

Research Article

Application of Virtual Reality for Teaching Rock Climbing in Colleges Using Big Data

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Since rock climbing was added to the Olympic Games, nations around the globe have started to pay more attention to the instruction of rock climbing and have established it as a program in colleges and universities to train college students and adolescents, who make up the majority of rock climbers. However, there are many problems faced while teaching rock climbing in colleges and universities, such as no standardized teaching materials, short teaching time, and cumbersome teaching content, which are few to mention. As a result, students can only master the basic methods and techniques of climbing on rock while studying at colleges and institutions, and their climbing ability cannot be improved. Most of the current college's rock climbing teachers only pay attention to the technical problems. The correct methodology of teaching is a vital factor for student's guidance. To overcome these issues, this research demonstrates the virtual reality in classroom instruction; this has the potential to improve the impact and standard of collegiate rock climbing. The authors focus on the concept of virtual reality technology, technical characteristics, virtual reality system composition, and virtual reality modeling and apply the theory and technology to college rock climbing teaching for building a teaching model basis on virtual reality in this research paper. This model is applied to college rock climbing teaching, and the experimental group and the control group are set to analyze the students' interest in rock climbing teaching. The comparison demonstrates that employing virtual reality technology dramatically increases the experimental group students' enthusiasm in rock climbing education. Upon analyzing the students' recognition rock climbing instruction in colleges and institutions, the result shows that 93.3% of the experimental group and 60% of the control group agree that the rock climbing course can motivate their own learning initiative and enthusiasm. When analyzing the motivation of students to learn rock climbing, the highest proportion is to get credit and recognition, the proportion of which is 35.6%.

1. Introduction

After the introduction of rock climbing in China, it is sought after and loved by young people. Rock climbing is a kind of climbing sport carried out on the premise of using protective measures to ensure personnel safety. According to the classification of places, rock climbing is divided into outdoor rock climbing and indoor rock climbing. Indoor rock climbing is a variety of facilities constructed by imitating the climbing environment, so as to enable people to complete the climbing movement, which has high safety [1]. Outdoor rock climbing is difficult and dangerous to climb the naturally formed rock mass, but it is very challenging.

Nowadays, climbing has penetrated into people's life and become one of the recreational activities in people's spare time [2].

Nowadays, colleges and universities have set up rock climbing courses to carry out rock climbing teaching for college students. In the teaching process, there is a tradition and simplification of rock climbing course teaching, and students cannot master rock climbing skills. Rock climbing requires many times of practice to master the essentials. However, students cannot grasp the essence of field teaching only by classroom teaching, resulting in poor effect of after-school practice. For this problem, virtual reality technology is applied in rock climbing teaching in colleges and

universities and multimedia technology and virtual reality technology are used to visually display rock climbing movements and obtain students' rock climbing movement data [3, 4].

In [5], virtual reality enables users to view the virtual world from any angle, and users can interact with virtual items. Virtual reality created a scenario in which users assumed that computer and scientific technology had transformed objects in real environments and digital data into visible and even touchable 3D virtual scenes. It also matched these scenes with a unique man-machine interface to allow for direct human participation in the virtual world as in a real environment. In [6], the authors discussed that immersion, interaction, multisensory perception, and conception are the four features of VR technology. To maintain oneself in a virtual environment and achieve nearly realistic human-computer interaction, the user dressed sensor equipment like a helmet display and gloves. As a result, the user has sensory perceptions such as sight, touch, taste, and other ones in the virtual reality environment. Due to its openness, virtual reality has the ability to integrate with a wide range of applications, e.g., teaching various courses in the colleges and universities that include rock climbing as well. The main innovations of this paper are as follows:

- (1) Firstly, it introduces the basic concept and characteristics of virtual reality technology, the constituent modules of virtual reality system, and its set modeling, which can be used as the basis of rock climbing teaching technology in colleges and universities
- (2) This study creates a rock climbing teaching model at higher education institutions based on virtual reality and discusses the teaching techniques and assessment methods of rock climbing courses in colleges and universities

The rest of this study is organized follows. Section 2 represents related work section. Section 3 demonstrates human motion recognition algorithm based on depth information. The application of virtual reality for teaching rock climbing in colleges will be explained in Section 4. In Section 5, analysis on the application of rock climbing teaching in colleges and universities is presented. Finally, we conclude our work in Section 6.

