collation of data recorded for interview questions. For opinion surveys and interview results, the qualitative analysis will be conducted by comparing other data or referring to relevant theories. The analysed data and the sorted qualitative data will be discussed and presented separately in this investigation. The data, variables, and main analysis methods corresponding to the research goals are shown in Table 2.

Table 2. Corresponding data, variables and main analysis methods for research purposes.

Research Purpose	Data, Variables	Main Analysis Method
1. Discuss the effect of learners' use of AR software on video-based teaching materials, performance in motor skills learning.	Independent variable: group. Dependent variable: Post-test total score, Covariate: Pre-test total score,	Covariate analysis.
2. Discuss the use of AR software compared to video-based teaching materials for learner's motivation of motor skills learning.	Independent variable: group. Dependent: Learning Motivation.	Independent sample *t*-test.
3. Discuss how learners use AR software compared to video-based teaching materials. Differences in performance of motor skills.	Independent variable: group. Dependent: Action rating.	Independent sample *t*-test.
4. Explore the use of AR by learners environment software and video-based teaching materials, both attitude and connection to the use of teaching materials degree of acceptance.	Textbook Satisfaction. Opinion survey and interview.	Data results discussion. Qualitative data analysis.

5. Findings and Discussion

5.1. Finding Learning Effectiveness

In this study, the pen-and-paper assessment of motor skills was employed as a pre- and post-test tool to analyse whether different learning materials could affect the learning effect of motor skills comprehension. This involved dividing the course into two lessons, as well as taking a pre-test before each lesson and then a post-test after learning. There were 14 questions in each test, and each question was worth 1 point. Therefore, the pre- and post-test scores of each class were calculated out of 14 points. The data in the table demonstrate that the post-test scores were greater than the pre-test ones in the comparison of the two lessons in the two groups, indicating that the experimental learning activities of the two groups produced a progressive learning effect in the learners. The paired samples *t*-test was performed on the total scores of the pre- and post-tests in each lesson of the experimental and control groups.

A covariate analysis was carried out, and the results are shown in Table 3. After excluding the influence of the starting point ability test on the learning effectiveness test, the F value of the first lesson analysis was 1.48, $p = 0.25 > 0.05$, not reaching a significant level; in the analysis results of the second one, the F value was 15.61, $p = 0.000 < 0.05$, achieving a significant level.

Table 3. Covariate analysis summary table of experimental group and control group.

Source of Variation	Degrees of Freedom	Square	Mean Square	F	*p*
Lesson 1	2	8.41	8.42	1.43	0.21
Group	2	6.29	6.26	1.11	0.29
Error	8	7.90	5.65		
Lesson 2	2	4.32	4.32	15.61	0.00 **
Group	2	54.13	54.11	10.05	0.03 **
Error	48	63.90	5.34		

** $p < 0.01$.

In the experimental version of the first lesson, the periods spent on equipment operation in the control group and the experimental one were slightly different. The experimental group spent more time than the control group on software familiarization and equipment operation as well as understanding the teaching mode. During the lessons, the students in the experimental group had to be familiar with the button functions and operation procedures, while the control group only needed to select the designated teaching video to watch. Compared with the experimental group, there were fewer processes and button operations required to watch the 3D module. Therefore, the experimental procedure of the control group in the first lesson was smoother than that of the experimental group, which also affected the performance of the experimental group in the post-test. The mean of the control group was slightly higher than that of the experimental group, not reaching a significant level. In the experimental version of the second lesson, the experimental group reviewed the operation process before the class and also printed it into paper textbooks to facilitate students in understanding it. The learning environment was also slightly changed. Both groups first moved to the classroom to watch and learn the action skills and then went outdoors to practise in groups. The proficiency of the environment and equipment reduced the number of teachers' demonstrations and equipment debugging.

The learning experience of the first class meant the experimental group was more fluent in equipment and button operations, while the two groups reached a significant level in the covariate analysis results of the second class, indicating that the learners learned through different motor skills. This had a significant impact on the learning effect of their motor skills. In addition to using the covariate analysis of the motor skills achievement test to assess the learning effect of the learners as described above, this study also analysed the learners' progress through different motor skills through the pre- and post-tests. The learning mode had an impact on the performance of the motor skills. For the improvement amount obtained by subtracting the total score of the pre-test from that of the post-test of the two lessons, the independent sample *t*-test analysis was performed on both groups. After the analysis of the progress of the first lesson, the t value, $p = 2.71 > 0.05$, did not reach a significant level; in the second post-test analysis results, the t value, $p = 0.002 < 0.05$, achieved a significant level. Generally speaking, the total score of the post-test for students in both groups was higher than that of the pre-test, and only a few students achieved a total score of the post-test that was lower than the total score of the pre-test.

