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# Screen-based Simulation Supporting Problem-based Learning to Improve Football Tactics

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**Abstract:**

***Introduction:*** This study measured the effect of Problem-Based Learning (PBL) with Screen-Based Simulation (SBS) on undergraduate football tactical decision-making, tactical skills, and student engagement. The Screen-Based Simulation showed tactical scenarios in real games to learners, promoting the identification and analysis of tactical problems in learning. Problem-Based Learning enabled learners to get a deeper understanding of the tactical problems and discuss them effectively.

***Materials and Methods:*** Two simulation tools were used in this study. The first one, 'football match basic offensive and defensive tactical simulation experiment platform,' is scaffolding in football tactics teaching. Students could use the simulation platform to find tactical problems and learn tactics. The second one, TacticUP, is a screen-based simulation tool to test football tactical decision-making. We used second-year students majoring in physical education at a Chinese university. Seventy-nine students were divided into an experimental group using PBL-SBS and a group taught traditionally. Before the experiment, the tactical decision-making of both groups was assessed in a pretest, and at the end of the six-week experiment, the students were tested again. They also completed a questionnaire on tactical skills and student engagement.

***Results:*** There was no significant difference between the pretest scores on tactical decision-making between the two groups (independent-sample t-test, sig = 0.997 > 0.05). However, after the experiment, significantly better improvement was observed in tactical decision-making in the experimental group. The pretest mean score (59) was significantly lower than the post-test one (67) on a scale of 100 (paired sample t-test, sig <0.01). ANOVA showed that the experimental group performed better in all aspects, namely tactical decision-making, tactical skill, and student engagement, than the traditional group (Sig values were all less than 0.01).

***Conclusion:*** Compared with traditional teaching, PPL-SBS students performed better in tactical decision-making, tactical skills, and student engagement than students in the traditional teaching group.

**Keywords:** Problem-based learning, Screen-based simulation, Student engagement, Decision-making, Tactical skills, Football tactics.



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## 1. INTRODUCTION

Football is a widely played sport globally. The 2019 report from the Fédération Internationale de Football Association (FIFA), which included data from 187 nations, counted more than 128,000 professional football players

globally. There is an abundance of football enthusiasts, and diverse football tournaments appeal to individuals of all ages and backgrounds. Football research covers several aspects, such as training, competitiveness, physical conditioning, technical and strategic analysis, injury prevention, and recuperation, leading to a growing body of research on instruction and training. Tactics is a branch that needs further study, since technology can now provide better views supporting a better understanding of the implications of players' actions. Given the complexity of team sports performance, understanding a team's tactical behavior and interactions (*i.e.*, player positioning and passing) is critical to understanding individual game activity requirements [1].

Football players must consistently make rapid judgements depending on the locations and motions of their teammates and opponents. These judgements are a crucial skill, referred to as decision-making or tactical behavior. Coaches aim to assess the tactical behavior of young players by providing them with information *via* suggestions, corrections, and feedback. For coaches, this is considered a crucial aspect of their technical capabilities [2]. Tactical behavior in a game involves the player making decisions and solving problems that arise [3]. It includes interaction with an opponent, where each player tries to overcome the actions of the opponent, with the aim of reaching partial goals, such as gaining space or making a pass on a well-positioned teammate [4-7]. Intervention training programs have been used to cultivate automatic links between stimuli and responses, hence enhancing decision-making abilities [8]. Gabbett *et al*. (2008) reported that intervention programs that adopted video training are beneficial in enhancing decision-making [9]. Football academies in Europe and other regions place an emphasis on decision training to improve the tactical skills and problem-solving abilities of players [10].

Problem-Based Learning (PBL) is an instructional approach that fosters the acquisition of knowledge, competencies, and proficiency by engaging in collaborative inquiry and solving real-life, complex problems. This method involves defining problems, working in teams, communicating effectively, gathering data, making decisions, planning, setting goals, actively performing tasks, and reflecting on the outcomes [11]. PBL fulfils the varied requirements of players on a team by integrating a broad spectrum of instructional methods in a distinctive inquiry- and context-oriented approach to team and individual development [12].

The use of simulations for instructing essential strategies has emerged recently due to advances in technology. The simulation converts genuine competition situations into virtual tactical scenarios, allowing the virtual environment to be connected to the real world. Through the computer system, students may study and implement fundamental attack and defense strategies [13]. The system will exhibit tactical actions selected by students in the competitive scenario and provide an impartial assessment grounded on scene identification, decision-making speed, and the logic of action [13]. Jia *et al*. (2024) identified three types of tools for applying simulation techniques to football training. These tools include head-mounted displays, cave automatic virtual environments, and screen-based simulation, which are effective in training both football skills (including goalkeeping, heading, *etc*.) and football tactical skills (including perception and decision-making) and can be used as a supplement to regular training [14].

In traditional sports instruction, instructors often provide examples and explanations while students passively follow their guidance. Over time, students experience a decline in interest and engagement in physical education, making it difficult to foster their enthusiasm and involvement. Xie (2021) noted that the absence of enthusiasm for physical education led to a natural disinterest and lack of enjoyment in physical activity, resulting in an inability to actively engage in physical exercise [15]. In traditional football teaching, tactical teaching often emphasizes theoretical knowledge and tactical drills. Due to the low basic skills of students, it becomes challenging for them to control or play well in matches. Additionally, it is also difficult for them to have the energy to pay attention to tactical decision-making, and thus difficult to test their tactical ability.

In physical education, learning football tactics is still a challenging task. Traditional teaching methods often rely on oral instruction and live presentations, which may not always provide an immersive interactive learning experience. As technology advanced, screen-based simulation emerged as a potential tool to enhance the learning process. However, the significance of integrating screen-based simulation with problem-based learning (PBL) in teaching tactics remains questionable. Hence, this study aimed to investigate its effectiveness. It was found that it developed a teaching strategy that enabled students to experience real-match situations in the classroom using a screen-based simulation to present tactical problems. Students could use the simulation platform to find the tactical problems in real matches and solve them with PBL strategies; PBL was used to encourage students to think about tactical problems in groups, propose solutions, and demonstrate the solutions in the form of drills or games.

The research questions were:

1 Has student tactical decision-making improved after using the model?

2. Is the new model more effective in improving tactical decision-making, tactical skills, and learning engagement than traditional teaching?

## 2. LITERATURE REVIEW

### 2.1. Simulation Technology in Sports

Video simulation has been extensively studied for its efficacy for some years [16, 17]. During typical tests, participants were exposed to video clips of high-level games, which were shown on a computer TV screen or projected on a wall. They were then instructed to engage

themselves mentally in the action. The experimenter intermittently paused or obscured the video and asked participants to indicate the action they would take if they were engaged in the activity [16]. Through repeated practice and receiving constructive criticism, participants often enhanced their skills and acquired the ability to choose the most effective behaviors in controlled experimental settings [18, 19]. Tsai (2018) used virtual reality (VR) as a personal basketball coach for technique training in a highly immersive engagement system that could enhance the efficacy of the training [20].

Fortes *et al*. (2021) investigated the impact of seeing brief first-person movies showcasing two different attacking strategies in football, either *via* VR or on a conventional television screen [21]. The subjects were 15-year-old players participating at the national level. They were randomly allocated to two groups, one using VR and the other using video screens only, in an eight-week intervention. The VR group exhibited more significant enhancements in decisions to pass and visual search behavior compared to the video screen group. This suggested that using VR to develop perceptual-cognitive abilities in young players was more successful than video screen-based training methods.

