

Research Article

College Cross-Country Skiing Teaching and Sports Training Based on VR

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As a kind of simulation equipment that can correctly simulate skiing actions, ski simulators are widely used in ski teaching and training in colleges. With the rapid development of VR, it has been widely used in the development of ski simulator systems. This article mainly talks about the research of college cross-country skiing teaching and sports training based on VR and intends to provide ideas and directions for combining VR with college cross-country skiing teaching and sports training. This article puts forward the research methods of cross-country skiing teaching and sports training in colleges based on VR, including the literature retrieval method, expert interview method, survey method, mathematical statistics method, logical analysis summary method, ski simulator algorithm, etc. At the same time, this paper also conducts experiments on cross-country skiing teaching and sports training in colleges and universities. The experimental results in this paper show that 96.67% of students believe that the college cross-country skiing teaching and sports training system based on VR can stimulate the enthusiasm of ski training.

1. Introduction

Cross-country skiing is one of people's favorite sports. It is very popular in some countries with abundant snow resources. In school physical education in these countries (these countries mainly refer to some countries in Northern Europe), cross-country skiing is an important part of winter physical education. Cross-country skiing can not only improve the physical and mental health of students but also enhance people's spirit of not being afraid of severe cold and improve their ability to adapt to the external environment. In the process of cross-country skiing, it is necessary to continuously perform overturning movements, which can enhance the skier's physique. Integrating VR into college cross-country skiing teaching and training, the application of the sports simulation platform and its control can completely simulate the changes of people's posture in skiing, and the computer-generated ski simulation scene can provide students with visual and auditory channel feedback and then use hardware technologies such as fans to provide students with tactile and other channel feedback, so as to provide students with a real sense of skiing. For the

application of VR in skiing, the most important thing is to ensure the safety of the novice in the process of simulation training. Cross-country skiing is a sport that uses basic skills such as mountaineering, downhill, turning, and sliding to slide on the hills and snowfields with the help of ski equipment.

Lv et al. proposed a virtual reality-based immersive glasses technology for learning elementary geographic knowledge, while synthesizing many of the latest information technologies, including multimode human-computer interaction, GIS, 3D geographic information system, and virtual reality. Through the virtual reality glasses proposed by Lv et al., geographic learning software can provide an immersive geographic structure environment [1]. Chen et al. introduced the latest development of all-round video processing flow. For this type of video, in order to adapt to the input of the existing video encoding system, each image needs to be projected onto a two-dimensional plane for encoding and decoding [2]. The purpose of Menegoni et al.'s research is to explore the influence of virtual reality (VR) with interference or without interference on gait. This research analyzed the ground walking of ten healthy subjects

under different conditions: standard gait, VR gait, and VR gait instability. The results showed that the subjects who underwent the experiment in the virtual environment walked slowly, and the stride frequency (-13%) and stride length (-28%) decreased, and the support base of step width (+20%) increased. Compared with undisturbed VR conditions, many calculation parameters (not meeting standard gait conditions) have been improved. All in all, walking in VR can cause unstable gait. There are few experimental data in this study, which lack certain convincing force [3].

The innovations of this paper are as follows: (1) propose related algorithms of ski simulator; (2) propose system mechanical structure design; and (3) carry out ski simulator drive design.

2. Method of College Cross-Country Skiing Teaching and Sports Training Based on VR

2.1. Method

2.1.1. Document Retrieval Method. To understand and study the application of VR in ski teaching and sports training, according to the research content of this article, check Reading Brick Show, Baidu Academic, SpringerLink, CNKI, International Philosophy and Social Science Documentation Center, and Wanfang Data knowledge service platform, search and retrieve keywords such as “virtual reality, college cross-country, ski teaching, and sports training,” and carefully summarize and analyze by consulting related literature materials such as ski teaching and training, VR, teaching methods, and theories [4].

2.1.2. Expert Interview Method. According to the research direction of this article, through interviews with excellent skiers and other senior ski instructors, experts and scholars, and other related experts and scholars, analyze and discuss the role and application of VR in teaching and listen carefully to expert opinions and adopt them [5,6].

2.1.3. Investigation Method. This study visited large-scale ski resorts with relatively good equipment and facilities and conducted a questionnaire survey on teachers and students in 10 colleges and universities related to the experiment [7].