2. Related Work

With the rapid development of society and the rapid improvement of humanistic consciousness, major colleges and universities have added rock climbing courses from the reform of physical education teaching and applied virtual reality technology to rock climbing teaching in colleges and universities. Experts all over the world have also begun to focus on this aspect. Whitaker pointed out that rock climbing technology has been fully popularized, and rock climbing has become a sport loved by young- and middle-aged people. This sport can exercise and relieve pressure, as well as competitive competition [7]. Melo et al. proposed that virtual reality technology (VR) is a high-tech technology integrating sensing technology, computer technology and microelectronics

technology [8]. Elsa et al. pointed out that virtual reality technology (VR) is characterized by interactivity, immersion, and imagination, which belongs to computer advanced man-machine page technology [9]. Chamorro Atalaya et al. claimed that virtual reality technology in physical education instruction may decrease accidents, avoid teaching conditions, virtualize diverse characters, overcome time and space constraints, and fully utilize the teaching capacity of colleges and universities [10]. Jacinto argued that using virtual reality technology in college physical education classes might minimize sports injuries and intensity [11]. Chen et al. uses virtual reality technology in physical education teaching to make full use of teaching knowledge, virtualize rock climbing, and carry out skill training and to realize distance physical education. The authors in [12] used virtual reality technology to make physical education courseware and carry out physical training. In [13], the authors combined Research Training Scheme (RTS) teaching method to formulate collaborative teaching mode and applied it in rock climbing teaching. During collaborative teaching, multiple teachers give full play to their own strength to formulate teaching contents [13]. During the study of teaching methods, the authors pointed out that the teaching techniques of rock climbing sports must be innovated. Teachers should focus on cultivating students' balance ability and improve students' climbing technology; let students master climbing technology in a short time and strengthen their own balance ability [14]. The authors of [15] focused on the climbing technology and training methods of rock climbing and divided the climbing technology into mobile technology and balance technology. Mobile technology mainly includes climbing foot method, basic technique, body method, climbing rhythm, hand foot same point, and three-point fixed climbing. Rock climbing technology is used in college rock climbing teaching.

3. Human Motion Recognition Algorithm Based on Depth Information

The inherent traits of human behavior, such as motion information aspects, temporal and spatial interest points, and geometric features, are analyzed by traditional algorithms to recognize human behavior. Among these, spatial-temporal interest spots have the highest identification rates, the best feature expression, and strong resistance to changes in lighting, background, and environmental noise. Various human motion recognition technologies have been discussed as follows.

3.1. Virtual Reality Technology. Virtual reality technology is an interactive artificial virtual environment created by simulation technology and multimedia technology. It combines intelligent technology, sound, computer graphics, sensing, image processing, voice processing, and network technology to transform digital information processed by computers into various types of multidimensional information. Users make full use of hearing, vision, and touch to control user behavior and complete dynamic interactive response. Based on virtual reality technology, users create a

virtual environment to let people experience an immersive feeling, which is similar to the real environment. Multidimensional information interaction can be realized between people and the virtual environment, and participants can obtain the rational cognition of objective things from quantitative and qualitative virtual environment to form new ideas and ideas.

3.2. Characteristics of Virtual Reality Technology. VR 3D modeling uses computers to create a virtual world with multiple senses such as hearing, vision, touch, feeling, and smell. The virtual world is a completely fictional or virtual reproduction of the real world. Immerse people in the virtual environment and experience the feelings of hearing, vision, smell and hearing. VR immersion mutual inductance puts forward requirements for VR technology. It must have computer processing ability and natural and harmonious interpersonal interaction ability to make the experimenter feel more immersed.

Currently there is no such cohesive concept for VR technology. The following three main parts are very important to compose regarding technology implementation and the generation and implementation of VR system:

- (1) Compute and measure the action system, install a measurement sensor to track human movement in real time and realize human-VR interaction.
- (2) The goal of sensory information synthesis is to create a simulation system that allows users to employ information output and display devices on sensory organs to experience virtual reality.
- (3) The third and last part is performance system: virtual world performances are created with the intention of creating VR, and they make use of the performance system to illustrate the causal link between sensory input and action execution. The structure of virtual reality is depicted in Figure 1.

3.3. Composition of Virtual Reality System. The components of VR system mainly include 3D model library, virtual environment, real world, module control, and sensor module. Some scholars pointed out that, in addition to the above modules, it also includes feedback module and detection module, which is shown in Figure 2. The system composed of this module should take into account software and hardware of VR system and pay attention to the main position of VR system at the same time. There is a special relationship between the design and application of VR system, and the emphasis is different. Therefore, the feedback module, detection module, control module, sensor module, 3D model library, and modeling module will be changed. For example, compared with immersive VR system and desktop VR system, the two systems are quite different in visual perception.

