Designing And Evaluating Game-Based Learning With AR Teaching Model In Sanda Teaching For Learners' Learning Effect

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ARTICLE INFO	ABSTRACT
	The purpose of this study is to study the learning and the efficacy of game-based learning with AR in the context of studying Chinese Sanda Teaching. This study aims to improve the learning effect of learners and the satisfaction of game-based learning with an AR teaching model so as to provide technical enhancement in related martial arts education in martial arts education. The impact of teaching. This study is based on previous research and current educational technology trends to fill the research gaps and understand the importance of game-based learning with AR for Sanda teaching. This study uses the experimental method to randomly select the experimental and control groups of Capital University of Physical Education and Sports, Yunnan Normal University, and Lvliang University of Sanda Course. The experimental group used game-based learning with an AR teaching model, and the control group used a traditional teaching model. The research effect of the experimental group during the research assumption of this study is significantly better than the control group. ANCOVA is used for quantitative analysis. This analysis learned that when the experimental group and the pre-test of the control group did not have significantly different differences, the final test results showed that the learning effect of the experimental group was significantly better than the control group. In addition, this study surveyed 20 learners in the experimental group (5-point Likert scale), and the results showed that the learners had high satisfaction. This study emphasizes game-based learning with AR to improve martial arts teaching. In the end, this research aims to encourage technologically enhanced learning experiences in martial arts education and expand teaching technology in the field.

Keywords: Immersive Augmented Reality, Game-Based Learning, Learners' Satisfaction, Learning Effect |

1. Introduction:

In recent years, the field of educational technology has seen considerable breakthroughs, particularly in the areas of immersive augmented reality (AR) and game-based learning (Alper et al., 2021; Yu, Denham & Searight, 2022). These technological advancements have altered traditional educational approaches by providing dynamic and engaging learning experiences (Blaschke, 2021). However, Sanda, a Chinese martial art that stresses physical combat methods, is one domain that has welcomed these advances (Jia, Theeboom & Zhu, 2020). Nevertheless, immersive AR game-based learning in Sanda training has enormous potential to improve instructional efficacy and raise learner engagement (Tahir & Wang, 2022; Wu & Chen, 2020). Educators have looked into the benefits of using sports as a learning tool on multiple occasions. The positive benefits it has on student motivation, information acquisition, and skill development were, however, described by (Krouska, Troussas, and Sgouropoulou, 2022; Liao, Chen, and Shih, 2019). The majority of game-primarily

based getting-to-know benefits have already been verified in quite a few instructional settings (Camacho-Sánchez et al., 2023; Zuo et al., 2023). Whereas, limited research has been conducted on the implementation of AR game-based learning interventions in the context of Sanda teaching (Hilmun, Abella, & Sabrina, 2020; Tsihouridis et al., 2023). The latest developments in the field indicate an increasing inclination towards the incorporation of AR and other immersive technologies within educational environments (Badilla-Quintana, Epulveda-Valenzuela, & Salazar Arias, 2020; Fracaro et al., 2022). The utilization of this technology presents a distinctive prospect for students to engage with actuality, formulate tactics, and obtain instantaneous data, thereby enhancing their educational encounter (Lampropoulos et al., 2022).

Despite the existing research on game -based learning and immersive AR technology, there is still a significant research gap in the background of Sanda Teaching (Liu et al., 2020; Paolanti et al., 2023). First of all, there are few research on the use of immersive AR game learning in Sanda teaching (Yu et al., 2022; Yu, Wu & Huang, 2022). Secondly, there are few studies on learners' game learning experience (Belda-Medina & Calvo-Ferrer, 2022; Hooshyar et al., 2021). Finally, the role of learners in immersive AR game learning has not been explored to a large extent (George 2020). These research gaps show that more studies need to better understand the effectiveness of immersive AR game learning in Sanda teaching.

This study aims to explore learners' learning effects of game-based learning with AR in Sanda teaching. The research questions in this study are:

1. How to develop game-based learning with AR teaching model in Sanda course?
2. Compared with the traditional teaching mode in the Sanda course, how effective is the game-based learning with the AR teaching mode in the Sanda course?
3. How is learners' satisfaction with the game-based learning with AR teaching mode in the Sanda course?

By studying the combination of sports games and AR games based on game learning in Sanda Teaching (Fernandez Galeote et al., 2021; Harden, 2022; Ishak, Din & Hasran, 2021). By investigating the satisfaction of students' learning -based learning, research found that the satisfaction of learners provides necessary feedback on the teaching mode of game learning. (Foster et al., 2019; Ivanjko, Pavlina & Grubješić, 2020; Ling et al., 2022).

The value of this study is to provide information for teaching practice and curriculum design in the field of martial arts education. This study reveals the learning effect of game-based learning with AR learning effects, and learners' satisfaction with the game, help educators and practitioners use technical enhancement methods to improve teaching and learning experience. Finally, the study hopes to include immersive AR games into martial arts education by providing evidence-based suggestions to help students, teachers and researchers. Because these findings can contribute to the wide range of the role of immersive technology and game-based learning in other fields, thereby contributing to a wider range of education technology fields.

In summary, this study aims to explore the impact of game-based learning and AR in Sanda Teaching on the learning effect of learners in Sanda Teaching. This research aims to contribute to the field of education technology and martial arts education based on previous research and current trends. It will provide important insights and suggestions for practitioners and scholars.

2. Literature Review and Theoretical Background

Technology's fast growth has created the door for novel ways to teaching and training, notably in the field of physical education (Liu, Tretyakova, Fedorov & Kharakhordina, 2020). Augmented reality (AR) has emerged as a viable technique for boosting learning experiences, notably in the context of martial arts education, in recent years (HanLiang & LiNa, 2022). Sanda, a Chinese martial art that mixes ancient fighting tactics with contemporary features, is an intriguing arena for investigating the possibilities of immersive augmented reality games (Zhang, 2021).