The results are similar to the post-test analysis results of the independent sample *t*-test. In the post-test analysis results of the first class, the two groups did not reach a significant level; but in the analysis results of the second, both groups did. In the experimental version of the first lesson, the differences between the control group and the experimental one in the familiarity of the process, software, and equipment operation affected the achievement test performance of the experimental group. Therefore, in the experimental version of the second lesson, the experimental group reviewed the process and adjusted the environmental field.

5.2. Finding Learning Motivation

In terms of an analysis of the attitude motivation scale, the learning motivation of the two groups of subjects was divided into four aspects, including attention, relevance, confidence, and satisfaction, and the results of the two tests will be discussed. In terms of data processing, since the learning motivation scale was measured after the teaching experiment of the two lessons, and the reverse questions were also designed according to the scale, if the subject missed a question in any test, or contradictory results were found for the reverse question, the learning motivation data of the subject were deleted and not counted, so as to increase the accuracy of the analysis results. Therefore, the number of deleted data was 25 for the control group and 25 for the experimental group. The independent sample *t*-test analysis was carried out on the motivation scales of the two groups, with the t-value, $p = 0.002 < 0.05$, reaching a significant level; in the analysis results of the two groups regarding the ARCS attitude and motivation scales in the second lesson, the t value $p = 0.001 < 0.05$, also achieved a significant level. According to the above statistical analysis results, for the ARCS attitude and motivation questionnaire, the overall mean of the two subjects in the experimental group was slightly higher than that in the control group, and the mean was above four. Then, the learning motivation of the two groups of subjects in the two lessons was divided into four aspects, namely attention, relevance, confidence, and satisfaction. The four aspects of the two motivation scales were analysed by an independent sample *t*-test.

Based the above statistical analysis results, the control group and the experimental group achieved attention according to the learning scale of the first and second lessons (the t value of the first lesson, $p = 0.001 < 0.05$; the second lesson t value, $p = 0.012 < 0.05$), relevance ($p = 0.012 < 0.05$ for the first lesson t value; for the second lesson, $p = 0.01 < 0.05$), and building confidence (the t value of the first lesson was, $p = 0.000 < 0.05$; the t value of the second lesson, $p = 0.001 < 0.05$), with these three aspects providing a significant difference in the statistical analysis. For satisfaction only (first lesson t-value, $p = 0.05$; the t value of the second lesson, $p = 0.210 > 0.05$), the statistical analysis of the first and second lessons did not reach a significant level. In terms of the statistical results for learning motivation in both groups, learners' attention, confidence building, and satisfaction were higher for those with information technology-assisted physical education teaching than for those without. The ARCS motivational teaching strategy design exhibited significant differences in maintaining attention, being relevant, and building confidence, but there was no major difference between the two groups in terms of obtaining satisfaction, which was a slightly different outcome from the previous study.

5.3. Analysis of the Textbook Satisfaction Scale

After the two-course teaching experiment, a teaching material satisfaction scale survey was conducted. The teaching material satisfaction of the two groups of subjects was divided into two aspects, perceived usefulness and ease of use, and an independent sample *t*-test analysis was performed. From the above statistical analysis results, based on the textbook satisfaction questionnaire, the average of the two aspects of perceived usefulness and perceived ease of use of the experimental group was slightly higher than that of the control group, and the average of both groups reached four. The above level, that is, between agree and strongly agree, indicated that both groups of learners positively accepted the content of the teaching material. In terms of the average difference between perceived usefulness and ease of use, the difference in ratings between the two groups for the perceived usefulness of the textbooks was higher than for the perceived ease of use. When using AR as a learning material for motor skills, the student's interest, effect, and understanding of learning were rated higher than for those using the video teaching material, and in terms of the perceived ease of use of the teaching material, the average difference between the two groups was not too large. In regard to the teaching materials, the amounts of time spent on equipment and software operation in the control and experimental groups in the first lesson were different. The students in the experimental group needed several repeated practices with the AR software and button operation. Given the familiarity and fluency of the learning process, compared with the perceived usefulness of the textbook, the average difference between the two groups for the ease of use of the textbook was smaller.