2.1.4. Mathematical Statistics. Use SPSS17.0 software and Microsoft Excel statistical software to summarize and count the data collected in the survey through the computer [8].

2.1.5. Logic Analysis Summary Method. In order to make the research results more scientific, this survey uses logical analysis and induction, analysis, classification, and summary methods [9].

2.2. Ski Simulator Dynamic Calculation. The COZE50 series electric cylinder is selected. The basic lead S of the electric cylinder screw is 5 mm. The minimum stroke L is 500 mm and the maximum is 1200 mm, which can meet the needs of

the system. Its movement speed is up to 0.25 m/s, satisfying the system demand for the movement speed of the electric cylinder [10]. The maximum lifting speed of the platform is 100 mm/s, and the total load M_3 of the moving platform is 200 kg. From the power conservation relationship, the following formula can be obtained, where F represents the endurance of the electric cylinder, V represents the linear speed of the electric cylinder, T represents the output torque of the motor, n represents the rotation speed of the motor, and m represents the transmission efficiency of the electric cylinder:

$$F \cdot V = T \cdot n \cdot m. \quad (1)$$

Since this system uses three electric cylinders to directly connect with the upper platform and there will be downward acceleration when the platform moves vertically, the bearing capacity of a single electric cylinder needs to be recalculated [11]. Under normal circumstances, the downward acceleration a value is too small. This system takes $a = 0.6g$ to ensure sufficient margin. The connection points of the three cylinders and the upper motion platform are evenly distributed on the platform to support the upper platform together. By consulting the relevant literature, it is concluded that the three electric cylinders bear slightly different platform forces [12]. The electric cylinder with the largest load is 1.131 times the average load. Here, the maximum thrust of the electric cylinder is set to 1.3 times the average load to fully ensure the carrying capacity of the moving platform and effectively improve the operation and safety performance of the system [13].

Assuming that the bearing capacity of a single cylinder is F_1 , the following formula exists :

$$F_1 = M_3(a + g) \cdot \frac{1.3}{3}. \quad (2)$$

The linear speed of the electric cylinder and the motor speed have the following relationship :

$$V = \frac{S \cdot n}{2\pi}. \quad (3)$$

Substituting formula (3) into the power conservation expression, we can get

$$T = \frac{F \cdot S}{2\pi m}. \quad (4)$$

The formula for calculating the maximum torque output by the motor is

$$T_{\max} = \frac{F_1 \cdot S}{2\pi m}. \quad (5)$$

The formula for calculating the maximum motor speed is

$$n_{\max} = \frac{V_{\max}}{S}. \quad (6)$$

The formula for calculating the rated power P_e is

$$P_e = \frac{F_1 \cdot V_{\max}}{m}. \quad (7)$$

Through the calculation of the above formula, we can better set the specific system-related parameters, so that the set system parameters are optimal.

2.3. Signal Preprocessing Algorithm of Ski Simulator. Because oscillation caused by the discontinuous signal sent by the ski VR scene may threaten the safety of skiers, the input signal (mainly the deflection angle) needs to be pre-processed [14]. In addition, the movement schedule of the ski platform is limited, and continuous descent movement cannot be simulated. This article needs the ski platform to simulate the actual ski downhill feeling within the limited itinerary [15, 16].

2.3.1. Delivery System. It can be seen from the above results that the establishment of the stepping system needs to go through a cycle of data, and each stepping system can be correctly represented by the mathematical model [17]. The following transfer functions are present in the first-order system.

$$\varphi(s) = \frac{1}{Ts + 1}. \quad (8)$$

Assuming that the correct description of the model can be explained by the main transfer function, it is very important to correctly find the appropriate T value because only by finding the appropriate T value as a parameter can the geometric mean in the main transfer function be resolved for related issues [18]. If the input is the unit step function $R(t) = L(t)$, the unit step response function can be calculated according to the following formula:

$$h(t) = L - e^{-t/T}, \quad t \geq 0. \quad (9)$$

The transfer function is

$$\varphi(s) = \frac{1}{5s + 1}. \quad (10)$$

2.3.2. Discretization of the Delivery System. Because the computer system is a discrete system, the computer cannot directly recognize the continuous step function mentioned above, so the continuous function must be discretized to be recognized by the computer [19].

