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Design and practice of gamified basketball teaching model based on edge computing: Exploration of improving middle school students' participation and learning outcomes

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Abstract: Leveraging edge computing to support gamified physical education in junior high schools enables real-time data processing and interactive, low-latency feedback that overcome the limitations of traditional, static sports game instruction. In our study, 496 students completed questionnaires, and 45 classes participated in a controlled experiment comparing edge-empowered gamified lessons to conventional methods. The results showed a 38% faster class assembly time (2.5 vs. 4 minutes) and an average PE score improvement of over two points, with higher rates of excellence (approximately 50% vs. 36%) and passing (96% vs. 92%). These findings confirm that integrating edge computing into sports games diversifies teaching strategies, enhances student engagement, and improves physical performance.

Keywords: *Diversified teaching, Edge computing, Gamification teaching, Gamified physical education model, Junior high school physical education, Sports games, Youth growth.*

1. Introduction

Physical education curriculum is a comprehensive quality education characterized by physical training, which is based on the cultivation of lifelong sports awareness and ability. However, in the actual sports teaching, people pay less attention to sports activities and have less understanding of sports activities. They lack the understanding of independent exercise in sports activities, which has become a bottleneck restricting the consciousness of lifelong physical exercise. Therefore, it is an important subject of physical education in colleges and universities in China to use various methods in physical education teaching.

In the past, many experts and scholars studied junior high school sports games. For example, Lee and Lee [1] applied artificial intelligence technology to sports teaching, which enriched the means of sports teaching and was very beneficial to educators and learners Lee and Lee [1]. Alcalá and Garijo [2] learned about teachers' and students' cognition of junior high school sports games through questionnaires, and carried out research by means of comparative experiments. It was found that the group with good cognition of junior high school sports games had a higher level of sports Alcalá and Garijo [2]. Filiz and Konukman [3] studied the current situation of sports game teaching under the corona virus disease 2019, and pointed out that today's sports teaching was affected by the epidemic and traditional teaching strategies were difficult to implement. He suggested that distance education and mixed education should be combined to promote the diversification of physical education Filiz and Konukman [3]. Hu [4] overcame difficulties in physical education teaching through computer aided system and made physical education teaching resources and teaching methods more diversified to attract students to participate in interest [4]. These methods have enriched the diversity of sports game teaching to a certain extent and also provided reference for future sports game teaching strategies.

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However, there are also some shortcomings, so this paper discusses the diversified teaching strategies of junior high school sports games based on edge computing to further improve the research of junior high school sports games.

Edge computing is a fast response method, which has shown its advantages in many fields. For example, Hu [5] proposed a quality evaluation technology for physical education and a digital hybrid learning application of mobile edge devices to improve the hybrid teaching of physical education and evaluation. At the same time, the fuzzy extensive analysis method was adopted to successfully realize the mixed physical training quality evaluation and digital evaluation method Hu [5]. Wang, et al. [6] studied sports injury detection through the method of edge computing and conducted experiments to find that the medical monitoring system based on edge computing was more than three times faster than the recognition speed of general methods [6]. Fernández-Caramés and Fraga-Lamas [7] developed new intelligent applications by introducing technologies such as edge computing and the Internet of Things to build smart campuses and protect students' health [7]. In order to improve the hybrid teaching level of online and offline physical education, Bao Lei proposed an online and offline hybrid teaching quality evaluation method based on mobile edge computing. According to the evaluation objectives, indicators, indicator weights and evaluation criteria, an online and offline mixed sports quality evaluation indicator system was constructed. The importance evaluation grade data of each index was analyzed by factor and cluster analysis to simplify the index items. Combined with mobile edge computing, the weights of mixed teaching quality evaluation indicators were calculated respectively, and the fuzzy comprehensive evaluation model was used to effectively achieve offline quality evaluation of mixed sports [8]. Therefore, the above researches are enough to show that edge computing has many advantages in today's society, which also provides research ideas and methods for this paper.

In view of this, this paper analyzed the diversified teaching strategies of junior high school sports games based on edge computing, and combined edge computing with sports game teaching. Through the use of edge computing, students' interest in participating in junior high school sports games could be improved, and the physical quality of teenagers could be improved. It also hoped to provide reference for future research work.

2. Junior High School Sports Games

2.1. Definition of Junior High School Sports Games

Sports game is a kind of regular game, which is also called "active game" and is one of the contents and methods of sports teaching [9]. In order to stimulate students' interest in learning, some stories or rules are added to the sports events, or the results of the competition are used to judge the win or lose of the competition, which can promote students' enthusiasm to participate in sports. The foundation includes physical activity, plot, rules, methods, results, venues and tools. In sports, physical fitness is essential. Students are grouped according to teaching requirements and students' age characteristics. For example, students are grouped or not grouped according to whether they have plots or not and the amount of activities, or they can be grouped according to the basic movements of the human body, such as running, jumping, shooting, etc. Junior high school sports games can improve students' enthusiasm to participate in sports and also exercise students' thinking ability, which is conducive to the cultivation of good psychological quality [10].