### 2.2. Decision-Making and Tactical Skills

Success in team sports relies on the ability of each member to make effective judgments using two types of skills: perceptual-cognitive skills and perceptual motor skills. Both of these abilities play a role in the development of expertise [22]. A perceptual-cognitive talent involves the capacity to receive and comprehend information, whereas a perceptual motor skill is the ability to perceive and accomplish tasks *via* physical movement. Within this framework, decision-making may be described as an action choice. This is the result of an observable motor or verbal response [23].

Tactical skills depend on several cognitive abilities, such as understanding the game and its objectives and actions, being aware of monitoring skills, and comprehending actions within the game context [24]. Cognitive abilities are often divided into declarative and procedural knowledge [25, 26]. Declarative knowledge relates to understanding the game rules and objectives or essentially knowing what actions to take next [27]. Procedural knowledge refers to the ability to choose the right course of action in specific circumstances, essentially the process of “doing it” [27]. Sport is distinctive in that tactical abilities include not only the capacity to discern the most suitable option in a particular scenario but also to assess whether this decision can be effectively carried out within an athlete’s capabilities for the necessary physical movement. The limits that the athlete faces are both physiological and technological, and they restrict the range of tactical choices open to them [28].

### 2.3. Student Engagement

Student engagement refers to the interaction between a student and the school’s investment of time, energy, and other relevant resources aimed at optimizing the student experience, improving learning outcomes and development, as well as the school's performance and reputation [29].

The integration of behavior, emotion, and cognition within the framework of engagement is advantageous, as it allows for a more comprehensive understanding of players beyond the limitations of studying individual components in isolation. By independently defining and studying the components of engagement, we can separate behavior, emotion, and cognition. These components are intricately interconnected rather than being separate processes. Comprehensive studies focus on each component individually, but recognizing engagement as a complex concept suggests that we should investigate the factors that influence and result from behavior, emotion, and cognition at the same time and in a dynamic manner in order to determine if there are cumulative or interactive effects [30].

According to Fredricks *et al*. (2004), three aspects of student engagement may be identified:

1) Behaviorally engaged students usually follow norms of behavior, such as attendance and participation, and do not exhibit destructive or negative behaviors.

2) Emotionally engaged students experience emotional responses, such as interest, enjoyment, or belonging.

3) Cognitively engaged students engage in learning, seek to go above and beyond, and enjoy challenges.

### 2.4. Theoretical Framework

#### *2.4.1. Constructivist Learning Environments*

Constructivist Learning Environments (CLEs) are commonly characterized as technology-based settings in which students explore, experiment, create, converse, and reflect on what they are doing [31]. Compared to traditional teacher-centered instructional environments, CLEs offer various advantages, including being more student-centered, collaborative, engaging, and reflective [31, 32]. These benefits, however, do not occur naturally unless the learning settings are carefully constructed. A CLE's pedagogical design should promote student knowledge construction and achievement of learning objectives. Constructivist learning theories suggest that learners actively construct knowledge based on prior experience rather than receiving it directly from the teacher; that is, they actively develop knowledge based on personal experiences and new information rather than passively receiving information [33, 34]. According to Perkins (1993), knowledge production involves remembering and reconstructing external reality through individual engagement with the content [35].

In our research, a football tactical learning environment was constructed through a screen-based simulation platform. It was designed to help players improve tactical decision-making abilities. In trials, the system played a real scene back into the virtual scene and gave the students a good perspective for scene recognition

and decision-making. It used an authentic scene, improved the efficiency of teaching and learning, and optimized the traditional teaching practice by supplementing it. In the simulation, the match scenario changed rapidly, and students had to make decisions in an instant. Through the simulation, we presented instantaneous competition scenes to students more clearly and accurately, which better helped identify competition scenes.

### 2.4.2. Problem-based Learning

Hidi and Renninger (2006) proposed a situational interest hypothesis underlying PBL, which stated that problems or puzzles create a desire to determine more about the topic, which leads to increased concentration, focused attention, and willingness to learn [36]. Problems are used to stimulate learning. Students work through the problem and determine what they already know and what they should know to solve it. Through this active and reflective thinking, students become responsible for their learning. By applying their knowledge to the problem, students test and integrate what they learn. In general, PBL motivates students to participate in the learning process and fosters problem-solving skills [37].

Finkle and Torp (1995) defined problem-based learning as "a curriculum development and instructional system that simultaneously developed both problem-solving strategies and disciplinary knowledge bases and skills by placing students in the active role of problem-solvers confronted with an ill-structured problem that mirrored real-world problems" [38]. The "Seven Step" approach or the "Seven Jumps" was designed at the Maastricht University [39, 40], which is a commonly used model for the "PBL as a mental model construction" view.

The "real situation" in a constructivist learning environment promotes problems in PBL. The key part of PBL is the design of questions, and the constructivist learning environment provides theoretical and technical support for the PBL questions. In this study, the screen-based simulation platform was the learning environment for constructing football tactics, and it promoted student understanding of tactical problems.