The integration of digital material into the real-world environment, giving consumers with an interactive and improved experience, is referred to as augmented reality (Turner, 2022). Across China, the use of augmented reality technology has accelerated across a variety of industries, including education and entertainment (Jayawardena et al., 2023). China, with its enormous population and profound martial arts tradition, is a good site for researching the function of immersive augmented reality games in Sanda teaching (Gong et al., 2021).

2.1 Immersive Augmented Reality Game's Role in China:

Immersive augmented reality games have enormous promise for revolutionizing conventional learning and training methods (Kazanidis, Pellas & Christopoulos, 2021). The extensive usage of smartphones in China, along with the availability of low-cost AR devices, has encouraged the mainstream adoption of AR technology (Sanfilippo et al., 2022). This technology environment has provided a fertile ground for the incorporation of immersive AR games into Sanda education, providing students with a compelling and dynamic platform to hone their fighting abilities (Hauerwas, Kerkhoff & Schneider, 2021).

Immersive augmented reality games may imitate real-world combat situations by employing AR characteristics such as realistic virtual opponents, visual input, and contextualized scenarios (Dargan et al., 2023). This allows students to practice and fine-tune their methods in a secure and controlled setting, while also encouraging immersion and drive (Kaplan-Rakowski & Gruber, 2022). Furthermore, the use of game-like

components such as progression systems, prizes, and challenges increases student engagement and fosters a pleasant learning experience (Adams & Du Preez, 2022).

2.2 Game-Based Learning in Sanda Teaching:
Game-based learning, which involves using games for educational objectives, has gained popularity as an effective teaching technique (Alam, 2022). Game-based learning systems that combine immersive augmented reality games serve as independent variables in the context of Sanda training, having the ability to greatly affect learners' skill improvement (Yang, Chu, Hsieh & Kuo, 2022).

Immersive augmented reality games created expressly for Sanda training may provide learners with an organized and gamified environment in which to practice and fine-tune their skills (Stephanidis, Antona & Ntoa, 2022). These games encourage iterative learning by providing rapid feedback, performance monitoring, and individualized challenges (Chen et al., 2021). Game-based learning promotes learners' active engagement and improves skill development by immersing them in a competitive and goal-oriented environment (Scholz, Komornicka & Moore, 2021).

Furthermore, game-based learning has the potential to act as a moderator in the link between immersive augmented reality games and skill development in Sanda training (Wen & Looi, 2019). Games' dynamic and engaging character improves learners' concentration, attention, and self-efficacy, resulting in greater levels of practice and effort (Shu & Liu, 2019). Learners improve their tactical thinking, decision-making ability, and physical coordination via repeated exposure to tough scenarios, eventually increasing their performance in real-world combat situations (Afonso et al., 2022).

2.3 Learners' learning effect of Educational Games:
The effectiveness of immersive augmented reality games in Sanda teaching depends on the learning effect of learners (Yu et al., 2022). The learning effect of learners is crucial for educational games (Bovermann & Bastiaens 2020).

User-centered design concepts and empirical research may lead the creation of immersive reinforcement reality games to enhance the learning effect of learners (Zhang, Liu, Kang & Al-Hussein, 2020). Developers can improve the participation and fun of learning through components including personalized selection, variable difficulty levels, and attractive user interfaces (Bang, Li & Flynn, 2023). The input from learners throughout the design and testing stage also guarantees the expectations of educational games to meet their learning effects, and provide relevant learning experience (Videnovik, Trajkovik, Kiønig & Vold, 2020).

2.4 Learners' Satisfaction:
The evaluation of the learners' learning results is called the satisfaction of learners (Hooshyar, Kori, Pedaste & Bardone, 2019). The satisfaction of the learner is a dependent variable, depending on their learning effect in game-based learning (Yang et al., 2022). However, learners' self-evaluation, learners' satisfaction of learning process, and learners' satisfaction with learning results is an important part of learner satisfaction (Granberg, Palm & Palmberg, 2021). These can know the evaluation of some kind of teaching model (Ferreira, Martinsone & Talić, 2020). Immersive augmented reality games allow learners to have a good experience and improve the satisfaction of learners. At the same time, the satisfaction of learners can also promote the transformation and upgrading of immersive and reality games (Nersesian, 2021). However, combined with the satisfactory survey of learners, learners' learning effects will be more targeted to improve teaching methods (Yang et al., 2022).

Finally, incorporate immersive reality games into Chinese Sanda Education has a huge potential to change traditional teaching methods (Russell, 2020). Learners' satisfaction determines the important aspect of the effect of immersive reality games in Sanda training (Harden, 2022). Through research on these factors, scholars and practitioners will be able to use the potential of augmented reality, improve their skills, encourage participation, and establish a good learning experience for Chinese Sanda learners.
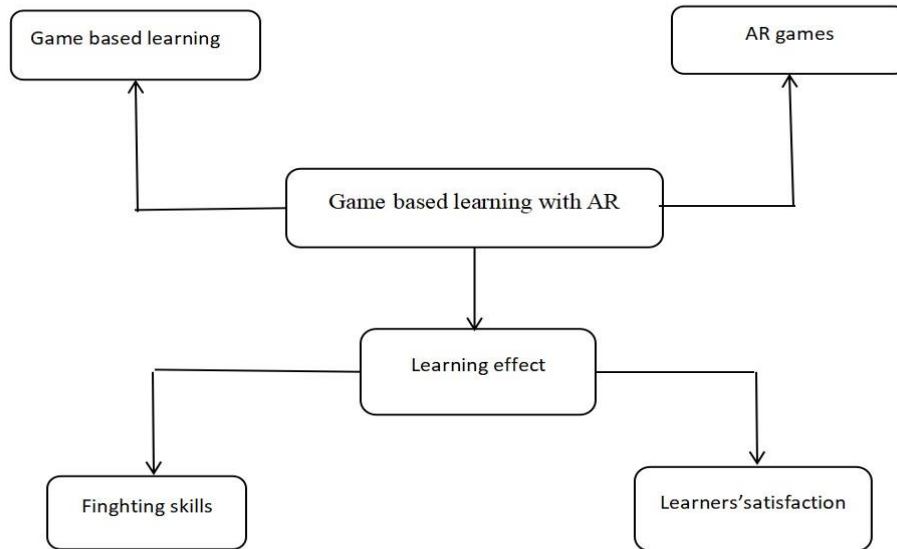
Figure 1: Conceptual Model

H1. The learners' fighting skills who learn with game-based learning with AR will be higher than the traditional teaching mode of learners' fighting skills

H2. Learners from game-based learning with AR teaching model will have great satisfaction

3. Methodology:

3.1 The Design and Development of Game-Based Learning with AR Teaching Model
According to the research objectives the process of design game-based learning with AR in Sanda course as

Figure 2.