2.2. Current Situation of Sports Game Teaching

In China, physical education is an important part of students' learning and the basis of education. Good education quality requires high-quality students. With the development of society and the continuous improvement of economic level, students' health is also improving. At present, the living conditions of students are constantly improving, but sports activities are not popularized in primary school. According to statistics, the average daily exercise time of Chinese pupils is only about 10 minutes. However, during normal classes, students spend more than 6 hours a day. The time for

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students' extracurricular activities is relatively reduced, so junior high school sports games have a certain impact on students' physical health. The students have a heavy learning task, so they have no spare time to participate in sports. Students are inactive for a long time, and their physical fitness would decline. This leads to problems in the human skeleton structure, which poses a greater threat to the human body. At the same time, it would lead to the decline of body immunity and increase the probability of disease. Junior high school sports games are a form of interesting activities. This activity can exercise and improve physical quality, which can increase children's interest and participation in sports and is conducive to the growth and development of teenagers' brains, muscles and bones, as well as the improvement of their mental health [11].

For many students, the setup of junior high school sports games in physical education classes is likely to have polarized perception differences. On the one hand, for students who are confined to the classroom and learning heavy cultural knowledge for a long time, junior high school sports games with fun and attraction are undoubtedly one of the best ways to relax and delight their body and mind beyond the classroom and learning; on the other hand, the current development of junior high school sports games does have many shortcomings and deficiencies, which need physical education teachers to conduct more in-depth exploration and analysis. The specific problems are as follows:

(1) The goal of the game is single, which lacks moral and emotional education. Influenced by traditional concepts and educational concepts, many people, even physical education teachers, confine physical education in a narrow sense to the methods and ways of exercising students' physical quality or strengthening their bodies, which basically only stays at the stage of strengthening their bodies. This lacks the consideration on the training and cultivation of students' moral cognition, emotional attitude, will quality, and personality.

(2) The game form is single and old-fashioned, which lacks diversity and innovation. As a kind of game, the original intention of sports game is to help stimulate students' interest in sports courses and physical exercise, which can fully mobilize students' enthusiasm, so that they can participate in sports classes more actively, voluntarily and happily and enjoy the class. However, as far as many sports classes are concerned, the setting of "interesting" and "attractive" junior high school sports games is questionable or even discounted.

Therefore, the innovation of sports game teaching is an urgent problem to be solved. In order to promote growth and health, junior high school sports games need to be infiltrated into the curriculum to ensure the healthy growth of young people. The diversification of mobile junior high school sports games through new scientific and technological equipment can not only effectively meet students' learning needs, but also solve the problem of improving students' physical quality. This paper analyzes the diversified teaching strategies of junior high school sports games based on edge computing.

3. Evaluation of Sports Game Teaching under Edge Computing

Edge computing refers to the concentration of network, computing, storage and application core capabilities on an open platform, which is located near objects or data sources and provides the closest service [12]. Its applications are started at the edge, which can provide faster network services to meet the industrial needs for real-time business, application intelligence, security and privacy [13]. Its application paradigm is shown in Figure 1:

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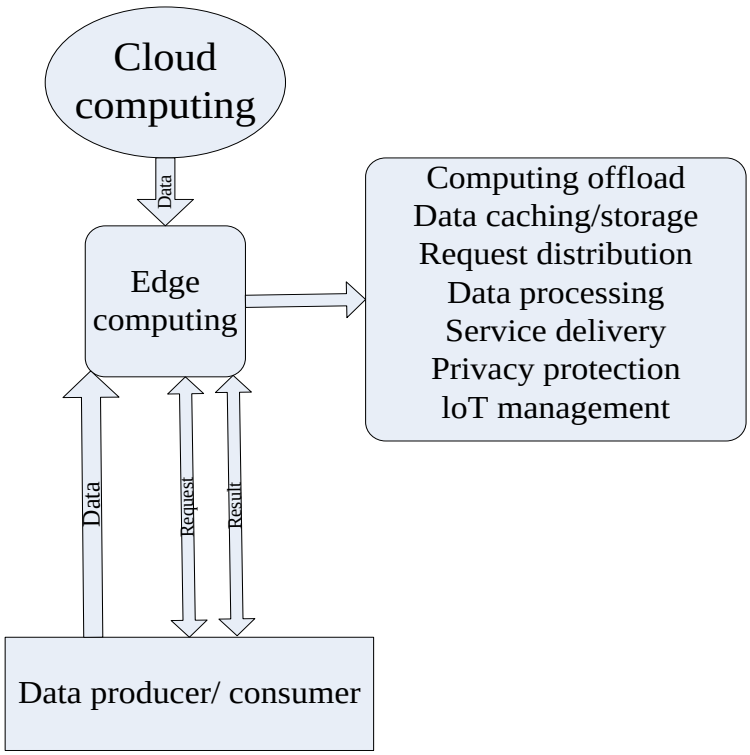

Figure 1.
Application paradigm of edge computing.