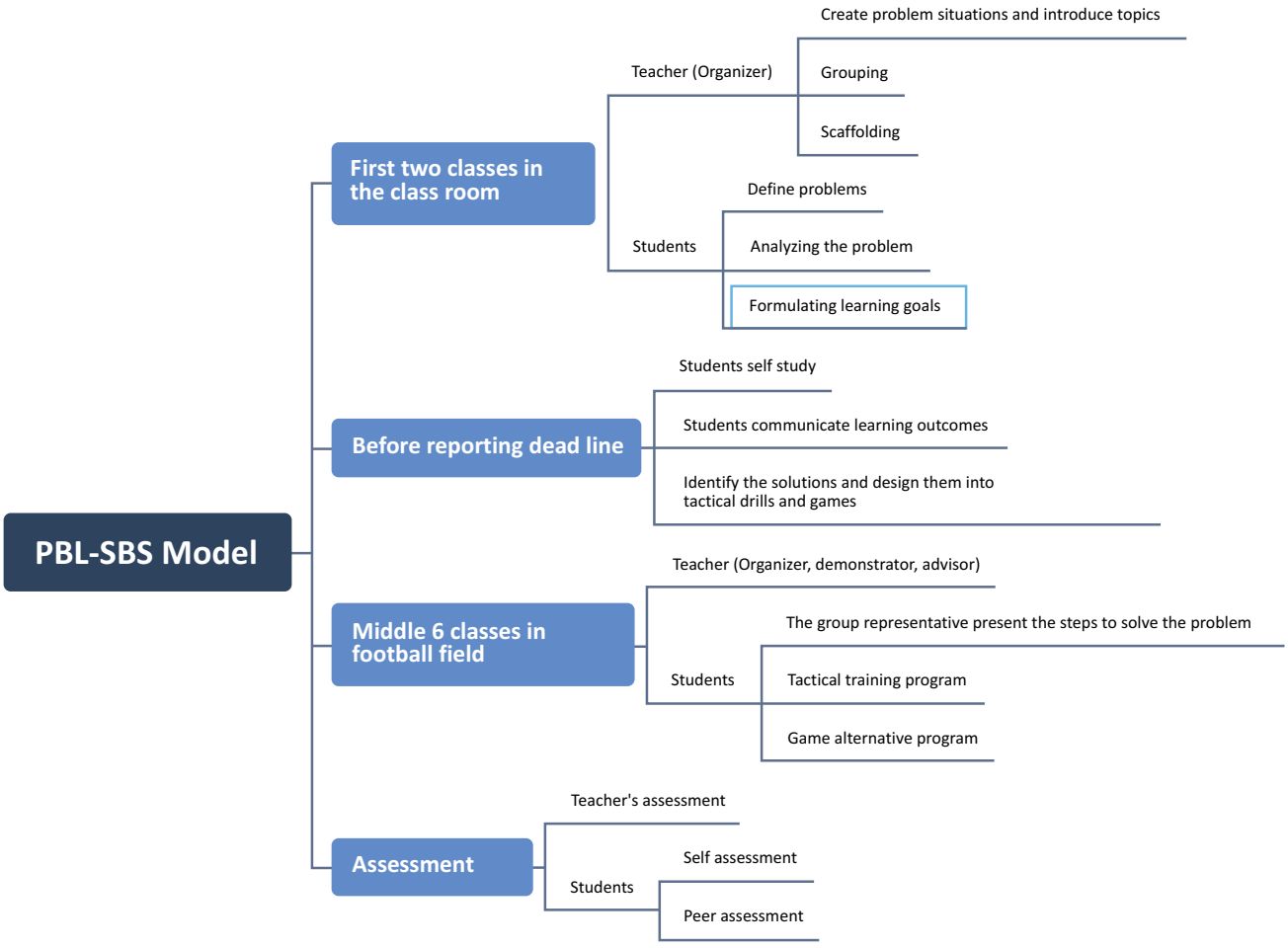


**Fig. (1).** PBL-SBS model.


**Fig. (2).** Student activities of PBL-SBS group.

## 3. DEVELOPMENT OF PROBLEM-BASED LEARNING WITH SCREEN-BASED SIMULATION INSTRUCTIONAL MODEL

PBL-oriented physical education differs from traditional teaching methods and emphasizes the relevance of active participation and exploration instead of classroom lecturing and practice. Therefore, the objective of the PBL method is not only to learn but also to acquire skills that enable students to take control of their learning [41].

The definition of problems in PBL is an important part. The Screen-Based Simulation (SBS) platform is used to present the tactical problem, and simulation can provide users with a better perspective and a virtual but realistic environment, so they have more energy and time to think about the problems in games. Guided by constructivist learning environments and PBL learning characteristics, we believed that PBL with SBS is an effective way to promote deep learning of tactics, so we combined them to build a new teaching model, “PBL-SBS”, as shown in Fig. (**1**).

Several important activities of PBL-SBS group students are shown in Fig. (**2**).

(1) Before the experiment began, students took a tactical decision-making test through Tactic UP software. The purpose of the test was to understand the student's tactical decision-making performance before the experiment.

(2) The football tactics simulation teaching platform was used as the scaffolding [42] to promote students' better understanding of football tactics. Students were first guided and stimulated by specific problem situations. This process was realized through screen-based simulation, teacher guidance, and group communication to promote student understanding and definition of problems.

(3) The group then brainstormed to discuss and analyze the problem and make learning goals and task plans. Then, after class, they solved the problems through self-study or cooperation among group members.

(4) At the appointed time, the group outcomes in the football field class were reported and discussed. A solution was proposed to design a tactical football game and lead all students to practice together to solve the corresponding tactical problems.

**Table 1. Participant demographics.**

| Group | N | Gender | | Nationality | Age (years) | | |
|---|---|---|---|---|---|---|---|
| | | M | F | | 19 | 20 | 21 |
| TG | 39 | 32 | 7 | Chinese | 29 | 9 | 1 |
| EG | 40 | 32 | 8 | Chinese | 30 | 8 | 2 |
| Total | 79 | 64 | 15 | - | 59 | 17 | 3 |

**Note:** TG = Traditionally taught Group; EG = Experimental Group.

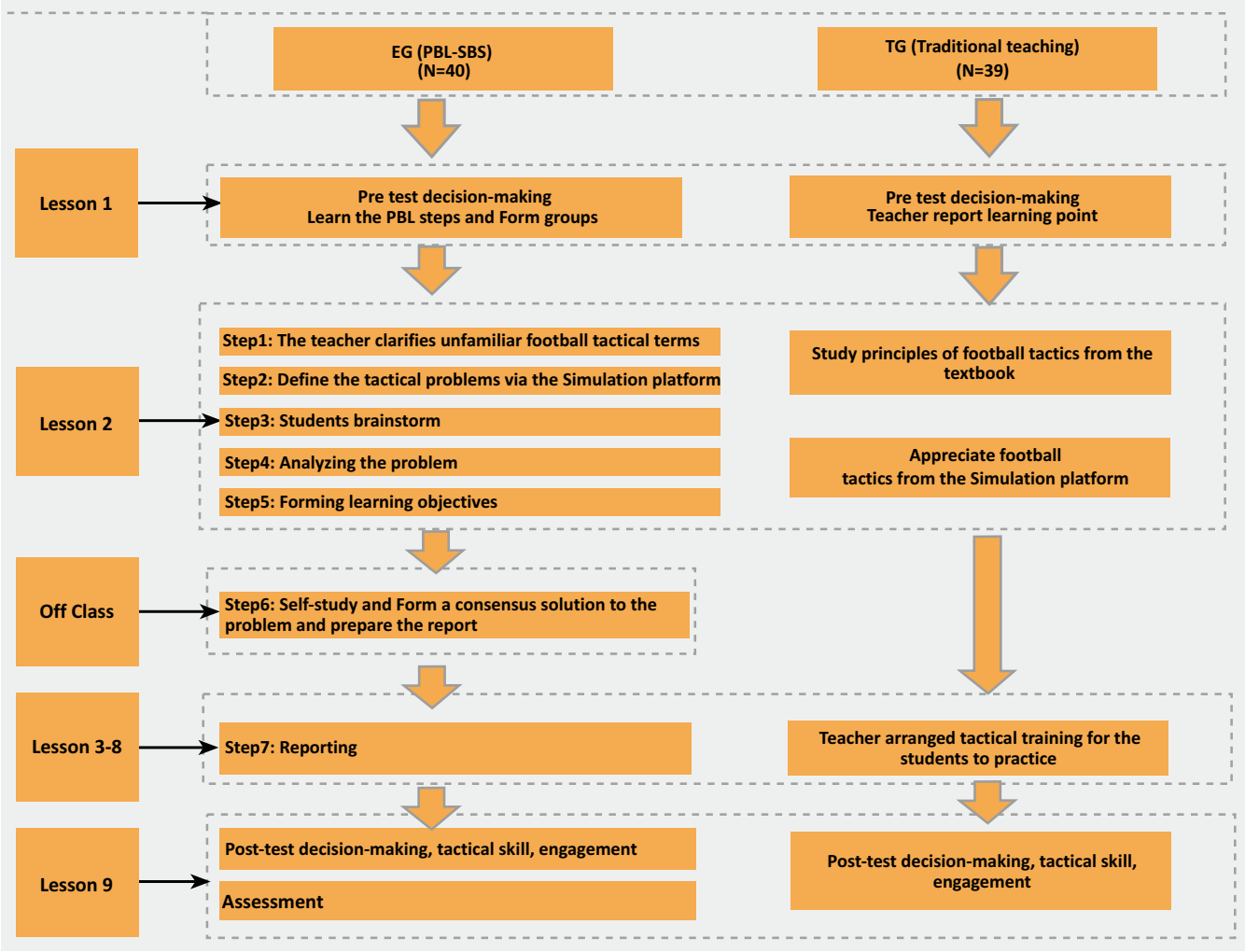


**Fig. (3).** Teaching process.

## 4. METHODOLOGY

### 4.1. Participants

The population was comprised of physical education grade two students in the Physical Education Department of Luliang University (Table 1). There were four classes, with nearly 40 students in each class; two classes were randomly selected for the study.