The detection module used by participants to regulate how the virtual world perception and sensor module interact as depicted in Figure 2; the real-time feedback data can be accessed by the real-time feedback module by the people.

The participant's instructions are received by the sensor module, which applies them in the virtual world and can simultaneously feedback the data produced to the participants. The control module operates the sensor to enable real-time communication between the participants and the virtual and physical environments. The modeling module acquires the real-world 3D data and builds a 3D model based on it. The 3D model library reflects the real world in 3D and creates the appropriate virtual environment.

3.4. Geometric Modeling in Virtual Reality. The majority of geometrical shapes are imaginary. Processing the geometric and topological data on the geometric model is the purpose of geometric modeling. All geometric objects have a certain number of constituent parts, and those parts are related to one another. Examples of these constituent parts include the number of lines, points, and faces, as well as the interactive position and the constituent parts surrounding other constituent parts. Measurements can be made of geometric information, such as the size and position of things.

The three-dimensional graphic transformation represents a brand-new three-dimensional graphic generated after moving the three-dimensional image position, adjusting the scale and rotating. The three-dimensional graphic geometric transformation is realized by using the homogeneous coordinate transformation clamp relative to the coordinate axis and coordinate origin.

3.4.1. 3D Translation Transformation. Transfer point $P(x, y, z)$ to point $P'(x', y', z')$:

$$\begin{aligned} P(x, y, z)x' &= x + T_x, \\ y' &= y + T_y, \\ z' &= z + T_z, \\ T_x &= x' - x, \\ T_y &= y' - y, \\ T_z &= z' - z. \end{aligned} \quad (1)$$

Thus, the following translation transformation matrix is derived:

$$T = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}. \quad (2)$$

The following is the translation coordinate transformation of this point:

$$[x' \ y' \ z' \ 1] = [x \ y \ z \ 1] \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ T_x & T_y & T_z & 1 \end{bmatrix} = [x \ y \ z \ 1]T. \quad (3)$$

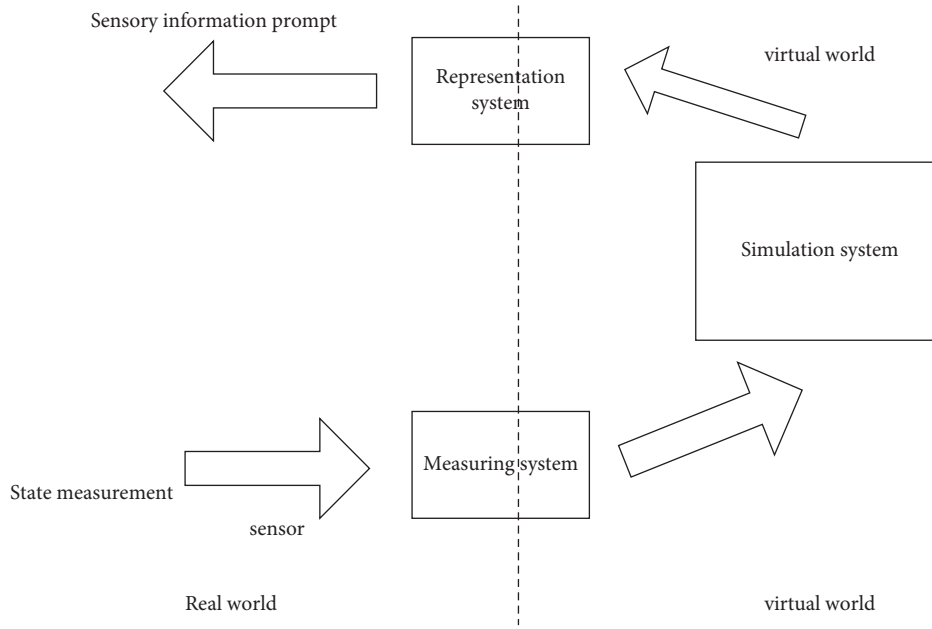


FIGURE 1: Virtual reality structure.