Assuming that $G(s)$ is a continuous object in a broad sense and $G(z)$ is a discrete object in a broad sense, the following formula expresses the elements that must be satisfied by the pulse transfer function of the generalized object:

$$G(z) = f \left[\frac{L - e^{-sT}}{s} G(s) \right]. \quad (11)$$

Next, a heuristic method is used to determine the structure of the controller $G(z)$.

$$D(z) = K_c \frac{z - z_c}{z - p_c}, \quad (12)$$

where z_c represents the zero point of a real number and p_c represents the pole of a real number in the unit circle. The following are some restrictions on $D(z)|_{z=1} = 1$ and K_c .

$$K_c = \frac{1 - p_c}{1 - z_c},$$

$$G(z) = f \left[\frac{L - e^{-sT}}{s} \frac{a}{s + a} \right] \quad (13)$$

$$= \frac{1 - e^{-aT}}{z - e^{-aT}}.$$

Difference equation is as follows:

$$c(k + 1) = c(k) + T \left[-\frac{L - e^{-aT}}{T} c(k) + \frac{1 - e^{-aT}}{T} u(k) \right]. \quad (14)$$

Substitute the transfer function into

$$y(k) = 0.9874c(k) + 0.0207u(k), \quad (15)$$

$$c(k + 1) = 0.0146c(k).$$

Try to keep the movement curve smooth, not only to ensure the smooth running of the ski platform but also to prevent serious safety accidents.

This article uses the above-mentioned methods in the study of cross-country skiing teaching and sports training in colleges and universities in VR. Figure 1 shows the flowchart of the VR-based ski teaching and sports training research method [20, 21].

3. College Cross-Country Skiing Teaching and Sports Training System Based on VR

3.1. Overall System Design

Demand Analysis. The designed system should be popularized in colleges and universities, with high simplicity and low cost.

3.1.1. Architecture. Modeling is the first step of system development, and only after the modeling is completed can it provide a basis for the creation of 3D images and so on. In general, it is recommended to use Matlab in mathematical modeling, but some topics need to deal with “a lot of data,” which may not be so convenient in Matlab compared to other languages. In this case, you can choose Python and other programming languages that have become popular in recent years. Next, describe the script to complete the functions required by the system.

3.1.2. Development Tools. C4D, 3DMAX, and VR development software programs are the most commonly used tools in system development. Ski simulator design principles are as follows.

- (1) **Security.** Since this system will make the experimenter make certain physical movements, the system must