5.4. Comparison Evaluation and Discussion Analysis

After the two groups of students completed the motor skills learning and achievement test, in order to understand their motor skills learning through different teaching materials, for the motor skills performance, the group exercises were performed according to the teaching content of each lesson, and the teachers' motor skills evaluation was conducted. Three teachers assigned each learner a score of one to five based on the correctness, fluency, and completeness of each learner's movements. After the evaluation was completed, the 3 scores were added together (the full score was 15 points), and the total scores of each action of the 3 teachers were averaged. Based on the average total score of each action, for the students in the control group and the experimental group, an independent sample *t*-test analysis was carried out on the teachers' motor skill rating scale for the two lessons.

Based on the above statistical analysis results, the students in the control group and the experimental group had significant differences in the statistical analysis of these 11 aspects in the evaluation of the motor skills of the teachers in the first and second lessons.

The experimental group outperformed the control group learners. AR integrates paper content with 3D dynamic modules, allowing learners to watch and manipulate 3D dynamic modules more clearly and freely. The learner experiences a better learning effect.

6. Discussion

Based on the research goals and experimental results of this study, the purpose of this investigation is to produce an overall summary and explore the reasons why student's learning effectiveness, motivation, and teaching material satisfaction, as well as teachers' motor skills evaluations, are influenced by the process of integrating information technology into physical education teaching.

6.1. The Performance of Learners' Use of AR Software on Motor Skills Learning Compared to Teaching Materials

Considering the results of this investigation, it is evident that the use of AR and video as teaching materials when learners conduct motor skills learning has a significant impact on their learning effect. This is reflected in the differences in the learners' scores in the pre- and post-tests. While the two groups of students have similar pre-test scores, the experimental group using AR scored better in the second post-test and achieved more progress. Their teaching material was significantly more effective than the film type of the control group. In the first lesson, the changes in the post-test and progress scores of the two groups of learners, the differences in the teaching processes, and the software and equipment operation familiarity between the control and experimental groups affected the achievement test performance of the experimental group. Therefore, in the second lesson, the experimental group reviewed the process and adjusted the environmental field (the same as the control group), shifted the learning of motor skills back to the classroom, and then went out to practise in groups after completing the learning. The fluency of the learning process and the proficiency of software operation are important factors affecting the learning effect for the integration of AR into physical education. According to the content of the qualitative interview, the students found learning the movement skills of the second lesson more demanding than the first lesson; the performance, rhythm, and fluency of the dynamic warm-up were challenging to comprehend and understand. The experimental group's AR teaching materials were better than the control group's video teaching materials based on the achievement performance of the second lesson. Obviously, the integration of AR into physical education can support learners in learning a smooth, rhythmic, and complex performance. Good understanding and comprehension ability in relation to action skills, in addition to the feature of the AR integration of virtuality and reality, incorporates the content of the paper textbooks and presents them in a 3D digital form. In terms of the correctness of movements, it can be more helpful to scholars. Three-dimensional materials assist teaching, which can be useful for teachers who are not able to monitor the errors of students all the time and can also deepen learners' cognition and memory through observation from different perspectives [66]. During the learning process, the learner can manipulate the 3D module with buttons, while the novel performance of the textbook drives the learners to devote themselves to self-learning and understanding as well as completing the action skills study sheet and also assists the students in enhancing the effect of memory enhancement and retention in learning [18].

6.2. Compared with Learners of Teaching Materials, Students Using AR Software Have a Higher Motivation for Skills Learning Activities

Based on the results of the attitude motivation scale, the students in the experimental group have significantly higher motivation scores than those in the control one, and the two groups also achieve significant differences in the final test results, indicating that in the integration of information technology into physical education, when compared with video-based teaching materials, AR teaching materials can assist in the learning of motor skills, and learners achieve a better learning interest and attitude. The students also highly praised the new learning mode. Then, in order to explore the learners' attitude motivation in more detail, the four aspects of the scale, including attention, relevance, confidence, and satisfaction, are analysed and discussed separately. The three aspects of maintaining attention, being relevant, and building confidence in both lessons have significant differences in the statistical analysis. According to the ARCS learning motivation model of [34], the AR textbooks in the experimental group can provide learners with the needs and goals of motor skills learning. Compared with the video textbooks in the control group, the AR method incorporates paper ones. With the digital 3D module, it provides the advantages of integrating virtuality and reality to guide students to learn, and AR combined with digital tools can provide more appealing and effective learning effects, such as the viewing angle, 3D character manipulation and innovation, as well as the study pattern, and so on, and produce a more active learning attitude. The attention factor in the two-course attitude and motivation scale exhibits a significant difference between the experimental and control groups.