From the perspective of teaching content and methods, football tactical teaching mainly focuses on elements such as tactical ideas, teamwork and players' sense of position, which are not affected by gender. Both male and female players need to understand and master basic tactical knowledge. Therefore, in the design of the teaching

content, we can ensure that male and female players receive the same teaching information. At the same time, the teaching method can also be flexibly adjusted to adapt to the learning characteristics and needs of different gender players to ensure the consistency of teaching effects.

### 4.2. Teaching Arrangement

The experimental group (EG) used PBL-SBS teaching, whereas the traditional group (TG) used a traditional teaching style. To ensure the experiment's accuracy, students in both groups devoted a comparable amount of time to studying and covering relevant subject matter, and both groups were guided by the same teacher. The experiment lasted for six weeks, and there were nine lessons in total. The first two lessons were indoor theory lessons, followed by a pretest, and lesson 9 involved the post-test and questionnaire. Lessons 3-8 were tactics, learning, and practices. The experimental group used PBL teaching steps from step 1 to step 7. The teaching steps are set out in Fig. (**3**).

### 4.3. Developing Research Instruments

#### *4.3.1. TacticUP*

TacticUP is a screen-based simulation tool to test decision-making, and it allows players to test their decision-making skills. The validity and reliability of the TacticUP test were discussed [43]. Fig. (**4**) shows a typical screenshot and explains what is presented to the user. The game positions and a status window are also shown.

Each scene is extracted from a real game; before each scene begins, the system will remind you of the position of the player and the ball you are about to observe. Then, it shows a short clip of a real game and stops on a static scene, in which possible actions or movements are presented by the black arrows near the player and in the captions below each sub-image; the user is asked to quickly select the best action from the four actions in the sub-images and click on the selection. In this scene, the sub-images show (a) move up, (b) hold the same position, (c) move left, and (d) move right. Then, the screen moves to the next scene, sometimes an offensive scenario, sometimes a defensive scenario. The user must make reasonable tactical decisions as soon as possible.

The tests were run on the TacticUP platform using an internet-enabled laptop. It took about 20 minutes per player in a quiet room; the platform automatically calculated both decision-making quality and decision-making time and outputted a final score [44]. In Fig. (**5**), the general score is an average of the offensive and defensive scores; the scores measure the quality of the decision, which are expressed as a percentage of accuracy. The decision time (seconds) is calculated between the time the player has completed viewing the scene and choosing to react to it [44].

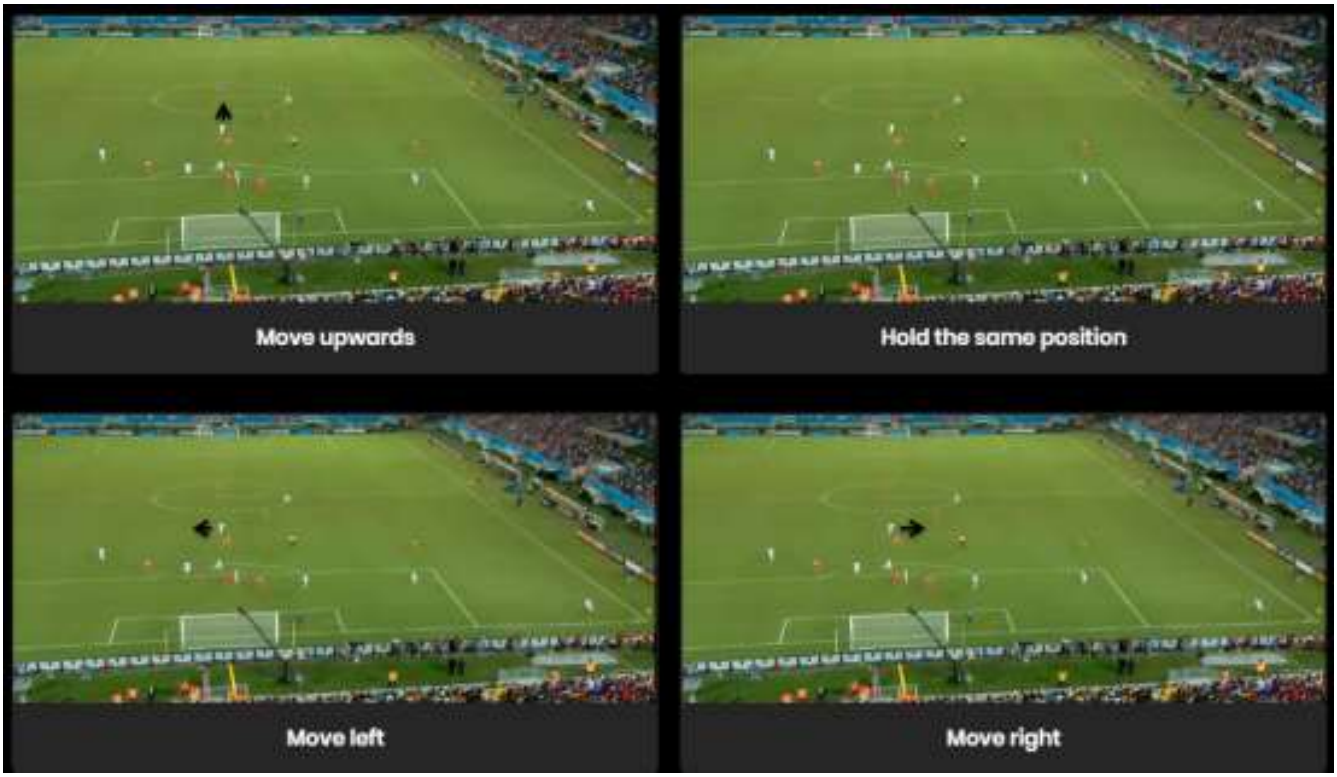


**Fig. (4).** TacticUP platform, taken from https://player.tacticup.com.br/#/dashboard [43].

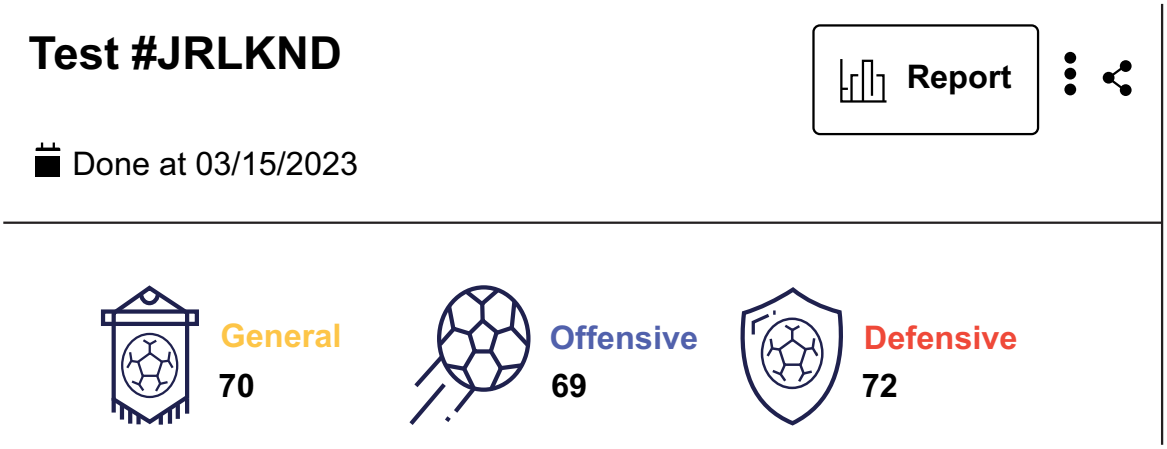


**Fig. (5).** Test score.

### *4.3.2. TACSIS*

The Tactical Skills Inventory for Sports (TACSIS) is a commonly used tool for measuring tactical skills in football and other team sports. Tactical skill refers to the ability of a single player to perform the right action at the right moment. Constructed with the help of expert coaches [45], athlete tactical skills were evaluated using the scales of declarative and procedural knowledge. In rating their performance, the players were asked to compare themselves to top players in their age group and rate the items on a five-point Likert scale, from "very poor" to "excellent" or from "almost never" to "always." The actual items are listed in Appendix A. The questionnaire aimed to understand how students rate themselves in tactical behavior. This will help us better understand the problems in the understanding of students, especially weak links in tactical behavior. It will also assist in improving future teaching design.