Figure 2. **Process of Design Game-Based Learning with AR Teaching Model**

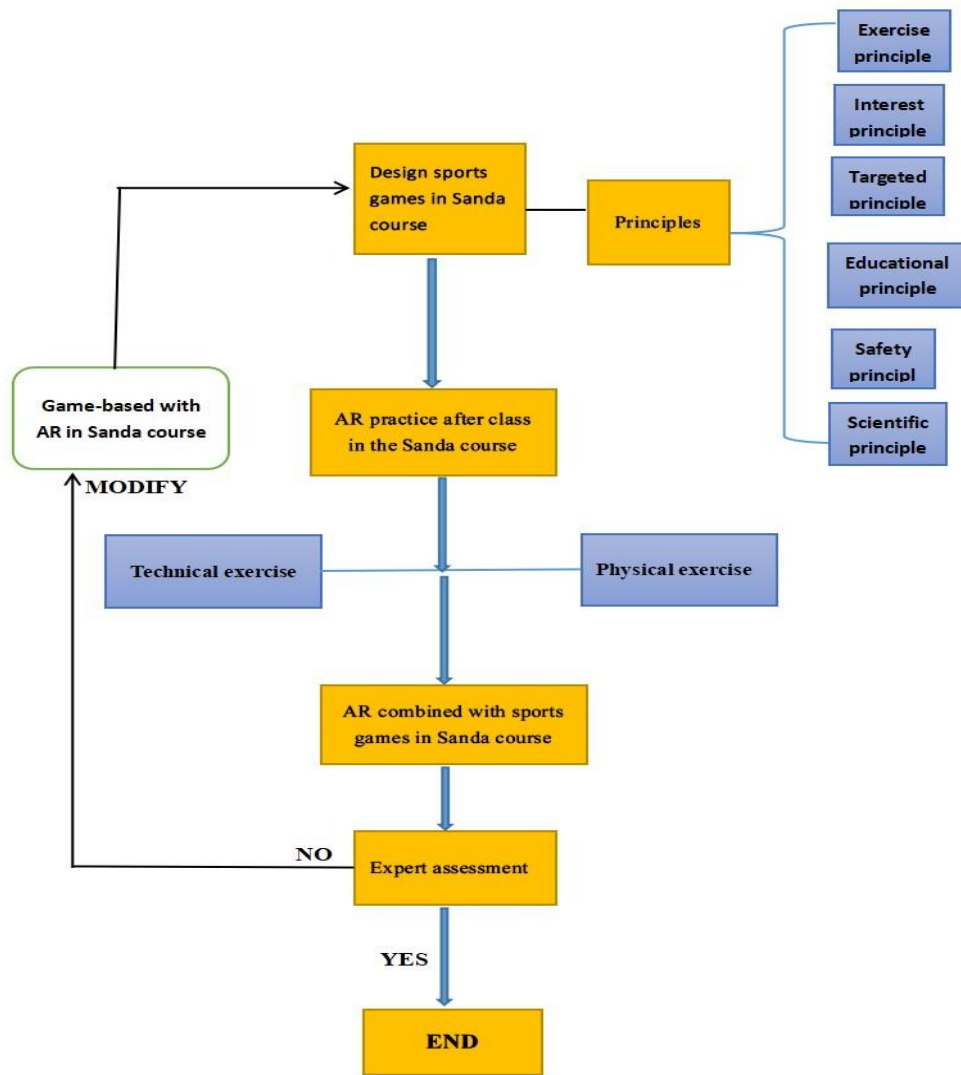According to the needs of this study, five experts in related fields have evaluated the teaching model of this study. At the same time, the teaching model design of this study is shown in Figure 3.
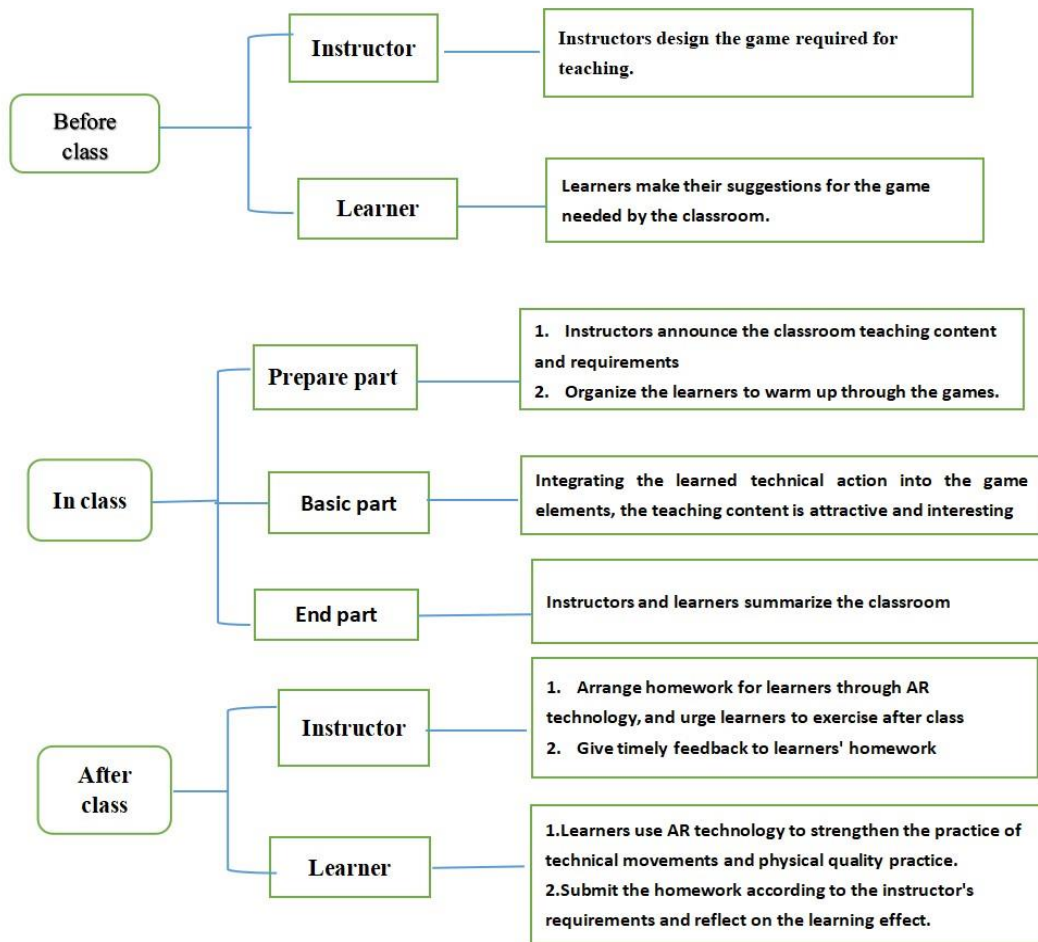
Before class
- **Instructor** — Instructors design the game required for teaching.
- **Learner** — Learners make their suggestions for the game needed by the classroom.