In terms of relevant motivational factors, the two groups conducted motor skills practices after completing the classroom learning objectives and achievement tests. These methods help learners to focus, understand the difference between practical movement skills and textbooks, and build self-confidence in their practice and performance. AR integrates the knowledge of paper textbooks into a virtual space and presents the contents of the textbooks in the form of visual 3D dynamic modules, so that in addition to watching the textbooks, the learners can also manipulate the 3D modules. They can control the viewing angle, the authenticity of the textbook content, and the function of the software button interface, which can stimulate students' interest in learning and motivate their efforts to achieve self-learning and practise the skills. For the manipulation of motor skills, the experimental group operated AR textbooks, which could change the viewing angle, position, and size of the 3D character module, and integrated paper and digital textbooks, compared with the control group. Video teaching materials can provide a faster and more subtle understanding of motor skills learning. In the feedback from the interview, the experimental group also mentioned that "it can help to understand what a good movement is and understand the importance of small places". AR and 3D dynamic modules assist in the learning of movement skills, so that learners can achieve better performances. In terms of confidence and attitude towards completing the learning objectives of each lesson, this result is also reflected in the difference between the two groups of scores in the teachers' motor skills assessment.

Finally, in terms of the satisfaction factor in the learning motivation of the two groups, because the two groups underwent a new experience involving integrating information technology into physical education teaching, which was somewhat different from the previous learning mode of physical education, they used a mobile device for learning in the classroom. For the learners, both satisfaction and effectiveness were given high evaluations, so there was no significant difference between the two groups in terms of obtaining satisfaction. While the experimental group expanded the learning mode by using AR textbooks, Chen et al. [6] believed that the combination of the teaching and learning environments would enhance the sense of satisfaction in motivation. AR textbooks can provide two- or three-dimensional ways to combine virtual and real objects to enhance learners' sensory perception and interactivity in the real world [75] and virtual modules and real-world learning for motor skills. The combination of the two can provide learners with a more appealing and effective learning effect than the video teaching material, and the experimental group achieved a higher score evaluation for satisfaction than the control group. The two different types of teaching content in AR and video teaching materials were integrated into the learning of motor skills. Regarding the change in motivation factors, the statistical results suggest that the application of AR to physical education produces an innovative learning model, which is different from the previous traditional learning one. The teaching mode provided learners with an engaging learning method and greater motivation. In the motivation scores of the two groups, the AR teaching materials of the experimental group produced a higher performance than the film-style teaching materials of the control one, and the scores and significance of each motivational aspect were also reflected in the learning effectiveness and motor skills performance.