The questionnaire was taken from Elferink *et al*. (2004). However, we adapted it to assess students' cognitive behavior in tactics. There are four subscales: knowing ball actions, understanding others, positioning, and deciding and responding to changing situations. In order to verify the reliability of the questionnaire, a pilot test used 40 students. Table **2** presents the estimated reliability for each aspect of the questionnaire as well as the overall reliability. In all cases, Cronbach's alpha > 0.7 indicated a high level of internal consistency with good reliability.

As mentioned in Table **2**, Cronbach's alpha of the overall tactical skills and engagement was higher than that of each subdimension, reflecting the high internal consistency for each dimension.

### *4.3.3. Student Engagement Questionnaire*

Student engagement is an important index to measure learning, interest, and participation. From it, teachers can find students' interest in tactics to better guide and stimulate their interest in learning. PBL was found to be an effective way to improve classroom participation [46]. All teachers should strive to engage students on a higher and more complex level in all classrooms [47].

We designed a Student Engagement Questionnaire adapted from Gunuc and Kuzu (2015) [48] (Appendix B). The purpose of this questionnaire was to improve teaching strategies, stimulate student interest in learning, and promote teacher reflection and self-improvement. It has three subscales: behavioral, emotional, and cognitive engagement. Behaviorally engaged students usually follow norms of behavior, such as attendance and participation, and do not exhibit destructive or negative behaviors. Emotionally engaged students experience emotional responses, such as interest, enjoyment, or belonging. Cognitively engaged students engage in learning, seek to go above and beyond, and enjoy challenges. As with the Tactical Skills Inventory questionnaire, we computed the individual and overall aspects and found Cronbach's alpha > 0.7, which indicated a high level of internal consistency and good reliability (Table **2**).

**Table 2. Tactical skills inventory for sports and engagement questionnaire reliability.**

| Aspect | α | Items |
|---|---|---|
| Knowing about ball actions | 0.805 | 4 |
| Knowing about others | 0.816 | 5 |
| Positioning and deciding | 0.812 | 9 |
| Acting in changing situations | 0.767 | 4 |
| **Overall Tactical Skills** | **0.818** | **22** |
| Behavioral engagement | 0.789 | 6 |
| Emotional engagement | 0.770 | 7 |

*(Table 2) contd.....*

| Aspect | α | Items |
|---|---|---|
| Cognitive engagement | 0.795 | 7 |
| **Overall Engagement** | **0.831** | **20** |

**Table 3. Teaching material for the PBL-SBS model.**

| - | PBL-SBS Model (EG) Learning Content | Traditional Teaching (TG) |
|---|---|---|
| Lesson 1 | Pre-test of tactical decision-making; guide students to understand tde PBL process and requirements. | Pre-test of tactical decision-making; teacher reports tactical theory |
| Lesson 2 | Define the tactical problems *via* the simulation platform. Group members analyze the problem and set learning goals. | Study principles of tactics from the textbook; appreciate tactics from the simulation platform |
| Lesson 3 | Solve the problem of individual offensive and defensive tactics | Individual tactics exercise |
| Lesson 4 | Solve the problem of small-group offensive and defensive tactics | Group tactics exercise |
| Lesson 5 | Solve the problem of overall offensive and defensive tactics | Team tactics exercise |
| Lesson 6 | Solve set-piece of offensive and defensive tactics | Set-piece tactics exercise |
| Lesson 7 | Solve problems with match formations and positions | Match formation and position exercise |
| Lesson 8 | Solve problems in matches as a coach | Match |
| Lesson 9 | Post-test of tactical decision-making; complete tactical skills and engagement questionnaire | Post-test of tactical decision-making and engagement questionnaire |

## 4.4. Instructional Materials

### *4.4.1. Teaching Content*

The new teaching design combined the widely used Chinese traditional football textbook *Ball Sport – Football* [49] with the PBL problem design [12] to organize the teaching content. The problem scenarios were carefully conceived, opening new avenues to important learning outcomes that align with the course goals [12]. The tactics chapter of our teaching content includes individual tactics, group tactics, team tactics, and set-piece tactics. Table **3** compares the teaching content of the new PBL-SBS Model and traditional teaching. The learning content of the EG group was designed and presented in the problem scenario.

### *4.4.2. Simulation-Assisted Teaching Platform Introduction*

This platform is named the 'Football Match Basic Offensive And Defensive Tactical Simulation Experiment Platform'. Real tactical problems in football matches were presented to promote the understanding of tactics and thinking skills. This platform is an expanded experimental teaching content developed by the Football Teaching and Research Office of Beijing Sport University in 2019 (https://www.ilab-x.com/details/page?id=5071&isView=true#1001).

Fig. (**6**) presents a real game scene taken from the teaching platform. The clip shows the red player controlling the ball. Here, he has many offensive options, such as dribbling or passing to any teammate, and we need to judge the player's next move.

Students should select one of the four actions in the sub-image and click on the selection. Actions in the sub-images from left to right are:

a) Long pass in the middle

b) Pass to the nearest teammate on the right

c) Dribble forward and

d) *Dribble back*.

Fig. (**7**) shows four different tactical options from the player's perspective, and this perspective is used to allow students to simulate the actual game and better identify the scene. In our PBL-SBS system, the most reasonable choice is decided through group discussion. According to the choice made, the platform will show different match expectations for that option. Then, the platform will show the best action, and the actual video of the match will be restored. Finally, this platform will summarize the teaching points to help students better understand the tactics.

**Table 4. Experiment design.**

| Group | Pre-test | Treatment | Post-test |
|---|---|---|---|
| EG | O1 | X | O3, O5, O7 |
| TG | O2 | - | O4, O6, O8 |

**Note:** X=Treatment.
O1: Pre-test of decision-making in EG.
O2: Pre-test of decision-making in TG.
O3: Post-test of decision-making in EG.
O4: Post-test of decision-making in TG.
O5: Tactical skills scale in EG.
O6: Tactical skills scale in TG.
O7: Student engagement scale value in EG.
O8: Student engagement scale value in TG.

**Table 5. Decision-making pre-test scores.**

| Group | n | $\bar{X}$± S | Levene's test | | t | df | Sig. |
|---|---|---|---|---|---|---|---|
| | | | F | Sig. | | | |
| TG | 39 | 59±6 | 0.982 | 0. 325 | 0.004 | 77 | 0.997 |
| EG | 40 | 59±7 | | | | | |

**Note:** $\bar{X}$ = mean; S = standard deviation.


**Fig. (6).** A game scene in the teaching platform.

**Fig. (7).** Different tactical choices for the foreground player.

### 4.5. Experiment Design

Table **4** presents the two groups' pre-test and post-test designs. The experiment lasted six weeks. The following data was collected.

As mentioned in Table **5**, the mean scores for the decision-making test in the pretest for both groups were 59, with standard deviations of 6 and 7. From Levene's test, the significance valuea =0.325>0.05; thus, the variances were homogeneous. There was no substantial disparity between the groups (Sig = 0.997 > 0.05); thus, we could assume that the two groups were equivalent.