In class
- **Prepare part** —
  1. Instructors announce the classroom teaching content and requirements
  2. Organize the learners to warm up through the games.
- **Basic part** — Integrating the learned technical action into the game elements, the teaching content is attractive and interesting
- **End part** — Instructors and learners summarize the classroom

After class
- **Instructor** —
  1. Arrange homework for learners through AR technology, and urge learners to exercise after class
  2. Give timely feedback to learners' homework
- **Learner** —
  1. Learners use AR technology to strengthen the practice of technical movements and physical quality practice.
  2. Submit the homework according to the instructor's requirements and reflect on the learning effect.

Figure 3. Game-Based Learning with Augmented Reality in Sanda Course

3.2 The Experiment of Game Based Learning with AR Teaching Model

This study uses experiments to conduct research. However, samples was selected by the systematic sampling method. In this study, overall, there were 400 learners of the Sanda course. They are from Capital University of Physical Education and Sports, Yunnan Normal University as well as Lvliang University. According to the research needs, the selection of experimental samples is divided into three steps: 1. From the three universities and one as an experimental research object; Sanda Class (four classes in each university); 3. Two classes, one is the experimental group, and the other is the control group.

According to the characteristics of Sanda, in order to maintain the balance between fighting skills and security during the process of Sanda's teaching. Sanda is a sport with greater risks. In learning progress, the two need to fight. Through practice, it is more likely to be injured when there are too many people. To provide that the learners are trying to avoid injuries and maximum actual combat skills during the training process and to ensure a good classroom atmosphere. Therefore, 20 learners each in the experimental and control groups. Teaching arrangements are as shown in Table 1

Table1. Teaching Schedule Arrangement of Sanda

Week	Class	Content of Courses
Week 1	Lesson 1	The offensive techniques of basic posture, footwork and straight fist in Sanda
Week 1	Lesson 2	Swing fist, hook fist, fist fighting skills
Week 2	Lesson 3	Forward kick, side kick
Week 2	Lesson4	Whipping kick, kick fighting skills
Week 3	Lesson 5	Wrestling technique learning
Week 3	Lesson 6	Fist and kick fighting practice
Week 4	Lesson 7	Fist, kick, Wrestling fighting practice
Week 4	Lesson 8	Sanda fighting skills assessment

3.2.1 Pre-test Content of the Experiment

Before the experiment, the physical fitness of the two groups was tested, and the data of each index of the experimental group and the control group were analyzed. After confirming that there was no significant difference between the two groups, the teaching experiment was conducted.

The pre-test is to test the learners' stamina (800m), explosive power (standing triple jump), speed (20 seconds whip kicking sandbag) according to the standard formulated by the General Administration of Sport of China of the People's Republic of China.

3.2.2 The Teaching Process of the Experiment

Experimental Group

Before Class: Through the learning platform, learners put forward their own suggestions on the game required by teaching, and at the same time, teachers properly modify the games required by teaching.

In Class: The teaching in the classroom is divided into three parts, namely, the preparation part, the basic part and the end part. First of all.

Prepare Part: Instructors need to announce the content of the class and the specific requirements of the course. Next, we need to mobilize students' spiritual excitement through the game, so that students can quickly enter the learning state. The selected games such as "Count into the group". In short, the principle of the preparation stage is to promote students' warm-up activities to be fully in place and lay a foundation for the following learning.

Basic Part: Integrate technical action into game-based learning elements to promote the interesting teaching content. For example, when teaching wrestling techniques, students can be grouped, and then two groups of students can fight in the form of A team, or taking boxing techniques as an example, the situation can be assumed: for example, if A uses boxing to attack B, B should defend and counterattack. Mobilize the enthusiasm of students to the greatest extent.

End Part: Instructors and learners summarize the classroom.