The Edge Computing Node (ECN) controller evaluates the link capacity M under the current network according to the feedback status information, and uploads video frame data L and delays D. When L and D meet the conditions at the same time, the edge node manager allocates the upload channel.

It is assumed that the packet loss rate of the current communication environment is l and the physical layer transmission rate is R, the current link capacity C is expressed as follows:

$$C = （1 - l） R(1)$$

The amount of video frame data uploaded by ECN is L, and the maximum amount of data allowed to be transmitted per unit time of the network is I. If I≤L, the current network environment meets the upload conditions; on the contrary, it means that in order to ensure the real-time performance of the video stream, the video frame with larger O is preferentially selected for regeneration.

According to the characteristics of computing flow diversion in the edge model, the current preprocessing task is expressed as E. Among them, T is the maximum processing time allowed to complete the task, and x is the number of CPU instructions required to complete the unit bit data task. The ECN preprocessing delay is as follows:

$$D = T + x(2)$$

The total delay of sending s to the cloud computing center can be expressed as follows:

$$D = \frac{1}{f}\sum_{s=0}^{s} D(3)$$

In the formula, L represents the size of the ith frame; f represents the CPU dominant frequency applied by ECN to Virtual Manufacturing (VM); D represents the delay of transcoding and compression of video stream s.

After considering the delay and bandwidth, the frame filtering model is obtained, and the calculation formula is as follows:

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$$D = \max_{O_{i,\ s}} \sum_{i}^{N} O_{i,\ s} (4)$$

After the current network transmission capacity and total delay meet the conditions, the ECN controller allocates the upload channel and starts task scheduling.

Edge computing is between physical entities and industrial connections or at the top of physical entities. However, cloud computing can still access the historical data of edge computing.

3.1. Application of Edge Computing in Diversified Teaching of Junior High School Sports Games

Diversified gamification strategies such as task-based challenges, point accumulation, level upgrades, and team competitions were integrated into the sports games to increase student motivation and interaction, with edge computing technology enabling real-time monitoring and feedback. Combined with the current diversified teaching situation of junior high school junior high school sports games, this paper would analyze the diversified teaching strategies of junior high school sports games based on edge computing technology [14] and build the application process as shown in Figure 2.