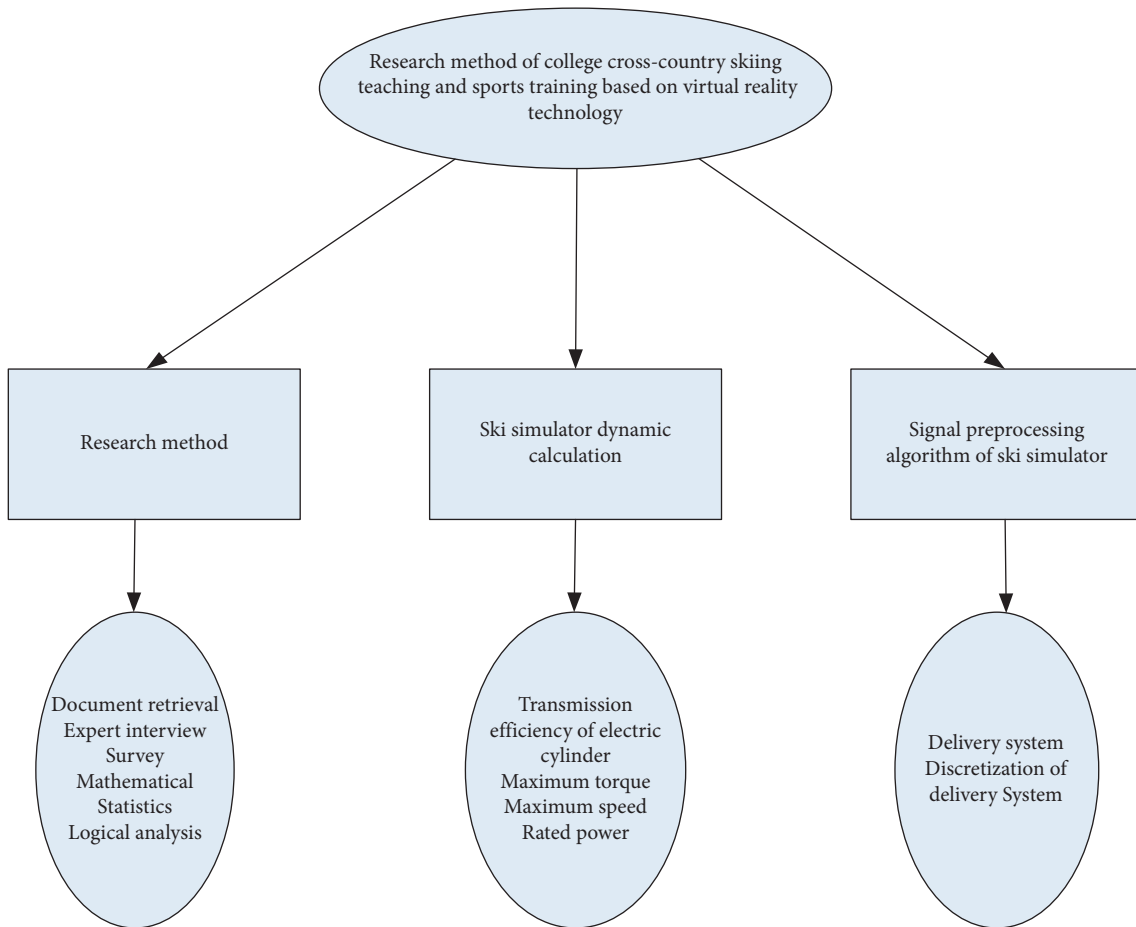


FIGURE 1: Part of the technical flowchart of this method.

strictly follow the safety principle to ensure the overall safety of the system and the safety of the experimenter during the experience.

- (2) *Stability*. The stability of the system is an important goal that must be achieved.
- (3) *Practicality*. The design of the system should meet the experience requirements of the experimenter, so that the experimenter can fully experience the fun of the entire skiing process, and enhance the authenticity of the simulated skiing by adding auxiliary devices such as fans.
- (4) *Advancement*. The current advanced technology is used in the selection of the system and method design to ensure the reliable performance of the system functions, and its overall level has reached the leading level of domestic counterparts [22]. In order to ensure the stability of the system, this paper uses the corresponding sensor technology to conduct real-time monitoring of the system before improving the system to ensure the stable operation of the system.
- (5) *Flexibility*. The entire support platform uses the standard interface, which is easy to maintain and has the ability to flexibly expand.

3.2. Mechanical Design

3.2.1. Selection of Platform Structure. A three-degree-of-freedom parallel mechanism is used to simulate the main hardware platform in the virtual ski. The upper surface is preliminarily determined as a rigid body loading surface to realize the activities of three simulated degrees of freedom of pitching, rolling, and vertical displacement.

3.2.2. Platform Organization Composition. The movement is mainly composed of a fixed bottom base surface, three cylinders that can achieve telescopic and axis rotation, and a top load surface that can achieve pitch, flip, and up and down displacement. The simulator stands on the pedals and simulates skiing through three cylinders and can simulate a variety of actions.

3.3. Drive Design

3.3.1. Drive Mode Selection. The mechanism chooses the electric drive mode, and the design of the servo electric cylinder module becomes the main component of the motion platform. In this paper, the system chooses the DC servo motor as the drive motor and the servo drive as the control host.

TABLE 1: Experimental steps in this article.

Design of college cross-country skiing teaching and sports training system based on VR	3.1	Overall system design	1	Architecture
			2	Development tools
	3.2	Ski simulator design principles	1	Safety
			2	Stability
			3	Practicality
			4	Advancement
			5	Flexibility
	3.3	Mechanical design	1	Platform structure selection
			2	Platform organization
			1	Drive mode selection
	3.4	Drive design	1	Drive mode selection
			2	Servo motor drive mode selection

TABLE 2: The survey respondents' evaluation of the importance of different ski teaching and training stages.

Serial number	Teaching stage	Expert evaluation		Student evaluation	
		Men	Women	Men	Women
1	Adapt to skiing	4.67	4.35	4.54	4.72
2	Adapt to ski equipment	4.31	4.29	4.62	4.38
3	Basic technology learning	4.26	4.41	4.13	4.31
4	Mastery of rhythm and balance	4.11	4.72	4.22	4.57
5	Improve skiing skills	3.78	3.56	3.91	3.84

3.3.2. *Selection of the Drive Mode of the Servo Motor.* If there are certain accuracy requirements for position and speed, but no special requirements for real-time torque, select speed or position control mode; in terms of the response speed of the drive, although the position mode has a large amount of calculation, its control signal response speed can meet the needs of general equipment.