After Class: What instructors need to do from the teaching level is teach reflection and urge learners after-class exercises. Due to the particularity of physical education, the intelligent physical education classroom is currently in the initial stage, and it is essential to reflect on teaching, which is more conducive to optimizing teaching. Learners need to strengthen their technical consolidation and physical practice, Sanda fight class sports, in addition to the technical action, need speed, strength and reaction practice; these are fighting class projects engaged in the personnel need to have the quality. Only in this way can the role of technical action be to the best. Learners need to do is to use the mobile phone application, such as skipping rope every day (AR used in sports), it can consolidate technical action, but also can physically practice, compared with the traditional training mode is safe; fight sports engaged in personnel in training need to overcome practitioner's fear and fight in the face of the ring. Using intelligent technology can not only overcome the practitioner's fear, but also benefit the technical action. At the same time, the AR technology platform is also a technical means for students to complete their homework. This technology can give timely feedback to learners, so that instructors can better understand each learner's knowledge. After completing the exercises, the learners will submit the records to the learning pass so that the teacher can understand the students' daily after-class exercises, which is also the systematic basis for the assessment after the course.

Control Group

The control group adopted the traditional teaching mode and conducted the routine teaching steps in the beginning, preparation, foundation, and end part according to the teaching plan. With the instructors as the subject of teaching and training, and after four weeks of teaching and training to test.

3.2.3 Final Test Content of the Experiment

The final test is that the experimental and control groups test their fighting skills through actual combat according to the rules of the Sanda competition. Fighting should not only ensure the intensity of the confrontation, but also ensure the safety of learners, as far as possible to avoid injury. The score in fighting according to the rules of the technical system of Sanda: fist method, kick method and wrestling methods the entry point. The scoring standards of learners in fighting are as follows (General Administration of Sport of China of the People's Republic of China):

Degree	Excellent	Good	Middle	Poor
Scores	100—86	85—76	75—60	Less than 60 p
Standard	The technical use is correct, the timing is accurate, the tactical consciousness and strain ability are strong, the offensive and defensive conversion is timely, and the performance is courageous, respecting the opponent and obeying the referee.	The use of specialized techniques is more correct. The timing is more accurate, the tactical consciousness and resilience are strong, the offensive and defensive conversion is timely, the performance is brave on the spot, respects the opponent, and obeys the referee.	The technical use of the timely opportunity to grasp the average, the awareness of tactics is more prominent, the ability to change is average, and the offensive and defensive conversion is timelier.	The use of techniques is I the timing is in the consciousness a ability are po offense and conversion is no and the perform timid, disrespe opponent, or ob obeys the refere

Table2. Fighting Skills Score Table

3.2.4 Data Analysis

The data analysis method was ANCOVA. Analyze the data generated by the experimental combination control group during the pre-test and the post-test to determine whether game-based learning with AR teaching mode in the Sanda course significantly improves learners' fighting skills.

3.3 The Questionnaire of Learners' Satisfaction

The learners' satisfaction needs to be tested by the questionnaire, which can fully know the final effect of the new teaching mode and provide a basis for improving the teaching. The questionnaire belongs to Likert 5-level scale. The questionnaire was used for the learners' satisfaction survey. The 20 learners are from experimental group.

In order to enable the survey questionnaire to accurately reflect the satisfaction of the learner, the questionnaire of this survey was analyzed by the Communalities as follows

Table 3. Communalities

	Initial	Extraction
1.Your overall evaluation of your own Sanda course study?	1.000	.847
2. Is your fighting skills significantly improved compared to before?	1.000	.874
3.Is your physical fitness significantly improved compared to before?	1.000	.633
4.Through the combination of game-based learning with AR, whether your after-class physical exercise is more than before?	1.000	.799
1.Whether the arrangement of the games in the classroom teaching is targeted?	1.000	.865
2.How do you think the arrangement of game-based learning with AR compares with the situation you expect ?	1.000	.699
3.Learners'satisfaction with learning progress?	1.000	.807
4. Learners can overcome the fear in the fighting with opponents?	1.000	.864
5.Whether the homework assignment after class is helpful to improving fighting skills ?	1.000	.642
1.How are you generally satisfied with the classroom atmosphere?	1.000	.923
2.How do you feel about the instructors' teaching methods ?	1.000	.705
3.Whether the teaching facilities can meet our expectations?	1.000	.747
4.Whether the after-class exercise can be effectively connected with the class?	1.000	.719
5.Whether the homework after class is interesting ?	1.000	.877
6.Instructors and learners in each class can carry out effective feedback?	1.000	.582
Extraction Method: Principal Component Analysis.		

From the results in the above table, it can be seen that the common variance of these variables is greater than 0.5, and most of them are close to or exceed 0.8, so the questionnaire can reasonably reflect the satisfaction of learners.

4. Results

4.1 The Results of the Development of Game-Based Learning with AR in the Sanda Course Teaching Mode

We invited five experts in related fields to conduct professional evaluations on game-based learning with AR in the Sanda course teaching mode, and conducted a questionnaire survey on the evaluation of game-based learning with AR teaching mode. Here's what these experts have to say:

Li Jiangong, Beijing Sport University: "I think this AR-based game-based teaching mode is an innovative attempt, and this mode is likely to make students more motivated to learn. But I think the technical action game design needs to be improved, we need to think more deeply about the complexities of the actual operation."

Wang Kaiyin, Shanghai Institute of Physical Education: "I think the teaching plan is quite thoughtful and can meet the actual needs of students. However, the design of homework after class may bring pressure to students. I hope this can be improved."

Zhang Wei, Capital Institute of Physical Education: "I very much agree with the design of classroom warm-up games, which can effectively improve students' participation. But I think that when designing technical action games, individual differences of students need to be considered more."

Gao Shanghai, Zhejiang University: "I am generally satisfied with this AR-based game-based teaching mode, and I think it is a useful supplement to the traditional teaching mode. Especially the design of after-class assignments, clear structure for students' understanding It is very beneficial to consolidate knowledge." Zhang Sanfeng, Nanjing University: "AR games have done a very good job in designing physical fitness and combat skills, which I appreciate. However, I also want to emphasize that we should pay more attention to the actual feedback of students to ensure the effectiveness of the teaching model."