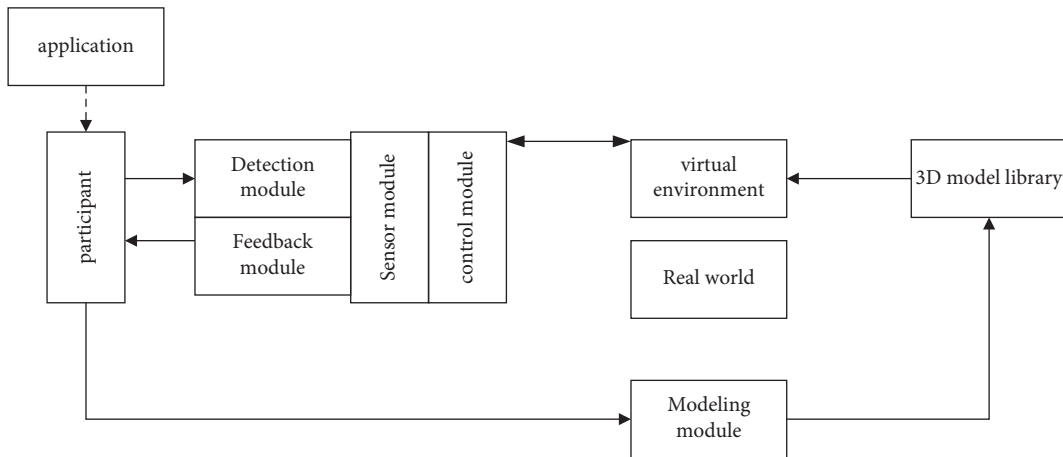


FIGURE 2: VR system composition.

3.4.2. *3D Scale Transform.* If the transformation scales are different, the object is transformed in different local scales, and the $P'(x', y', z')$ coordinates can be determined by the transformation if the coordinate transformation is applied to the three vertical coordinate axes of the $P(x, y, z)$ center of an object at the origin of the coordinate and the transformation scale is set to a , b , and c . The transformation matrix is as follows:

$$T = \begin{bmatrix} a & 0 & 0 & 0 \\ 0 & b & 0 & 0 \\ 0 & 0 & c & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}. \quad (4)$$

The following are the scaled coordinate formulas for points:

$$[x' \ y' \ z' \ 1] = [x \ y \ z \ 1] \begin{bmatrix} a & 0 & 0 & 0 \\ 0 & b & 0 & 0 \\ 0 & 0 & c & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} = [x \ y \ z \ 1]T. \quad (5)$$

3.4.3. *3D Rotation Transformation.* $P(x, y, z)$ points are transformed into $P'(x', y', z')$ points after the object rotates around the coordinate axis, and the corresponding transformation matrices of P' on different coordinate axes are different. If you convert around the X -axis, the P -point change is represented by the following:

$$\begin{aligned} x' &= x, \\ y' &= y \cos \partial - z \sin \partial, \\ z' &= y \sin \partial + z \cos \partial. \end{aligned} \quad (6)$$

The following is the transformation matrix:

$$T = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos \partial & \sin \partial & 0 \\ 0 & -\sin \partial & \cos \partial & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}. \quad (7)$$

When transforming around the X -axis, the following are the coordinate transformations of point P :

$$[x' \ y' \ z' \ 1] = [x \ y \ z \ 1] \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos \partial & \sin \partial & 0 \\ 0 & -\sin \partial & \cos \partial & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} = [x \ y \ z \ 1]T. \quad (8)$$

When transforming around the Y -axis, the following are the coordinate transformations of the P -point:

$$[x' \ y' \ z' \ 1] = [x \ y \ z \ 1] \begin{bmatrix} \cos \partial & 0 & -\sin \partial & 0 \\ 0 & 1 & 0 & 0 \\ \sin \partial & 0 & \cos \partial & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} = [x \ y \ z \ 1]T. \quad (9)$$

When transforming around the Z -axis, the following are the coordinate transformations of the P -point:

$$[x' \ y' \ z' \ 1] = [x \ y \ z \ 1] \begin{bmatrix} \cos \partial & \sin \partial & 0 & 0 \\ -\sin \partial & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} = [x \ y \ z \ 1]T, \quad (10)$$

where ∂ represents the angle of rotation of point P around the coordinate axis.

4. Application of Virtual Reality Technology in College Rock Climbing Teaching

4.1. Teaching Methods of Rock Climbing Course. In colleges and universities, virtual reality technology is used to teach rock climbing, and the teaching techniques of standard physical education students and rock climbing courses are contrasted. The cognition and interest of different students of different teaching methods are also very different and can fully reflect the teaching ability and professional ability of rock climbing teachers. This study makes a comparative analysis of the teaching methods adopted in rock climbing teaching in none of our colleges and universities and draws Table 1 to show the teaching contents [16].

By analyzing the data in Table 1, it is concluded that whether teachers can complete their teaching tasks and adopt teaching methods are directly related. Teachers should strengthen their professional ability, teaching ability, and operation ability from their own point of view and design teaching models in the way of demonstration and explanation.