6.3. The Effect of Learners' Use of AR Software on Skills Performance Compared with Teaching Materials

In order to understand the how the student's motor skills learning differed according to the different teaching materials, three teachers conducted a motor skills assessment test for each lesson content, with a total of 11 movement evaluations. Judging from the scores of the two groups of learners on the teachers' motor skills assessment test, the performance of motor skills by the experimental group, using the AR textbook for learning, was better than the control group with the video textbook, an outcome which also corresponded to the two outcomes of the achievement test. In the performance of the achievement test in the first lesson, the experimental group's performance was affected in terms of familiarity and the learning process because of their first contact with the mobile device and AR software, which acted as a motivation factor to build confidence. The experimental group had high confidence and positive attitudes in completing the learning objectives and believed that teachers could obtain high scores in the assessment of skills. Based on the total scores, the performance of the experimental group in the mastery and proficiency of movements is higher than that of the control group. Based on the feedback from the interview, the students found it more difficult to comprehend and understand the movement skills of the first lesson than the second one due to the difficulty of the mark exercise in the first lesson—with the dynamic warm-up performance, which is also reflected in the evaluation scores of the teachers' motor skills. In the evaluation scores of the last two actions of the second lesson, including three steps, one leg lift, three steps, and one leg extension, compared with the previous actions, there is a significant downward trend. The difference between the experimental group and the control group is smaller than that within the control group. From the point of view of the score and the difference, for movements with higher difficulty and rhythm, the use of AR can provide the characteristics of combining virtual and real objects in two- and three-dimensional ways, which, when brought into the teaching of motor skills, can effectively assist learners to use 3D images to enhance the cognition of three-dimensional, spatial, and performance aspects, and interacting with 3D objects can enhance student's ability in performance and self-learning. With the feature of the virtual and real integration of augmented reality, the text and image contents of the paper textbooks are presented in a 3D moving belt module to achieve the effect of virtual reality integration, linking the paper and digital textbooks in series. Using AR software to learn movement skills can produce innovative teaching models, which can be highly appealing to learners. In practice, it also solves the issues within physical education at this stage, such as the viewing angle problem. The self-learning ability, etc., can be seen when learners perform and practice motor skills. Compared with physical education teaching with videos, it offers more new teaching modes to teachers and helps students improve their learning effectiveness.

6.4. Discuss the Learners' Use of AR Software and Teaching Materials

Based on the results of the textbook satisfaction questionnaire, the average of the two groups in the two aspects of perceived usefulness and perceived ease of use reached the value of four or more, indicating that the two groups of learners have a good degree of teaching and acceptance of the textbook design, and the average of the AR textbooks in the experimental group was slightly higher than that of the video ones in the control group. In both the experimental and control groups, the same paper textbooks were employed for learning activities. The experimental group had AR textbooks with more equipment and button operations, but the satisfaction of the textbooks increased rather than decreased. When familiar with the operation of equipment and software, the use of AR textbooks for motor skills learning activities enabled the learners to generate a positive attitude and acceptance. Judging from the results of the opinion survey and learning feedback data, the students' opinions of the textbooks were mostly positive, with terms such as “very fun”, “very interesting”, “very special”, etc., being mentioned. The two groups had less experience integrating information technology into learning and believed that the new learning mode and the design of teaching materials could maintain interest in its application. In terms of the AR textbook of the experimental group, some learners noted that after the 3D dynamic module appeared in the scanned image, watching the 3D module and performing button operations were very unique and could provide learners with novelty and innovation. When offering suggestions in relation to the teaching material, some learners pointed out the difficulties encountered in AR scanning. Perhaps after improvement, students could have a better user experience with the teaching material system. With more choices and interactive functions, if the system can be stabilised, and the environmental and field factors can be resolved, the original intention of action learning can be more successfully fulfilled, the advantages of AR can be brought into learning activities, and learners’ interest in learning can be enhanced. This also shows that the participants had positive expectations for the system and teaching materials.

6.5. Learners’ Use of AR Software and Teaching Materials Difference in Standard Deviations

Compared with the post-test scores of the achievement test, the standard deviation of the AR teaching materials in the experimental group is slightly higher than that of the video teaching materials in the control group. This has an impact on the gap between the score groups. In terms of the smooth operation of the software, the adaptability of AR to different learners is relatively uniform, which can effectively improve the learning performance of learners in low groups and narrow the gap between students in high and low ones [73]. The design of teaching activities will also have an impact on the performance of learner achievement tests as well as progress. The teaching activities of this study were carried out by two people and one machine. Under such guidance, learners who operate AR software textbooks will experience better progress. This is also true for the experimental group using augmented reality. This was one of the factors that caused the slight difference in the standard deviation of the achievement post-test between the AR teaching material and the video type in the control group.

6.6. Learners’ Use of AR Software and Teaching Materials, and Their References to Software Teaching Materials and Device Barriers

During the testing process of this research, a small number of students had difficulty scanning the AR software textbook and operating the interface buttons. When operating the AR software, it was necessary to match the textbook. Text teaching materials that are prone to reflections, deep shadows, or blurred texts will affect the recognition of the system and cause scanning failures. The stability and guidance mode of the software operation interface is also one of the keys to achieving smooth learning activities and processes. The simple and visual design and learning guidance make it more convenient for learners to operate the AR teaching material system to accomplish the learning effect of auxiliary teaching.