From the feedback of these experts, we can summarize several key observations and implications:

1. The innovation of the teaching mode: As a new teaching mode, almost all experts are optimistic about the potential of using the AR game-based teaching mode, which shows that this new teaching mode may indeed have the ability to attract and motivate students, and we can also Consider using this technology more broadly in future educational research and practice.

2. Challenges in the design of technical action games: Some experts pointed out that the design of technical action games needs to be further improved, and more consideration should be given to the complexity of actual operations and the individual differences of students. This reminds us that when designing teaching activities, we need to balance innovation and operability to ensure that all students can benefit from it.

3. Design of homework: Feedback on the design of homework suggests that we need to consider its impact on student stress and adjust the difficulty and burden of homework so that it reinforces knowledge without being overly taxing.

4. Address actual student feedback: Some experts have highlighted the consideration of actual student feedback as something we need to keep in mind when designing and implementing instructional models. We need to regularly collect and analyze student feedback in order to adjust teaching programs in time to maximize their effectiveness.

Our questionnaire designed seven questions, namely: The overall evaluation of the teaching model, The overall evaluation of teaching plan, Evaluation of warm -up games in the classroom, Evaluation of technical action game design, Overall evaluation of after class l homework design, Evaluation of AR games in terms of physical fitness design, Evaluation of AR games on fighting skills design. The descriptive statistics of the experts' answers to the questions raised in the questionnaire are as follows:

Table 4. The Result of Game-Based Learning with AR Teaching Model Evaluation

	N	Minimum	Maximum	Mean	SD
1.The overall evaluation of the teaching model	5	3.8	4.9	4.48	0.4207
The overall evaluation of teaching plan	5	3.9	4.8	4.46	0.3435
3.Evaluation of warm -up games in the classroom	5	3.7	4.9	4.56	0.4879
4.Evaluation of technical action game design	5	3.8	4.9	4.32	0.4147
5.Overall evaluation of after-class homework design	5	3.9	4.9	4.5	0.4301
6.Evaluation of AR games in terms of physical fitness design	5	4.3	4.9	4.58	0.2775
7.Evaluation of AR games on fighting skills design	5	3.6	4.9	4.54	0.5413

4.2 The Results of the Effect of Game-Based Learning with AR on Learners' Learning Effect

According to the characteristics of Sanda, to maintain the balance between fighting skills and security during the process of Sanda's teaching. Sanda is a sport with greater risks. In learning progress, the two need to fight. Through practice, it is more likely to be injured when there are too many people. To provide that the learners are trying to avoid injuries and maximum actual combat skills during the training process and to ensure a good classroom atmosphere. Therefore, the number of teaching people in the Sanda Course is about 20.20 learners in experiment group (Game-based learning with AR teaching mode) ;20 learners in control group (Traditional teaching mode).

In our study, we used the One-Sample Kolmogorov-Smirnov test to examine whether the four variables, namely "800-meter run", "stand-up triple jump", "whip the sandbag", and "average score", obeyed normal distribution. This test is a nonparametric test that is mainly used to assess whether the sample data follow a specific theoretical distribution, in this case a normal distribution.

Table 5. One-Sample Kolmogorov-Smirnov Test

		800-meter runniing	Standing triple jump	Whip kicking sandbags	The average score
N		40	40	40	40
Normal Parameters[a,b]	Mean	83.73	84.00	84.78	84.167
	Std. Deviation	4.867	4.718	4.382	2.5853
Most Extreme Differences	Absolute	.120	.105	.118	.127
	Positive	.120	.105	.090	.127
	Negative	-.116	-.100	-.118	-.087
Test Statistic		.120	.105	.118	.127
Asymp. Sig. (2-tailed)		.149[c]	.200[c,d]	.173[c]	.105[c]
a. Test distribution is Normal.					
b. Calculated from data.					
c. Lilliefors Significance Correction.					
d. This is a lower bound of the true significance.					

According to our results, the two-tailed P values for all four variables were greater than 0.05, 0.149, 0.200, 0.173, 0.105, respectively. This shows that we do not have enough evidence to reject the null hypothesis that the data follow a normal distribution. In statistics, if the P-value is greater than our chosen significance level (usually 0.05), then we accept the null hypothesis, that is, our data are statistically considered to follow a normal distribution.

We played a game between the experimental group (the group that adopted the AR new teaching mode) and the control group (the group that adopted the traditional teaching mode). The winning and losing results of the competition and the scoring results are as follows:

Table 6. The Results of Learners' Fighting Skills

Group	Round 1	Round 2	Round 3	Winner	Winner	Loser
		Experiment g			Scores	
		Control group				
1	E	E		E	89	82
2	C	E	E	E	90	81
3	E	C	C	C	89	85
4	E	C	E	E	91	83
5	E	E		E	88	81
6	C	E	C	C	87	83
7	E	E		E	90	84
8	E	C	E	E	87	81
9	C	E	E	E	90	83

10	E	C	E	E	88	80
11	E	E		E	87	81
12	C	E	C	C	88	84
13	C	E	E	E	87	82
14	E	E		E	88	84
15	C	C		C	87	81
16	E	C	C	C	86	83
17	C	E	E	E	93	82
18	C	E	C	C	84	81
19	E	E		E	88	83
20	E	C	E	E	87	82

In our study, we conducted a post-test examination of Sanda fighting skills. The students who participated in the test came from the experimental group and the control group, and they fought in actual combat according to the rules of the Sanda competition. To ensure the accuracy and reliability of our analytical results, we performed normality tests and tests for heteroscedasticity and collinearity on the data. All of these steps are designed to keep our analysis results free from potential data issues.

After the above preprocessing work, the analysis of covariance (ANCOVA) method was used to analyze the data. The results show that the F value is 13.979, and the corresponding Sig. (i.e., P value) is .001, which is much smaller than the general significance level of 0.05. This means that we can reject the null hypothesis (i.e., the scores between the experimental and control groups are not significantly different) and accept the alternative hypothesis (i.e., the scores between the experimental and control groups are significantly different). That is to say, the performance of the group that adopted game-based learning with AR is significantly better than that of the traditional teaching mode. This result is within our expected range and consistent with our hypothesis.