## 5. RESULTS

### 5.1. Normality Test

Tests for normal distribution of results were run for all data sets. Since both groups included less than 50 students, Shapiro-Wilk was used to check normality in data distribution (Table **6**).

### 5.2. Decision-Making Scores: Experimental Group (EG) for Pre- and Post-Test

Table **7** presents the mean pre- and post-test scores for decision-making using a paired sample t-test. The pretest mean score (59) was significantly lower than the post-test one (67) on a scale of 100. The paired differences analysis showed a mean of 8 (SD 3.8). The t-value was 13.532, with significance < 0.01, confirming that the means differed significantly.

### 5.3. Groups Comparison

Table **8** presents the results of Levene's test for both groups; all three values were > 0.05, indicating that the variances were homogeneous. Post-test dependent variables' significance was < 0.001 and < 0.05 threshold. So, there were significant differences among the three dependent variables between the two groups.

Table **8** presents that the post-test decision-making scores of the traditional group (mean = 63, SD = 6) were considerably worse than those of the experimental group (mean = 67, SD = 6). The traditional group score for tactical ability (mean = 2.5, SD = 0.2) was also considerably lower than the experimental group score (mean = 3.0, SD = 0.1). Similarly, the traditional group score for student engagement (mean = 3.0, SD = 0.2) was considerably lower than the experimental group's score (mean = 3.6, SD = 0.2). This indicated that the experimental group achieved higher scores on all three

tests. This also showed that the new teaching method intervention had a significant beneficial effect compared to the traditional methods (Appendix C).

## 6. DISCUSSION

### 6.1. Design and Implementation of the PBL-SBS Model

When teaching football to undergraduates, Zhong (2023) noted that students lacked style and strategic thinking. They just followed single actions repeatedly [50]. However, football requires thoughtful analysis and decision-making, regardless of whether one is playing an offence or defense. It is crucial to accurately determine the appropriate action [50]. This lack of strategic thinking in football teaching was the basis for our study.

Ill-structured problems arise in dynamic, team-based games, where there are intricate processes, concepts, or issues to comprehend and strategies or skills to acquire (such as principles of offence and defense, set-pieces, positional formation and team play, non-ball or ball-carrier options, distinguishing relevant from irrelevant cues in the performance environment) [11]. This is consistent with the scenario of the actual games that we simulated on the screen for the students. Our goal was to engage students and encourage them to engage in critical thinking by presenting them with various challenges. An effective approach to acquiring strategies is to analyze real-game scenarios and provide diverse perspectives and insights into response to the varied situations encountered in matches. Our study enhanced the understanding of tactics by providing clear explanations of game dynamic scenes and problem descriptions. The material was delivered to students *via* a screen simulation, which guaranteed that the questions were difficult and would ignite curiosity to investigate further.

Group discussion is a potent method to enhance communication and collaboration among students. Teachers should act more like guides, going from group to group and helping students solve problems rather than simply providing information, ensuring that conversations remain focused and that every student is motivated to engage fully [51]. In a PBL environment, students play a direct role in the learning process. They have more power to design learning objectives, choose learning materials, and choose learning activities [52]. In our study, group discussion also played a key role, as it promoted the exchange of knowledge and ideas among students, mutual learning, inspiration, and the collaborative development of best tactical solution plans. However, the guidance of the teacher in the group discussion stage is also particularly necessary; the teacher should ensure that the students in each group do not have too much misunderstanding about the definition of the problem. Hence, with the help of simulation, this becomes easier, but the teacher should still pay attention to the discussion content of each group and correct the wrong discussion topics in the group. This process is effective for students who lack self-discipline.

In our study, in the off-class learning stage, students must create a precise tactical implementation plan using the collected material and the outcomes of group cooperative learning. Teachers should provide comments and recommendations on their plans to assist students in enhancing their plans. The learning communication between group members and the teacher's guidance on the group's results are all connected through social media to promote better learning results.

In the group reporting stage, the solution was to design a football tactical game and lead all students to practice together to solve the corresponding tactical problems. Such an implementation arrangement can encourage all students to participate in the football tactical training. In this way, through games, complex football tactics become easy to perform, thus increasing students' interest.

Finally, summary and reflection are the final part of the whole teaching process. Students should take a comprehensive assessment, synthesize their learning, and think about their achievements and setbacks in tactics understanding, tactics development, and real-world implementation. Teachers should help students extract key insights and motivate them to suggest improvements, thereby preparing them for further educational endeavors.

**Table 6. Normality tests.**

| Test | Group | Shapiro-Wilk | | |
|---|---|---|---|---|
| | | Statistic | df | Sig. |
| Decision-making test (Pre) | TG - traditional | 0.966 | 39 | 0.275 |
| | EG - experimental | 0.958 | 40 | 0.138 |
| Decision-making test (Post) | TG - traditional | 0.973 | 39 | 0.465 |
| | EG - experimental | 0.955 | 40 | 0.110 |
| Tactical skill | TG - traditional | 0.960 | 39 | 0.172 |
| | EG - experimental | 0.974 | 40 | 0.470 |
| Engagement | TG- traditional | 0.962 | 39 | 0.201 |
| | EG - experimental | 0.959 | 39 | 0.169 |

**Note:** For all groups, the significance value Sig was > 0.05, so all distributions were considered normal.

**Table 7. Pre- and Post-Test Decision-Making Scores+Paired Samples t-test.**

| - | N | $\bar{X}$± S | Paired Differences (Post average score - Pre average score) | | | |
|---|---|---|---|---|---|---|
| **Pre** | **40** | **59±7** | **Mean** | **Std** | **t** | **Sig.** |
| Post | 40 | 67±6 | 8 | 3.8 | 13.532 | <0.001 |

**Table 8. Scores for post-test, tactical skills, and engagement *versus* traditional and experimental groups.**

| DV | IV | n | $\bar{X}$± S | Levene's Test | | ANOVA | | | | Between groups |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | W | Sig. | SS | MS | F | Sig. | - |
| Post-test | TG | 39 | 63±6 | 0.186 | 0.667 | $SS_B$:409.846 | $MS_B$:409.846 | 12.914 | 0.001 | TG<EG |
| | EG | 40 | 67±6 | | | $SS_W$:2443.6 | $MS_W$:31.736 | | | |
| Tactical skills | TG | 39 | 2.5±0.2 | 3.888 | 0.052 | $SS_B$: 5.811 | $MS_B$:5.811 | 199.430 | <0.001 | TG<EG |
| | EG | 40 | 3.0±0.1 | | | $SS_W$:2.244 | $MS_W$:50.029 | | | |
| Engagement | TG | 39 | 3.0±0.2 | 0.306 | 0.582 | $SS_B$: 6.684 | $MS_B$:0.039 | 170.831 | <0.001 | TG<EG |
| | EG | 40 | 3.6±0.2 | | | $SS_W$: 3.013 | $MS_W$:0.039 | | | |

### 6.2. Student Learning Outcomes

According to Prabandaru *et al*. (2020), PBL learning enhanced students' abilities, both physical and cerebral, enabling them to think critically. Additionally, it fosters the development of their capacity to learn autonomously and the capacity to work together [53]. The advantages described by Prabandaru *et al*. (2020) are similar to those found in our PBL-SBS group. In our study, students solved problems by analyzing and critiquing relevant information. At the same time, group discussion and cooperative learning also cultivated their cooperative learning ability.

According to Azmi *et al*. (2016), students who were exposed to the problem-based learning approach had favorable and effective outcomes in their physical education courses [54]. His conclusions aligned with our own. The paired sample T validated the efficacy of this instructional method for enhancing tactical decision-making. The ANOVA analysis compared the effectiveness of the PBL-SBS model with traditional teaching methods. This analysis showed that there were significant differences in the overall impact of the two instructional approaches on tactical decision-making, tactical skills, and student engagement.