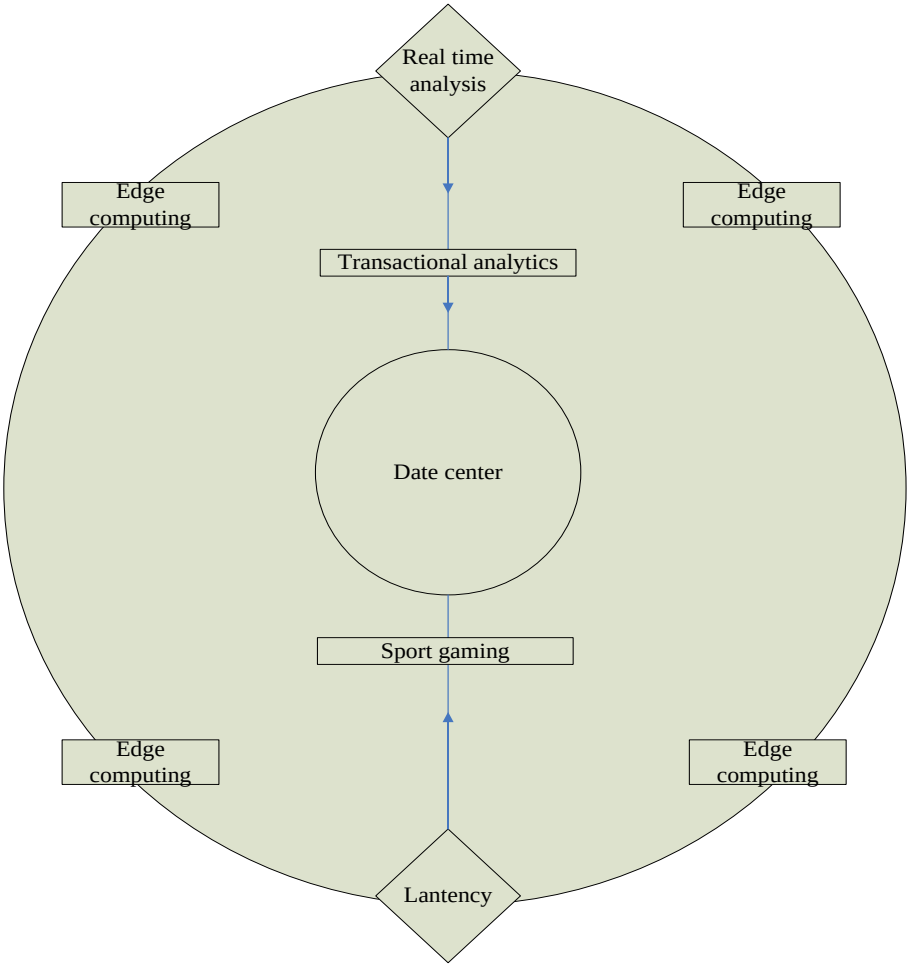

Figure 2.
Application process of edge computing.

First of all, the existing video courses are combined with edge computing, and the teaching content is constantly updated in a "point to area" way. Junior high school sports games are stored in different devices in the form of video or audio as the focus and difficulty. This can not only ensure the safety,

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stability and smoothness of teaching content transmission, but also ensure that video resources would not cause students to watch fatigue due to excessive content. Secondly, teachers should be the center to design diversified teaching strategies. The network is used to make various virtual objects in junior high school sports games into learning materials for students to learn, and evaluate the learning situation through software. The teacher would inform the students of the feedback information in time after the physical education class to ensure that the teacher can grasp the students' learning situation in time. Finally, the students are tracked and analyzed, and feedback is timely adjusted and followed up to solve relevant problems in the teaching process. In view of the problems such as unexpected situations that may occur in the actual teaching process of junior high school sports games, the emergency treatment plan is made. Based on this, first of all, various means are considered to be adopted to solve the problem: The video monitoring, network transmission and other technologies are used to improve the teaching effect and user experience. Secondly, the edge device is used to connect the PC platform to upload and edit junior high school sports games in real time, which not only ensures the image quality but also saves the amount of memory to ensure that the hardware resource occupation problem caused by the terminal system is reduced to the greatest extent. At the same time, it can also provide a high-quality, high-performance multimedia education equipment resources for each class to use according to its own needs. In addition, it can also be viewed at any time through the network platform, live broadcast information and online interactive communication forms to further improve the diversified teaching effect of junior high school sports games. Finally, the combination of emerging technology and traditional education model can enhance the role of teachers in junior high school sports games and promote the development of students' learning ability, so as to better improve classroom efficiency and the educational attraction and promote students' growth and school social development [15].

The diversification of junior high school sports games based on edge computing technology can improve the experience and interaction effect of physical education in the teaching process to a certain extent, so as to maximize and diversify the teaching effect. It is of great significance to promote students' autonomous learning, and it is also conducive to improving teachers' work efficiency [16].

The core of introducing a point system as a formative assessment tool in basketball teaching is to reconstruct students' learning motivation and participation mode through a multi-dimensional reward mechanism. Individuals or teams obtain dynamic points by completing specific tasks (such as maintaining dribbling stability, following the route, or showing a spirit of cooperation in an obstacle dribbling relay race). These data are collected in real time by edge computing devices and synchronized to a visual scoring system, so that competitive performance can be transformed into a quantifiable growth trajectory. Points not only record the degree of achievement of sports skills, but also emphasize the value of process efforts. For example, in a defensive task, students can get extra incentives by completing tactical cooperation through non-verbal communication. This design breaks through the traditional binary evaluation framework of winning and losing, so that students of different ability levels can obtain continuous positive feedback in the achievement of personalized goals, and then build a growth-oriented cognitive system with self-improvement as the core.

The design of rules and constraints stimulates students' tactical thinking and adaptability through structured constraints. Edge computing technology monitors the execution of rules such as "silent defense" or "three passes before shooting" in real time through intelligent sensing nodes deployed in the training field, and dynamically adjusts the task threshold to maintain a balance of challenges. For example, in 3v2 fast break training, the system will automatically generate spatial restrictions based on the team's real-time position data, forcing students to optimize their decision paths under dynamic constraints. This teaching strategy that deeply integrates physical rules with digital feedback not only simulates the real confrontation complexity of professional basketball, but also cultivates students' tactical migration ability through data-driven rule iteration. When the constraints of weekly rotation are pushed to the terminal device via the cloud, students need to reconstruct cognitive models within the limited information exposure window period, thereby strengthening their high-level thinking ability of on-the-spot response and team collaboration.