4.2. Examination Method of Rock Climbing Course in Colleges and Universities. The teaching objective is to direct how courses are taught and the primary focus of their material, and the relationship between how courses are implemented and the teaching objectives is complementary. Therefore, it is essential to have a thorough awareness of the present state of rock climbing education at academic institutions, as well as the teaching objectives that colleges and universities have established for the rock climbing course. This study investigates five colleges and universities from different cities or provinces in China. The results show that the teaching objectives of rock climbing course formulated by most colleges and universities mainly focus on improving students' physical fitness, while focusing on the value of the course itself and its impact on students' intelligence, physical strength and psychology. This study chooses the course of rock climbing as an example to illustrate that the teaching goal set by colleges and universities is to achieve the all-round development of students' morality, intelligence, body, and beauty. However, during the period of rock climbing teaching, the emphasis is still on the type of rock climbing as well as its skills [17, 18].

In this study, the techniques of evaluating rock climbing teaching courses in major higher education institutions are examined. To establish the rock climbing courses, most instructors employ three common auditing techniques: theory, attendance, and practice. Passing cruxes, strength and conditioning elements, interacting with the environment, and having a solid repertory of climbing movements, risk management, route management, mental balance, peer communication, and route preview were some of the performance factors that were discovered. When it comes to mentally and physically preparing for ascents, route previewing has proven to be essential. However, the teaching system of each college is different from the rock climbing courses, and its equipment and site are also different [19]. Some university teachers put the assessment center on theory and assessment, while others mainly focused on practice assessment. Therefore, the teaching level and teaching quality of rock climbing in five universities are different, and at the same time, students' mastery of rock climbing and the learning status of the course are also different [20]. In the instruction of rock climbing at higher education institutions, different teaching techniques are used, and students' perspectives and interests differ, which completely reflects the teaching skill and professional capacity of rock climbing teachers. Table 2 shows the performance appraisal methods of rock climbing teachers in five universities:

4.3. Analysis of the Virtual Reality Technology Teaching Model. In this study, when studying college rock climbing teaching based on virtual reality technology, it is necessary to establish a model of rock climbing teaching. Before building, it is necessary to clarify the teaching objectives, students' personal characteristics, teaching starting points, and course types [21]. The teaching of rock climbing in colleges and universities is usually carried out with practice and theory

TABLE 1: Teaching methods of rock climbing in five colleges and universities from different provinces or cities in China.

Colleges and universities of region	Teaching methods
Beijing	Explanation, demonstration, practice, and teaching competition
Shanghai	Explanation, demonstration, practice, and teaching competition
Zhejiang	Explanation, demonstration, decomposition exercise, and teaching competition
Guangxi	Explanation, demonstration, practice, and teaching competition
Guangdong	Explanation, demonstration, discussion, and teaching competition

TABLE 2: Achievement assessment methods for rock climbing teachers in five colleges and universities from different provinces or cities in China.

Colleges and universities of region	Performance assessment method
Beijing	Attendance (30%), theory (10%), and practice (60%)
Shanghai	Attendance (20%), theory (20%), and practice (60%)
Zhejiang	Attendance (30%), theory (10%), and practice (60%)
Guangxi	Attendance (10%), theory (10%), and practice (80%)
Guangdong	Attendance (20%), theory (10%), and practice (70%)

courses as the core. The two courses have very different properties and can be combined with the characteristics of the course content. This study establishes a college rock climbing teaching model based on virtual reality technology with the combination of situational teaching theory and constructivism, as shown in Figure 3.

5. Analysis on Application of Rock Climbing Teaching in Colleges and Universities

5.1. Comparative Analysis of Learning Interest in Rock Climbing Teaching. This study uses virtual reality to teach college rock climbing. To demonstrate the effectiveness of virtual reality in college rock climbing instruction, an experimental group and a control group are established. The control group presents the outcomes of the application of virtual reality technology in college rock climbing instruction, whereas the experimental group employs it to teach rock climbing. The experimental group's learning interest compared in Figures 4 and 5 shows the comparison of learning interest of the control group.

Analysis of the results in Figures 4 and 5 shows that the interest of students using virtual reality technology in rock climbing teaching in the experimental group has increased significantly, from 2 to 6 students who were very interested, and most of the choices were more interested and very interested. The data of the control group show that, before and after the experiment, the interest of the control group students in rock climbing teaching has not changed much, mainly in comparison. According to the comparison analysis, using virtual reality technology in rock climbing education may greatly improve students' interest in learning rock climbing, and the degree of interest is much greater than that of the control group. It completely demonstrates the significance and utility of virtual reality technology in rock climbing instruction and may significantly increase students' enthusiasm in learning.