By using the PBL-SBS, students were able to engage in realistic game situations, identify and analyze complex tactical challenges, and formulate strategic decisions based on the problems. This approach encouraged students to be responsible for their learning, actively pursue solutions, complete the teaching process, and follow the tasks given to each group. Consequently, students exhibited heightened motivation, inquisitiveness, and mental engagement in learning, leading to improved levels of overall engagement.

In addition, the PBL-SBS approach promoted the growth of tactical skills, allowing them to apply their knowledge and decision-making to real game situations. This model emphasizes contextual learning and practical application of tactics, which plays a key role in improving the ability to effectively implement tactical skills.

### 6.3. Student Engagement

Ravitz (2010) showed that PBL had a beneficial impact on student engagement, which was crucial for creating an effective learning environment [55]. There is little literature on student engagement in the field of physical education. Hastie *et al*. (2022) suggested that future interventions might include the question: "Do students change their level of engagement as a result of participating in a new form of physical education?" [56]. Following his suggestion, we used the engagement questionnaire to measure students' participation and evaluate the influence of the PBL-SBS model on behavioral, emotional, and cognitive involvement in learning. We carefully compared the engagement of students in the two groups. The PPL-SBS group scores on the overall aspects of the learning engagement questionnaire showed significant improvement compared to the traditional group. We discussed the three subdimensions of the questionnaire in the next section.

#### *6.3.1. Behavioral Engagement*

PBL teaching emphasizes the initiative and participation of students. In tactics teaching, students could understand and master tactics more deeply through the simulation teaching platform. They applied what they had learned in actual games and had a more intuitive understanding of the tactics, which helped them to constantly adjust and improve in practice. PBL-SBS group students showed more active participation in class discussions, completion of assignments, participation in after-school learning activities, and class presentations.

#### *6.3.2. Emotional Engagement*

In the new model, students can try new tactics in a safe environment. The simulation teaching platforms

reduce the risk of losing in real competitions, and this helps to boost self-confidence and reduce anxiety during the competition. In this study, screen-based simulation tools facilitated the presentation of tactical situations and the evaluation of tactical decision-making. Moreover, it also helped to promote interest and love so that they became more engaged and enjoyed football. In the PBL process, students explored problems and solutions independently, which helped to develop self-awareness and responsibility. At the same time, through group work, students could feel the power of the team and the fun of collaboration, which enhanced their sense of belonging and collective honor.

### *6.3.3. Cognitive Engagement*

PBL teaching emphasizes the cultivation of thinking ability and problem-solving abilities. In learning tactics, students not only need to know the tactical strategies but also need to understand the principles and logic behind the tactics. The simulation teaching platform helps students understand and analyze tactics and improve their analysis and decision-making abilities by simulating a real game. This teaching method also allows students to learn how to deal with complex match scenarios and improve their resilience by simulating a variety of different situations. Through analysis and problem-solving, students learn how to think critically and look at problems from multiple perspectives. This level of cognitive improvement helps students better cope with challenges in future studies and life.

## CONCLUSION

The implementation of the PBL-SBS teaching model significantly improved student tactical decision-making. The pre-test mean score (59) was significantly lower than the post-test one (67) on a scale of 100 (paired sample t-test, sig <0.01), satisfying research question 1. Compared with traditional teaching, PPL-SBS students performed better in tactical decision-making, tactical skills, and student engagement than students in the traditional teaching group (ANOVA test, Sig values were all less than 0.01), satisfying research question 2.

To summarize, the PBL-SBS model offered a potential teaching method to improve tactical understanding. This study substantiated the efficacy of using a student-centered and problem-based methodology in enhancing tactical decision-making, tactical abilities, and student engagement. Implementing the PBL-SBS model in sports education offers students a more immersive and interactive learning experience, promoting skill development and learning engagement.

Despite some limitations, the study adds valuable insights into sports education and provides educators and coaches with a valuable tool to optimize student learning outcomes in football and other team sports.

## CONTRIBUTIONS TO PHYSICAL EDUCATION

1) Screen-based simulation helps students to experience real tactical scenarios in a safe environment. It provides a reference for the teaching of team confrontation tactical sports.

2) Problem-based learning aids students in analyzing problems and proposing solutions by themselves, which provides a theoretical reference for the same type of physical education courses.

3) The combination of problem-based learning and screen-based simulation in football courses has not been previously discussed.

## LIMITATIONS

Since the sample in our study had students with low skill levels and it was difficult to support their tactical behavior in a real game, the tactical decision-making in this study was tested through simulation. Hence, it can be a good reference for the training of non-professional players and beginners. However, for high-level players, this teaching model has not yet been studied.

## RECOMMENDATIONS FOR FURTHER RESEARCH

The study was limited by geographical scope and sample size. Follow-up surveys should replicate and expand these findings in larger populations. In addition, extensive research is needed to determine the long-term retention of football tactical learning effects. At the same time, how to transfer the tactical ability to real matches still needs further research in the direction of professional training.

## LIST OF ABBREVIATIONS

| | | |
|---|---|---|
| PBL | = | Problem-Based Learning |
| SBS | = | Screen-Based Simulation |
| VR | = | Virtual Reality |
| SBS | = | Screen-Based Simulation |
| TG | = | Traditionally taught Group |
| EG | = | Experimental Group |
| TACSIS | = | Tactical Skills Inventory for Sports |

## ETHICS STATEMENT AND CONSENT TO PARTICIPATE

Ethical approval is not applicable to this research. It is a part of the innovation in the regular physical education teaching of the school.

## HUMAN AND ANIMAL RIGHTS

All procedures performed in studies involving human participants were in accordance with the ethical standards of institutional and/or research committee and with the 1975 Declaration of Helsinki, as revised in 2013.

## CONSENT FOR PUBLICATION

All participants were informed that it was a part of a research project and that they could decline to participate.

## STANDARDS OF REPORTING

STROBE guidelines are followed.

## AVAILABILITY OF DATA AND MATERIALS

Data is availabel upon request from the authors.

## FUNDING

None.

## CONFLICT OF INTEREST

The authors declared no conflict of interest, financial or otherwise.

## ACKNOWLEDGEMENTS

Declared none.

## APPENDIX A. Questionnaire for Student Engagement

| Likert 5-level scale | Strongly agree | Agree | Neutral | Disagree | Strongly disagree |
|---|---|---|---|---|---|
| Items to assess behavioral engagement<br>1. I try hard to do well in learning activities<br>2. After class, I will study deeply on the football tactical problems<br>3. When I'm in class, I participate in discussions and cooperation<br>4. I pay attention in class<br>5. I participate in football matches or games frequently after class<br>6. I will study carefully according to the teacher's teaching plan and carry it out | | | | | |
| Items to assess emotional engagement<br>1. When I'm in class, I feel good.<br>2. When we work on something in class, I feel interested<br>3. I think football is a very interesting course and I get fun from it<br>4. I enjoy learning new things in class<br>5. I think it is a pleasant experience to cooperate and communicate with others in class<br>6. I like this model of teaching football tactics<br>7. I find it satisfying to learn new knowledge or skills in class | | | | | |
| Items to assess cognitive engagement<br>1. I try to relate what I'm learning to what I already know when learning football tactics<br>2. I try to figure out how the tactics might be useful in real-world football games<br>3. I try to make all the different ideas fit together and make sense when l study<br>4. I make up my own examples to help me understand the football tactics<br>5. Before I begin to study, I think about what I want to get done<br>6. There is no right answer to a tactical problem in football. I have to find multiple solutions<br>7. I try to understand the football game and get familiar with the game situation | | | | | |