This experiment part proposes that the above steps are used in the design experiment of college cross-country skiing teaching and sports training system based on VR. Table 1 shows the specific process of the second experiment [23].

4. College Cross-Country Skiing Teaching and Sports Training Experiment Based on VR

4.1. Analysis of Survey Results

4.1.1. *The Survey Respondents' Evaluation of the Importance of Different Ski Teaching and Training Stages in VR.* The questionnaire of this study set the importance of evaluation of the respondents on different ski teaching and training stages. 50 skiers with roughly the same skiing time were randomly selected from the respondents, and the importance level was set from high to low of 1 to 5 points, statistical analysis on the survey results was carried out (the results were averaged), and they are drawn into Table 2 and Figure 2. The main purpose of distinguishing gender is to better study the effect of gender on the effect of ski simulation.

From the picture, we can see that most people think that getting used to skiing is the most important thing in the process of skiing teaching, and then getting used to skiing equipment, basic learning, and improving skiing skills are the second most important. According to the survey results, the importance of adapting to skiing is the most important, followed by adapting to ski equipment. Whether it is

learning effect or self-safety, it must be taken into account, which is important to control the balance of the body and reduce potential danger and injury.

4.1.2. *The Survey Respondents' Evaluation of the Importance of Different Skiing Technical Links in VR.* The questionnaire of this study set the survey respondent's evaluation of the importance of different ski technical links, and set the importance level from high to low of 1 to 5 points. Statistical analysis was performed on the survey results (the results were averaged), and the results are drawn into Table 3 and Figure 3.

It can be seen from the chart that teachers generally believe that plow downhill is the most important technical link. This is because only after mastering the plow down technology can you learn plow stopping, plow turning, and half plow turning techniques. It is also one of the most important basic technical links to improve skiing skills.

4.1.3. *Willingness of Teachers and Students.* In this study, the questionnaire set up related questions about whether teachers and students are willing to use VR for skiing teaching and training. The results of the questionnaire were statistically sorted and graphed, as shown in Table 4 and Figure 4.

According to the figures in the chart, the proportion of teachers who are willing to use VR for ski teaching and practice is 65.12%; the proportion of students who are willing to use VR is 79.23%; there are many teachers and students who do not want to use VR to teach and practice ski board.

4.2. Questionnaire Reliability Analysis

4.2.1. *Questionnaire Validity Test.* In order to make the whole questionnaire survey more feasible, the content of the

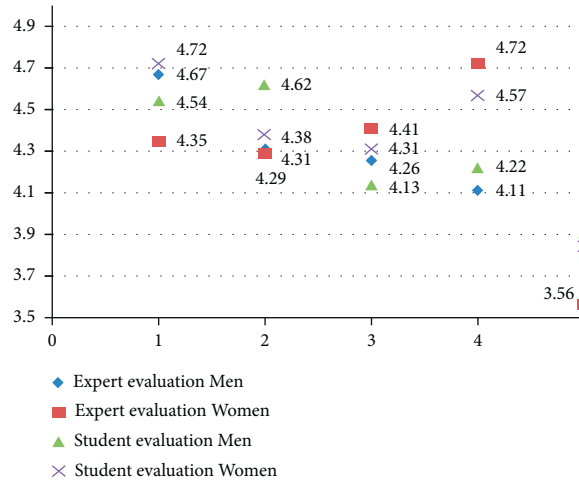


FIGURE 2: The survey respondents' evaluation of the importance of different ski teaching and training stages.

TABLE 3: The survey respondents' evaluation of the importance of different skiing technical links.