5.2. A Contrastive Analysis of Students' Identity to the Teaching Contents of Rock Climbing in Colleges and Universities. This study compares the learning effects of the experimental group and the control group and preserves the results in Table 3, beginning with the student's identification and ending with the content of rock climbing education.

According to the statistics in Table 3, the number of students in the experimental and control groups is 30. The 14 pupils in the experimental group demonstrate that the rock climbing teaching approach can completely activate their particular learning zeal and initiative. There is one individual who disagrees and the recognition rate is 93.3 percent. The recognition rate of the control group was 60%. Whether the practice of climbing course can improve the recognition rate of experimental group and control group is 80% and 73.3%. The appropriateness of load intensity in rock climbing course was 86.7% in the experimental group and 80% in the control group. The recognition rate of the experimental group was 100% and that of the control group was 93.3% when learning rock climbing.

5.3. Motivation Analysis of College Students in Learning Rock Climbing Course. By investigating students' motivation to participate in rock climbing courses, this study judges the degree of interest and recognition of students in rock climbing courses after using virtual reality technology, and the results are shown in Figure 6.

Based on the data shown in Figure 6, the motivation of the students to participate in the rock climbing course is analyzed on the premise that they want to participate in the course. Motivations are mainly divided into learning skills, learning climbing, getting credits, overcoming fear, hobbies, competitive competitions, and other motivations, 111 of which choose to learn skills, accounting for 22.2%; 74 students only wanted to know about rock climbing, accounting for 14.8%; 178 people chose to get credit, accounting for 35.6%; fifty five people chose to overcome their