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The time pressure mechanism internalizes the efficiency demands of competitive performance into students' self-regulation ability by constructing a time dimension close to actual combat. The edge computing platform provides a millisecond-level response feedback loop for tasks such as "key shot countdown" or "fast break tycoon" through the collaboration of wearable devices and environmental sensors: in the 10-second shooting timing task, the system not only records the shooting timing, but also generates efficiency scores based on motion trajectory data; in the time-limited fast break scenario, edge computing analyzes the team's offense and defense conversion frequency in real time and dynamically adjusts the remaining time window. This design, which transforms time resources into quantifiable tactical assets, forces students to find a balance between physiological load and decision-making accuracy. Its training effect is not only reflected in the improvement of the level of action automation, but also helps students establish evidence-based self-diagnosis and optimization capabilities through data attribution analysis under stressful situations (such as clustering of error types at critical moments), ultimately achieving a cognitive leap from mechanical repetition to strategic practice.

3.2. Experimental Evaluation of the Application of Edge Computing in Sports Game Teaching

In order to further study the application of edge computing in sports game teaching and verify its feasibility, this paper conducted a questionnaire survey and telephone interview on a well-known local middle school, and carried out a comparative experiment in physical education classes.

3.2.1. Questionnaire Method

About 3000 students in the school were taken as the survey objects, and questionnaires were randomly distributed in the school. During the survey period, 500 questionnaires were issued and 500 were returned, including 496 valid ones. The questionnaire data were analyzed and counted by using mathematical statistics. The results are shown in Table 1:

Table 1.
Investigation on students' cognition of junior high school sports games in experimental middle schools.

The main role of junior high school sports games	Number of people	Proportion (%)
Increase interest in sports learning	163	32.9
Relieve physical and mental fatigue	122	24.6
Improve the mental quality	91	18.3
Strengthen the body and enhance the physique	120	24.2

Among them, 32.9% of the students thought that junior high school sports games could improve their interest in sports learning; 24.6% of the students believed that junior high school sports games were mainly to relieve physical and mental fatigue; 24.2% of the students believed that junior high school sports games had the effect of strengthening the body; a small number of students believed that junior high school sports games mainly helped participants to improve their psychological quality.

In addition to the above statistics, the popularity of junior high school sports games among students is also counted, as shown in Table 2:

Table 2.
Investigation on the attitude of students in experimental middle schools towards junior high school sports games.

Attitude	Number of people	Proportion (%)
adore	283	57
enjoy	119	24
not to matter	53	10.7
dislike	41	8.3

More than half of the students were keen on junior high school sports games, and only 8.3% of the students chose "dislike" in the questionnaire. This fully reflects the students' love for junior high school

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sports games, which also shows that it is necessary and feasible to carry out junior high school sports games in sports teaching.

3.2.2. Telephone Interview

Interview method refers to the basic psychological research method of understanding the psychology and behavior of interviewees through face-to-face conversation between interviewers and interviewees. In this survey, the telephone interview method was mainly adopted, and 10 college students were interviewed about their cognition of junior high school sports games (multiple choices are allowed). The summary is shown in Table 3.

Table 3.
Interviewees' opinions on junior high school sports games.

Opinion	Number of people	Proportion (%)
Good for the development of physical education	9	90
Have received good sports game teaching	4	40
Maintain good sports habits	2	20
Still want to participate in junior high school sports games	7	70

Among the ten people, 9 believed that junior high school sports games were helpful to the development of sports teaching, which could not only warm up the body, but also enhance the interest in participating in sports. 7 college students wanted to participate in junior high school sports games, and only 4 received good sports game teaching. Only 2 college students maintained the habit of sports training. This shows that the past sports game teaching is insufficient.

3.2.3. Contrast Experiment

In order to verify the feasibility of edge computing in sports game teaching, comparative experiments were carried out in experimental schools. Two classes with 45 students were divided into experimental class and ordinary class. The experimental class implemented a gamification-based sports teaching model, integrating point accumulation systems, task challenges, and team competitions into the curriculum. Edge computing technology was employed to provide real-time monitoring, instant feedback, and dynamic task adjustments based on student performance. In contrast, the ordinary class followed the traditional teaching approach without gamification elements or technological support. After a month of teaching, the statistics and analysis of the physical education teaching of the two classes are as follows:

1. Gathering rate: The statistics of students' standing time in two classes are shown in Figure 3.

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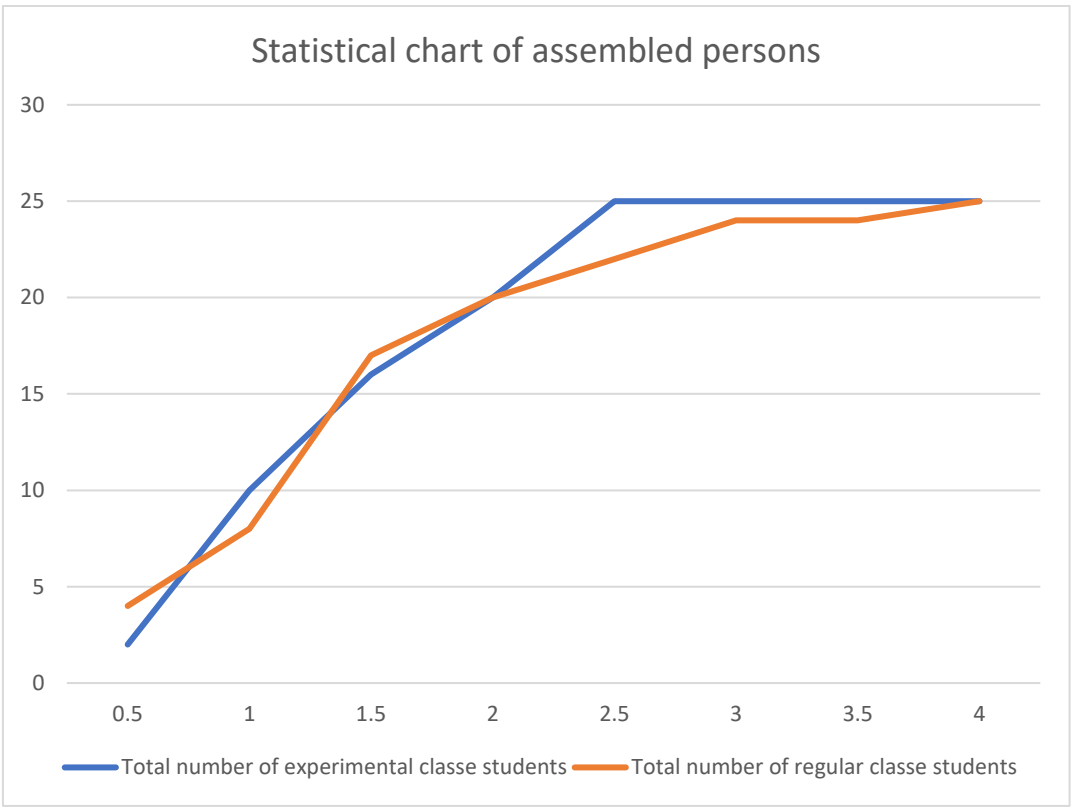

Figure 3.
Statistical chart of assembled persons.

Figure 3 shows the number of people arriving in two classes at different time points. The experimental class could complete the assembly in 2.5 minutes, while the ordinary class could only complete the assembly in 4 minutes. This is mainly due to the advantages of edge computing. Under its long-term effect, the collection rate significantly improves.

2. Final examination results: The final examination results reflect the comprehensive level of a class's sports ability. The final examination results of the experimental class are ranked as shown in Figure 4.

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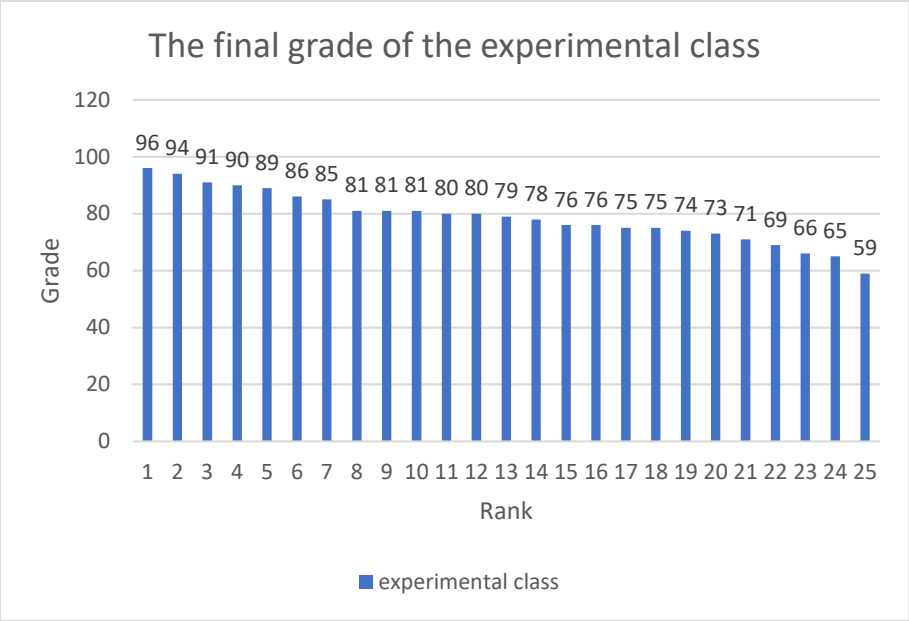

Figure 4.
Ranking of final scores of experimental class.