Table 7. Tests of Between-Subjects Effects

Dependent Variable: Score

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	122.500[a]	1	122.500	13.979	.001	.269
Intercept	290702.500	1	290702.500	33173.258	.000	.999
Group	122.500	1	122.500	13.979	.001	.269
Error	333.000	38	8.763			
Total	291158.000	40				
Corrected Total	455.500	39				

a. R Squared = .269 (Adjusted R Squared = .250)

4.3 The Results of Earners' Satisfaction with Game-Based Learning with AR Teaching Mode in The Sanda Course

Learners' satisfaction is an important indicator of evaluation of game-based learning with AR Learners' evaluation of teaching models can effectively test the teaching effects of game-based learning and AR teaching models. At the same time, the survey of learners' satisfaction is conducive to improving game learning with AR teaching model in Sanda course. Based on the research objectives, the researchers conducted a satisfaction survey of 20 learners in the experimental group.

4.3.1 Learners' Self-Evaluation

The self-evaluation of learners is the subjective understanding of the learners' learning effect, and the self-evaluation of the learner is the first step in the satisfaction survey of satisfaction.

Table 8. Learners' Self-Evaluation

Questions	Mean	SD	Meaning
1. Your overall evaluation of your own Sanda course study?	4.5	0.3	Very Satisfied
2. Is your fighting skills significantly improved compared to before?	4.6	0.3	Very Satisfied
3.Is your physical fitness significantly improved compared to before?	4.7	0.4	Very Satisfied
4.Through the combination of game-based learning with AR, whether your after-class physical exercise is more than before?	4.7	0.3	Very Satisfied
Total	4.6	0.3	Very Satisfied

The overall evaluation of the learner's self-evaluation from the entire learning process, whether the fighting skills have been significantly improved, whether the physical fitness improves, and whether they are more willing to exercise after-class physical exercise to self-evaluate the learning effect. The results are as follows: 20 learners in the experimental group through self-evaluation from game-based learning with AR teaching model through questionnaires (5 points), with a maximum value of 4.7 points and a minimum value of 4.5 points. It can be seen from the table that the overall average is 4.6 and SD = 0.3. Therefore, learners are very satisfied with their self -evaluation.

4.3.2 Learners' Satisfaction with Learning Process
The satisfaction of the learning process is an important part of the learner's learning evaluation of game-based learning with AR teaching model. According to learners' evaluation of the satisfaction of the learning process, we can learn more about the teaching mode from the details.

Table 9. Learners' Satisfaction with Learning Process

Questions	Mean	SD	Meaning
1.Whether the arrangement of the games in the classroom teaching is targeted?	4.5	0.4	Very Satisfied
2. How do you think the arrangement of game-based learning with AR compares with the situation you expect？	4.5	0.4	Very Satisfied
3.Learners'satisfaction with learning progress?	4.6	0.3	Very Satisfied
4. Learners can overcome the fear in the fighting with opponents?	4.6	0.3	Very Satisfied
5.Whether the homework assignment after class is helpful to improving fighting skills？	4.7	0.3	Very Satisfied
Total	4.6	0.3	Very Satisfied

The satisfaction of the learner's satisfaction of the learning process is the learner's evaluation of details: including the combination of the game with the teaching content, whether the design of the teaching meets the expectations of the learner, the overall evaluation of the learning process, and when fighting with the opponent can it overcome the fear of fear and whether the AR game used in physical exercise after class can help improve the fighting skills. The evaluation results are as follows:

Satisfaction with learning progress of game-based learning with AR teaching model in Sanda course evaluated by 20 learners from experiment group through questionnaire (5-point Likert scale), in which the maximum score was 4.7 and the maximum score was 4.5. As can be seen in the table the overall mean was 4.6 and SD=0.3. Therefore, learners are very satisfied with their learning progress.

4.3.3 Learners' Satisfaction of Learning Environment
Learners' satisfaction with the instructor's teaching methods, satisfaction with the atmosphere of the classroom, and whether the game is targeted, the effective connection of after-class exercise with the classroom teaching is an important manifestation of learners' satisfaction with learning environment.

Table 10. Learners' Satisfaction with Learning Environment

Questions	Mean	SD	Meaning
1.How are you generally satisfied with the classroom atmosphere?	4.6	0.3	Very Satisfied
2.How do you feel about the instructors' teaching methods？	4.7	0.3	Very Satisfied
3.Whether the teaching facilities can meet our expectations?	4.7	0.2	Very Satisfied
4.Whether the after-class exercise can be effectively connected with the class?	4.6	0.3	Very Satisfied
5.Whether the homework after class is interesting？	4.6	0.3	Very Satisfied
6.Instructors and learners in each class can carry out effective feedback?	4.5	0.3	Very Satisfied
Total	4.6	0.3	Very Satisfied

The overall evaluation of the satisfaction of the learning environment of the learning environment. The overall evaluation of the operating effect of the teaching mode. The satisfaction of the learner's satisfaction of the learning environment includes the use of teachers' teaching methods, the overall classroom atmosphere, and whether the game is combined with the teaching content, which also includes the class, which also includes the class, which also includes the lesson, which also includes the lesson, which also includes the lesson, which also includes the lesson, which also includes the lesson. Whether the AR games used in physical exercise can be fused like teaching content. The research results are as follows:

Satisfaction with learning environment of game-based learning with AR teaching mode in Sanda course evaluated by 20 learners from experiment group through questionnaire (5-point Likert scale), in which the maximum score was 4.7 and the miximum socre was 4.5. As can be seen in the table the overall mean was 4.6 and SD=0.3. Therefore, learners are very satisfied with their learning environment. Although learners' satisfaction scores are high, the teaching model still needs to be continuously strengthened, especially the feedback of teachers and learners still needs to be continuously strengthened.