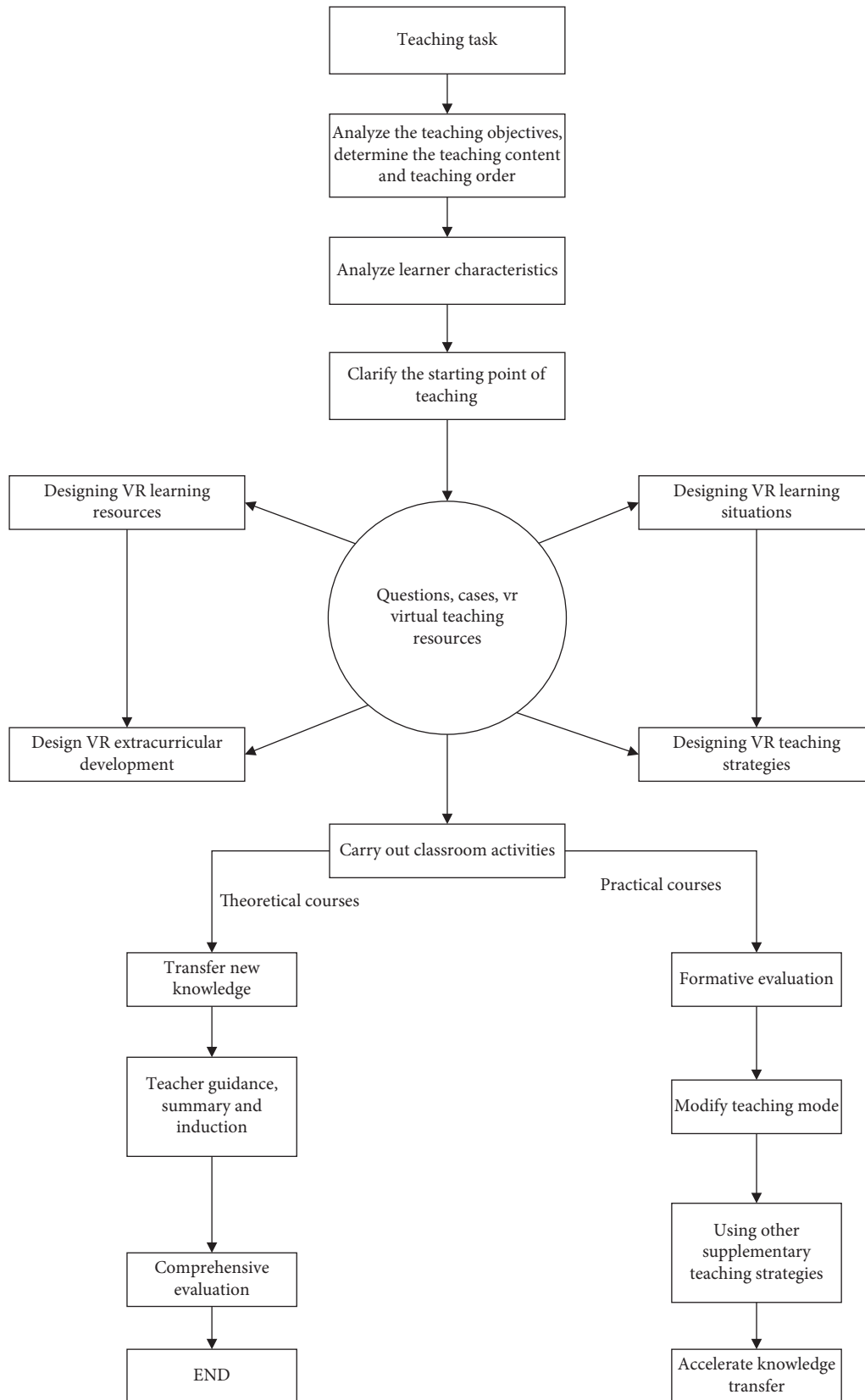


FIGURE 3: Teaching model of rock climbing in universities based on virtual reality technology.

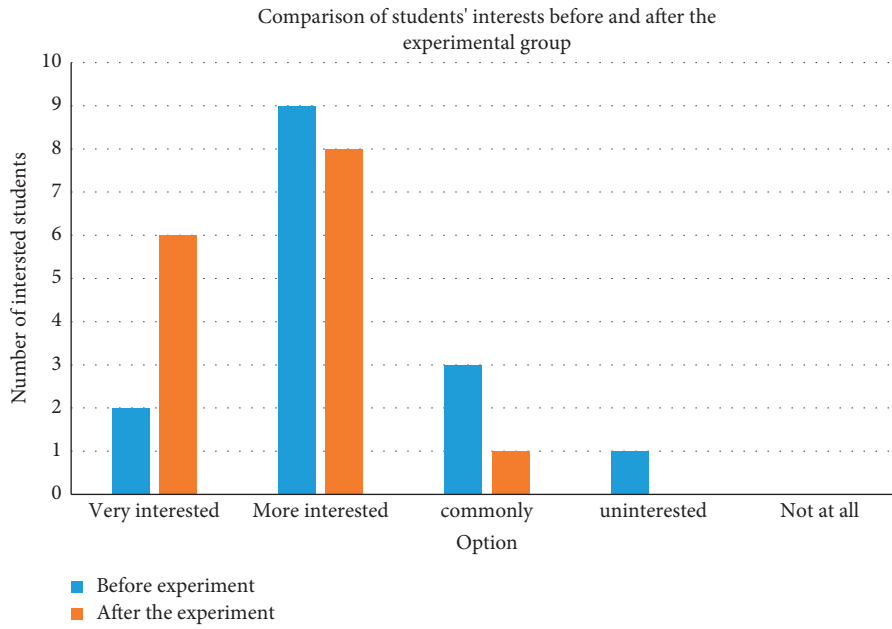


FIGURE 4: A comparison of learning interest in the experimental group.

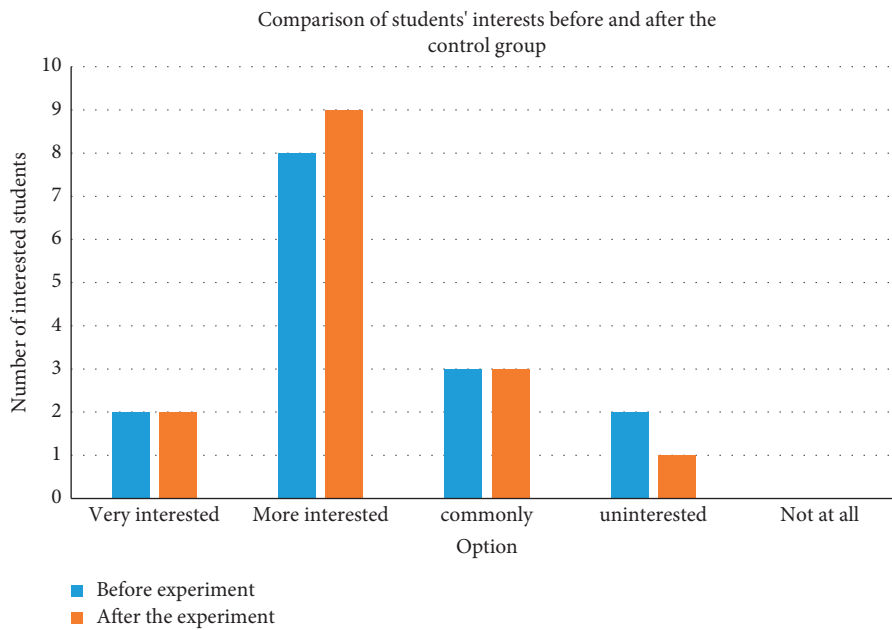


FIGURE 5: Comparison of learning interest in the control group.