## APPENDIX B. Questionnaire for Tactical Skills

| Likert 5-level scale | Strongly agree | Agree | Neutral | Disagree | Strongly disagree |
|---|---|---|---|---|---|
| Knowing about ball actions<br>1. I know exactly when to pass the ball to a teammate or when not to<br>2. If we capture the ball, I know exactly what to do<br>3. While executing an action in a match, I know exactly what to do subsequently<br>4. If I capture the ball, I know exactly to whom I should pass it | | | | | |
| Knowing about others<br>1. My judgement of the opponent's play is accurate<br>2. I know quickly how the opponent is playing<br>3. Although I do not see my opponents, I know where they are going<br>4. Without seeing my teammates, I know where they are going<br>5. If an opponent receives the ball, I know exactly what he is going to do | | | | | |
| Positioning and deciding<br>1. Decisions I make during games about preceding actions are generally effective<br>2. I know how to get open during a game<br>3. My positioning during a game is generally fit for the game<br>4. My observation and vision (in ball possession) are good<br>5. My anticipation (thinking about proceeding actions) is accurate<br>6. I am good at making the right decisions at the right moment<br>7. In the opinion of my teacher, my understanding of the game is good<br>8. My getting open and choosing position is good in the games<br>9. In the opinion of my teacher, my positioning is fit for the game | | | | | |
| Acting in changing situations<br>1. My interception of the opponent's ball has a high success rate<br>2. My interception of the ball is going to benefit the team quickly<br>3. If our team loses the ball during a game, I quickly switch to my task as a defender<br>4. I quickly react to changes, such as from not possessing to ball possession | | | | | |

## APPENDIX C. Lesson plan

<table>
<tr><th colspan="3">PBL-SBS Lesson Plan</th></tr>
<tr><td rowspan="6">Lesson 1</td><td colspan="2">Target:<br>1. Learning TacticUP software instrument<br>2. Pre-test of tactical decision-making by TacticUP software<br>3. The presentation method for solving tactical problems</td></tr>
<tr><td colspan="2">Place: Multimedia classroom</td></tr>
<tr><td colspan="2">Instrument: TacticUP software</td></tr>
<tr><td colspan="2">Duration: 100 mins</td></tr>
<tr><td>Teacher activities</td><td>Student activities</td></tr>
<tr><td>1. Supervise the students’ activities<br>2. Explain and demonstrate presentation requirements<br>3. Set up online chat groups to provide scaffolding for students to study on their own and solve problems<br>4. Explain formative evaluation methods</td><td>1. Learning how to make decisions on TacticUP software<br>2. Learning the problem-solving process and presenting solutions in the football courses<br>3. Join the chat groups and report the progress of the group working<br>4. Pre-test of tactical decision making</td></tr>
<tr><td rowspan="13">Lesson 2</td><td colspan="2">Target:<br>Step 1: Clarifying unfamiliar terms of football tactics<br>Step 2: Problem definition<br>Step 3: Brainstorm<br>Step 4: Analyzing the problem<br>Step 5: Formulating learning goals</td></tr>
<tr><td colspan="2">Place: Multimedia classroom</td></tr>
<tr><td colspan="2">Instrument: Football match basic offensive and defensive tactical virtual simulation experiment platform</td></tr>
<tr><td colspan="2">Duration: 100 mins</td></tr>
<tr><td>Teacher activities</td><td>Student activities</td></tr>
<tr><td colspan="2">Step 1: Clarifying unfamiliar terms of football tactics</td></tr>
<tr><td>1. Explain how to use the platform and organize students into groups with 6-7 members in each group<br>2. Present the real football game situation through a Virtual simulation platform and guide students to make tactical decisions based on football situations<br>3. Through the feedback and summary of the platform, guide the students understanding the principles of football tactics</td><td>1. Each group chooses a chairman, a scribe, and a presenter.<br>2. Make the tactical decisions through group discussion<br>3. The presenter of each group state the reasons for the choice</td></tr>
<tr><td colspan="2">Step 2: Problem definition</td></tr>
<tr><td>1. Categorized the principles of football tactics into six stages<br>2. Teachers visit and interact with each group to promote their understanding of tactical topics<br>3. Uses questions to promote depth and to help students identify their own misconceptions</td><td>1. Each group selects a categorized stage of tactical principles and discusses the topic<br>2. After discussion, the students reached an agreement on the tactical problems to be solved<br>3. The scribe notes down the problem definitions</td></tr>
<tr><td colspan="2">Step 3: Brainstorm</td></tr>
<tr><td>1. Supervises the learning process of students<br>2. Supports the chair and the scribe<br>3. Provides feedback to students about their own performance</td><td>1. The chairman organizes each team member to think of ways to solve tactical problems, and the scribe takes notes of everyone's explanations, ideas, and hypotheses<br>2. The chairman summarizes the contributions of group members</td></tr>
<tr><td colspan="2">Step 4: Analyzing the problem</td></tr>
<tr><td>1. Stimulates group members to find relations between topics<br>2. Chooses the right moment for an intervention</td><td>1. Group members discuss and analyze in-depth ways to solve tactical problems<br>2. The chairman stimulates group members to find relations between topics<br>3. The scribe makes brief and clear summaries of contributions</td></tr>
<tr><td colspan="2">Step 5: Formulating learning goals</td></tr>
<tr><td>1. Provides feedback to students about their own performance and the group performance<br>2. Supports the chair and the scribe</td><td>1. The chairman determines what knowledge the group lacks, and learning goals are formulated on these topics.<br>2. The chairman checks if all obscurities and contradictions from the problem<br>analysis have been converted into learning goals<br>3. The scribe summarizes learning goals</td></tr>
</table>

*contd.....*

| PBL-SBS Lesson Plan | | |
|---|---|---|
| **Lessons 3-8** | **Target:** Solve tactical problems for each group | |
| | **Place:** Football field | |
| | **Instrument:** Report the tactical training and game plan developed by the report group, football field, ball, and game equipment. | |
| | **Duration:** 100 mins for each lesson | |
| | **Time arrangement:** 100 minutes | |
| | Warm-up | 10 mins |
| | Tactical solution presentation | 10 mins |
| | Tactical training | 10 mins |
| | Game presentation | 10 mins |
| | Game playing | 20 mins |
| | Football competition | 30 mins |
| | Relaxing time and evaluation | 10 mins |
| | **Teacher activities** | **Student activities** |
| | 1. Introduce the topic of this lesson and lead the students to warm up<br>2. Give feedback on the tactical problems and solutions of the report group and arouse the thinking of all students<br>3. Supervise and guide the process of tactical training<br>4. Provide feedback and improvements to the game process<br>5. Guide students to play small group football matches and supervise the game process<br>6. To summarize and evaluate the work of the reporting group, organize students to evaluate the reporting group and self-assessment for the reporting group. | 1. Warm-up fully, report group students prepare the class equipment<br>2. A representative of the reporting group presents a football tactical problem and describes the solution (designed training program). The students in the reporting group demonstrate the training plan<br>3. According to the plan of the reporting group, the whole class will conduct tactical training<br>4. Reduce tactical training to games. The class plays games and understands tactics<br>5. Football competition<br>6. Relaxing time |
| **Lesson 9** | **Target:**<br>1. Post-test of tactical decision making<br>2. The tactical skills questionnaire<br>3. Student engagement questionnaire<br>4. Interview students' feedback on the new model | |
| | **Place:** Multimedia classroom | |
| | **Instrument:** TacticUP software, questionnaires, interview outline | |
| | **Duration:** 100 mins | |

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