7. Conclusions and Future Work

7.1. Conclusions

The purpose of this study was to investigate the effects of “information technology integration into physical education teaching” with different teaching material modes on learners’ performance in health and physical education courses in terms of learning outcomes, motivational attitudes, motor skills, and teaching material satisfaction. This investigation uses the advantages of AR to produce an innovative teaching model, which can have a higher appeal and provide motivation for learners. In practice, it also solves the deficiencies in the integration of information technology into physical education at this stage. The learners attained a better performance in motor skills learning. The results of the research are the following: the experimental group (AR group) that integrated information technology with physical education achieved a better performance in motor skills learning than the control one (the video group);compared with the control group, the experimental one experienced a higher learning motivation and accomplished a better performance in motor skills than the control group; and the experimental group had a more positive attitude towards and acceptance of the teaching materials.

7.2. Future Work

The popularization of the AR teaching material system into the actual teaching field is a problem that must be overcome in the future. If the creation tools, or courses that require 3D modelling technology or planning ability, are not provided, these factors may make it difficult to effectively implement AR in education (Ibáñez et al., 2014, [34]; Wei et al., 2015, [66]). In the future work, we can develop a set of back-end tools (an authoring tool) for the teaching material system, which can be employed by teachers who are actually on the teaching site to increase the research value. The follow-up unit courses can also continue to invite effective teachers. With physical education teachers as the object of study, the design of the innovative teaching mode can be discussed from their perspective. The contribution and implications for practice uses the advantages of AR to adopt an innovative teaching model, which can be highly appealing and motivating for learner behaviour. In practice, it also solves the deficiencies in the integration of information technology into physical education at this stage. In addition, a similar teaching material system could be applied to different areas of movement skills or field rules, such as “Tai Chi teaching”. Compared with running skills, Taijiquan requires more direction and rhythm. Moreover, it is difficult to master filming as an auxiliary teaching tool, as it is necessary to shoot videos from multiple angles to facilitate learners in watching and learning. With AR, the teaching material system can solve the problems encountered in film shooting perspectives, and the assistance of AR and 3D action skill modules can also achieve uniformity in demonstration actions. In addition to the use of augmented reality, more diverse virtual objects and equipment are also added to transform into a virtual environment.

7.3. Limitations

This study uses football as a research tool, and its results should not be extrapolated to other sports. The Learning Motivation Scale, which measures the quantitative data in this study, may be affected by factors such as the understanding of the meaning of the question, the willingness to answer, and the authenticity of the answer, which may lead to discrepancies between the research results and the actual situation. Due to the AR world-type, during the experiment, students may be concerned about viruses during the course, which may deviate from the actual operating conditions, thereby affecting the research results.

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Appendix A. ARCS Questionnaires

Learning Motivation Scale

1. The content of the course and textbook is relevant to what I personally expect to learn.
2. The design of teaching materials can stimulate my curiosity during the learning process,
3. The course content and teaching material design are moderately difficult for me, not too difficult or too simple.
4. I learned things in the course that I did not expect to learn,
5. The course content and teaching material design made me feel a little disappointed and depressed.
6. The course materials, using videos or multimedia presentations, let me understand the important part of motor skills.
7. I am very satisfied. The teacher gave me high affirmation and marks for my performance.
8. The course content, for me to get a good grade must depend on luck.
9. When the content knowledge of courses and teaching materials can be connected with the knowledge I have learned in the past,
10. I feel a sense of accomplishment when I finish the course movement skills exercises
11. After the course, I am confident that I can pass the class test,
12. Curriculum and teaching material design can let me know how to do better.
13. The pictures, animations and videos in the teaching materials help me to concentrate.
14. The content of the course is of positive help to my running skills.
15. During the course, I am confident that I will learn the course well.
16. The presentation of persuasive actions in courses and teaching materials, the presentation of teaching actions makes me feel very boring
17. I really like this way of learning, it makes me want to know more. learning topics related to running,
18. The content, pictures and examples of the teaching materials can meet the various running concepts to be taught in the course.
19. There are too many motor skills and knowledge taught in sports courses, and the content is complicated. I think it is difficult to focus.
20. Some interesting designs in the teaching materials can attract my attention,
21. The motor skills exercises arranged in the course are difficult for me.
22. I think this course is of little help to me, because I already know most of the knowledge.
23. The course content and teaching material design are helpful to my running movement and improvement,
24. The content of the teaching material seldom catches my attention and interest.

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