TABLE 3: Comparison of two groups of students' identity on the content of rock climbing teaching.

Survey questions	Experience group			Control group		
	Very agree	Identification	Disagree	Very agree	Identification	Disagree
Whether the teaching method of rock climbing course can mobilize learning enthusiasm and initiative	6	8	1	4	5	6
Can the practice method of rock climbing course improve the climbing skills	5	8	2	5	6	4
Is the practice mode and load intensity of rock climbing course appropriate	6	7	2	4	8	3
Do you expect to climb higher during the climbing course	7	8	0	8	6	1

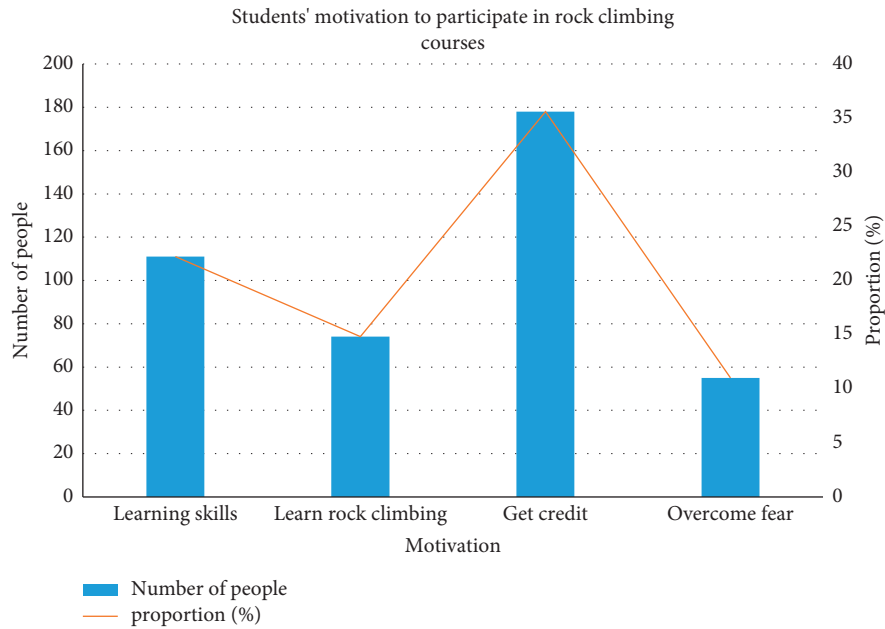


FIGURE 6: Students' motivation to participate in rock climbing courses.

fear, accounting for 11%; 49 people chose to learn climbing for their personal interests, accounting for 9.8%; twenty three people said that the proportion for participating in the competition was 4.6%; ten others were selected, accounting for 2%. After analysis, it is concluded that college students after virtual reality technology teaching have a strong interest in rock climbing courses and can accurately master the skills of rock climbing.

6. Conclusions

The most advanced computer technology is virtual reality, which has found widespread application in the entertainment, medical, military, and other industries. This technology's introduction has a significant impact on how rock climbing and traditional physical education are taught, and it hastens the reforms of physical education and physical training. With the rapid development of network technology and science and technology, virtual reality technology as a new media can improve the experience and feeling of athletes. The instruction of rock climbing at colleges and universities is used as a case study in this study to establish a teaching model for the topic. It then extends the idea to rock climbing education in colleges and institutions utilizing virtual reality technology. Three factors are investigated to determine the influence and actual impact of virtual reality on the teaching of rock climbing in colleges and universities: students' interest in learning rock climbing, their awareness of rock climbing teaching content, and their motivation for rock climbing courses. The findings indicate that using virtual reality in college rock climbing instruction has a substantial impact and can increase students' enthusiasm in learning rock climbing and skills. At the same time, 35.6% of students express that the purpose of learning rock climbing course is to obtain credit. Moreover, in future, virtual reality

technology may significantly improve the way physical education is taught, and it is also one of the greatest supplemental teaching strategies for physical education teachers [22].

Data Availability

The experimental data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors have no conflicts of interest regarding the publication of this work.

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