5. Discussion

Augmented reality games can indeed bring a good experience to learners. This conclusion supports recent research, that is, game -based learning can improve learning results (Chen et al., 2022; Yu et al., 2022). This article studies its effectiveness in Sanda training. The research results show that adding AR games in Sanda Teaching can allow learners to have an immersive experience, ensure the safety of learners during the movement of the learner, and improve the skills of learners.

In Sanda teaching, game -based learning has a positive impact on learners. Learners can get a good experience in the learning process (Lee & Witchel, 2022; Zhi & Wu, 2023), which supports this conclusion. This study emphasizes the importance of game learning to improve the learning effect of learners. This knowledge can help the creation and deployment of Sanda teaching plans to promote the teaching method of game -based learning to better serve for learners. Compared with the traditional teaching model, game-based learning with AR teaching model and traditional teaching model on the learning effect of learners, there are significant differences (Van der Graaf et al., 2022; Wei, Saab & Admiraal, 2023). In this study, learners' fighting skills of the experimental group learners are significantly better than the learners' fighting skills of the control group. The researcher believe that the experiment group won in fighting, and the score was significantly higher than the control group because the experiment group incorporated the game elements during the learning process (Bang et al., 2023). In addition to the game in classroom teaching, the AR games used in after-class exercise can be able to let the learners have an immersive experience (Scholz et al., 2021). They are improving in fighting skills without injury. Learners will gradually overcome their inner fear when fighting. After the inner fear is overcome, the learner will maximize the fighting skills when fighting. Future research may further study how to upgrade the game-based teaching mode and how to better improve learners' learning effect.

Based on game-based learning, learners' satisfaction has influenced each other (Lee, Shim & Kim, 2022; Wang et al., 2022). It promotes each other game-based learning can improve learners' satisfaction, and learners' satisfaction can promote the improvement of game-based learning teaching models. Studies have shown that when the game-based learning and the satisfaction of learners' satisfaction, a virtuous circle is formed, and the game-based learning teaching model in Sanda teaching is successful.

In summary, this study provides empirical evidence for the learning effect of learning to improve the learning effect of learners in Sanda teaching. The results of the study confirmed the theoretical foundation and past

research in the field, and emphasized that game-based learning can promote learners to have a good learning effect. The learner's own efforts are also critical. This requires teachers to think about how to mobilize learners' learning enthusiasm when organizing teaching.

Future research should explore how the gameplay learning that may affect the teaching of Sanda is further integrated with the teaching content.

6. Conclusion

This study explores the effectiveness of game learning in Sanda teaching. Through comparison with traditional teaching models, the research results show that game -based learning has significantly improved the learning effect of learners. The teaching method based on game learning are significantly better than traditional teaching method.

This study first shows that game-based learning with AR teaching model has improved the fighting skills of learners in Sanda Teaching. Game based learning with AR also gives learners a higher satisfaction. This shows that game-based learning with AR is a good teaching method that needs to be continuously upgraded while promoting.

The learning effect of game -based learning is that in addition to the learners 'own efforts, teachers' teaching skills also play a key role. The results of the study show that in the process of organizing teaching, teachers ensure the fun of the game, allowing learners to continue to be full of motivation through learning and make learners' willingness to learn more.

The results of this study show that game -based learning with AR is a teaching method that can improve the satisfaction of learners. Moreover, it has been found that game-based learning with AR can improve the satisfaction of learners, and at the same time, the satisfaction of learners can continuously improve the learning model of game-based learning with AR teaching model.

Whereas, this study was limited by area and sample. Future research should replicate and extend these findings across other groups. Moreover, immersive augmented reality game-based learning was also studied in this study. Long-term research is needed to determine the effects' longevity.

In summary, game-based learning with AR teaching model can be optimized with the deepening of research. Based on our discovery, researchers may investigate the process behind the benefits observed and determine other variables that may improve mixed learning. This study has improved the teaching method of Sanda training, and may improve the learning effect of Sanda learners.

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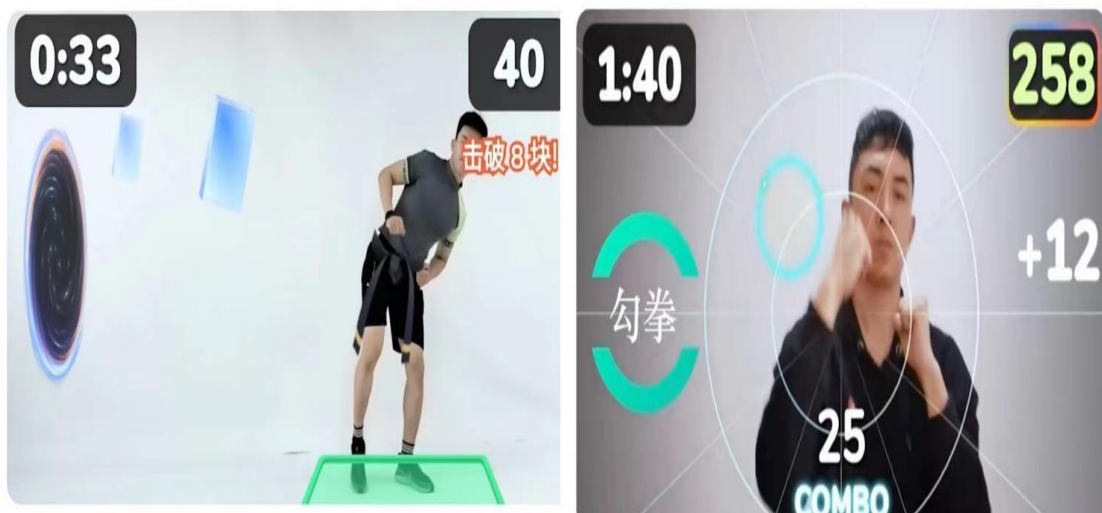
Appendix

Traditional teaching model in Sanda Course

Sports games in Sanda course

AR Games in Sanda Course