Figure 4 shows the final examination of the experimental class. Among them, the highest score was 96, and the average score was 78.8. A score of 80 or more was considered as excellent, and a score of 60 or more was considered as pass. The excellent rate was close to 50%, and the pass rate was 96%. The final examination of ordinary classes is shown in Figure 5:

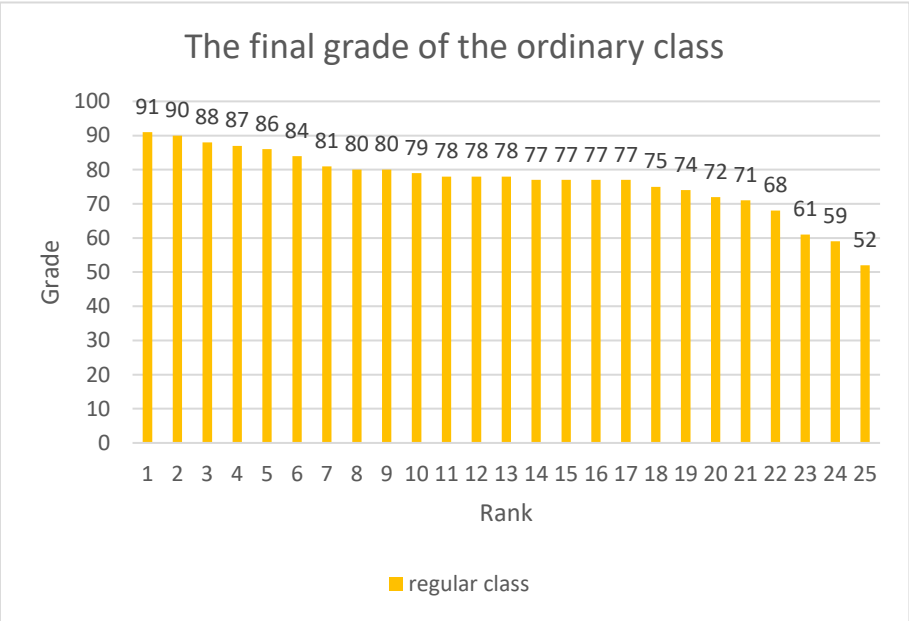

Figure 5.
Ranking of the final examination of ordinary classes.

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The highest score of the class at the end of the term was 91, with an average score of 76.8. The excellent rate was 36%, and the passing rate was 92%. Although the ordinary class also has a good score, its comprehensive performance in the final examination is significantly lower than that of the experimental class. In order to compare the data more intuitively, a data statistics chart is drawn as shown in Figure 6:

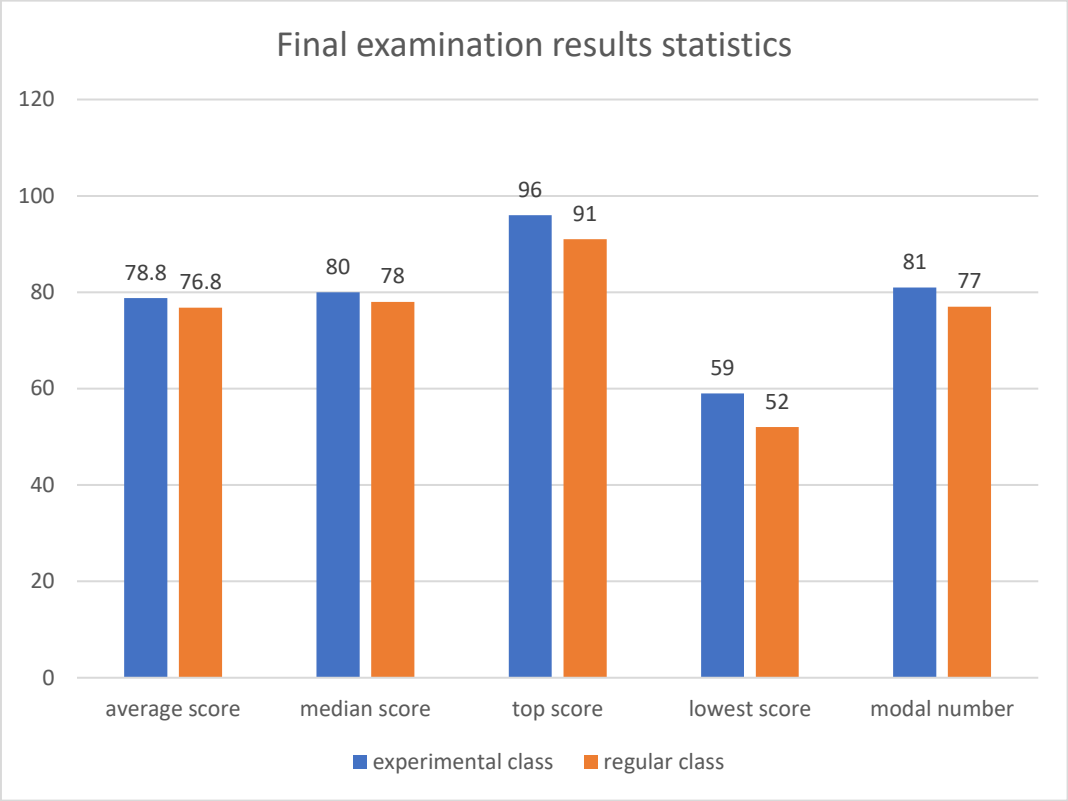

Figure 6.
Comparison chart of final examination results between ordinary class and experimental class.

In the final assessment, the full score is 100. It was not difficult to find from Figure 6 that all indicators of the experimental class were higher than those of the ordinary version, with an average difference of more than 2 points. It can be seen that edge computing is helpful for sports.

4. Discussion

In the wave of rapid development of information technology, educational technology also presents a trend of informatization. Information processing requires data processing on the device side, so traditional storage technology and cloud computing technology make computing and storage time become longer and longer. Therefore, more and more traditional online education technologies are gradually abandoned, while emerging technologies such as edge computing become an important complement to traditional education. In the future, edge computing technology would be further developed and improved, and educational applications would be more extensive and in-depth. Compared with traditional information technology, it has some advantages. First, the integration of edge computing technology and education makes it have a better application prospect in sports game education [17]. As junior high school sports games are a means of learning through sports, the current education reform pays more attention to process and effectiveness. Therefore, edge computing

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technology is used to implement the technology needed in junior high school sports games in hardware devices, but there is no large-scale processing and storage time problem in applications. In the traditional computing mode, the transmission of junior high school sports games to the server is tedious, time-consuming and labor-intensive. However, edge computing technology can quickly process, calculate and store data so that it would not be affected by physical environment factors and equipment energy consumption factors, which would have a huge impact [18]. Edge computing technology can avoid this impact and reduce the impact on the environment. In the development of junior high school sports games, it is necessary to reasonably choose the environment design and required computing power according to their own conditions to achieve the diversification and personalized effect of junior high school sports games. The full satisfaction of diversified teaching needs of junior high school sports games makes this process more relaxed and pleasant, which reduces the time cost and improves the teaching effect [19]. In the process of sports game teaching, it also plays a very good role in some junior high school sports games. For example, the use of edge devices in games can make better use of network transmission, so as to provide the required information content to make junior high school sports games more colorful. It is easier to have an immersive experience when watching videos to reduce the sense of delay; at the same time, it can also enable teachers and students to understand the dynamics of the game and master operating skills. This also makes the game more interesting and enhances the interest in learning, so as to stimulate students' enthusiasm and initiative in teaching.

5. Conclusions

Through the analysis of this paper, the full use of edge computing technology could effectively solve the problem that the current traditional junior high school sports games could not meet the diversified needs in the teaching of junior high school sports games. Edge computing technology was used to solve the problems of data storage, transmission and insufficient computing capacity. Edge computing could monitor the running status of equipment involved in sports in real time through cloud computing technology to reduce latency, so as to improve its performance and shorten working time. In addition, the application of edge computing technology could choose different technical routes according to different application scenarios. It could effectively solve the data problems arising from the use of traditional educational equipment. The edge devices could be used to solve the problems that could only be realized, stored and processed through data computing capacity in real life application scenarios. Through the combination of edge computing technology and cloud platform with server and computing equipment, the construction of sports game platform and the network architecture in the diversified teaching process of junior high school sports games were realized. Edge computing technology was used to build a platform for physical education curriculum and sports game teaching, which realized the close connection between information technology and students in the classroom, thus effectively realizing the diversification of games and maximizing classroom efficiency and benefits.

However, the times are advancing, and science and technology are developing. With the improvement of relevant research in the future, more useful technologies would emerge. In the future, it is necessary to strengthen the understanding of emerging technologies and let more useful technologies be used in sports game teaching, so as to enhance the interest of young people in participating in sports training.

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Transparency:

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

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