Serial number	Technical link	Expert evaluation		Student evaluation	
		Men	Women	Men	Women
1	Plow down	4.67	4.54	4.49	4.71
2	Putting on and taking off equipment	4.49	4.27	4.51	4.63
3	Plow stop	4.51	4.63	4.23	4.54
4	Semi-plow turn	4.62	4.55	4.64	4.50
5	Valley siding	4.28	4.21	4.58	4.51
6	Parallel turns	4.19	4.72	4.49	4.81
7	Straight knee double board parallel turn	4.31	4.54	4.31	4.67
8	Slide down	4.22	4.37	4.28	4.36
9	Ramp	4.56	4.21	4.37	4.24
10	Propulsion	4.27	4.36	4.54	4.39
11	Ski rhythm practice	4.16	4.41	4.21	4.28
12	Plow turn	4.25	4.18	4.29	4.31

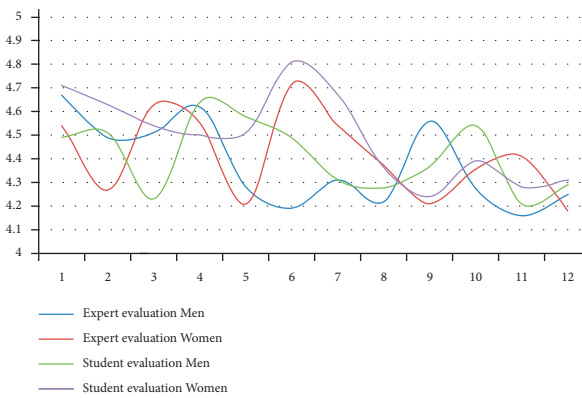


FIGURE 3: The survey respondents' evaluation of the importance of different skiing technical links.

TABLE 4: Willingness of teachers and students.

Willingness	Teachers (%)	Students (%)
Very willing	65.12	79.23
Willing	22.04	12.87
General	9.42	6.54
Reluctant	2.61	1.15
Very reluctant	0.81	0.31

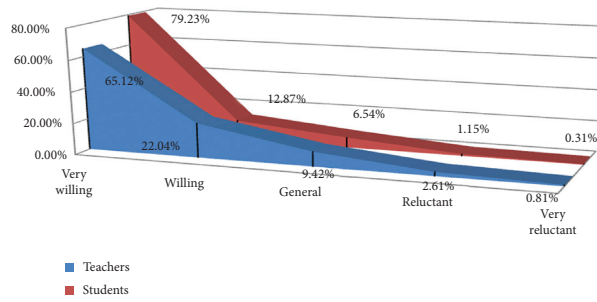


FIGURE 4: Willingness of teachers and students.

TABLE 5: Questionnaire design satisfaction survey.

Evaluation standard	Very reasonable	Reasonable	Basically reasonable	Not reasonable	Not reasonable at all
Questionnaire structure	6	5	2	2	0
Questionnaire content	4	7	3	1	0
Questionnaire logic	3	4	4	3	1
Questionnaire design	7	5	2	1	0

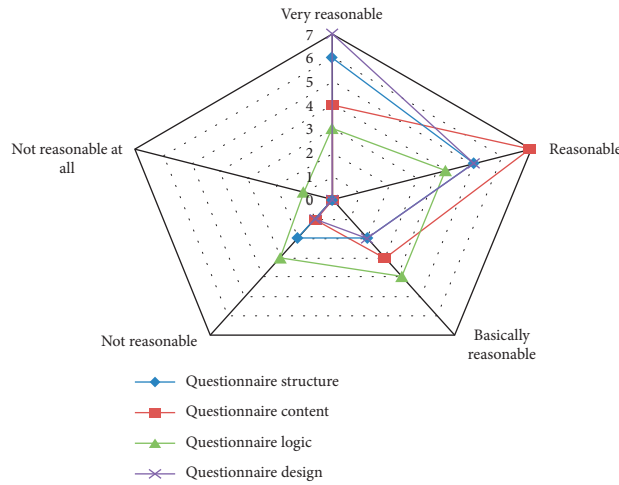


FIGURE 5: Questionnaire validity test.

TABLE 6: Questionnaire reliability test results.

	Questionnaire structure	Questionnaire content	Questionnaire logic	Questionnaire design
Correlation coefficient (r)	0.96	0.97	0.95	0.94

TABLE 7: Trial feedback.

Trial feedback		Number of people		Percentage	
		Students	Teacher	Students	Teacher
1	Stimulate training enthusiasm	29	21	96.67%	70.00%
2	Enrich the learning process	27	23	90.00%	76.67%
3	Novelty	28	19	93.33%	63.33%
4	Challenging	26	16	86.67%	53.33%
5	Improve concentration	22	24	73.33%	80.00%
6	Exploratory	29	19	96.67%	63.33%
7	Pleasure	25	16	83.33%	53.33%
8	There is a gap with the actual experience	6	11	20.00%	36.67%

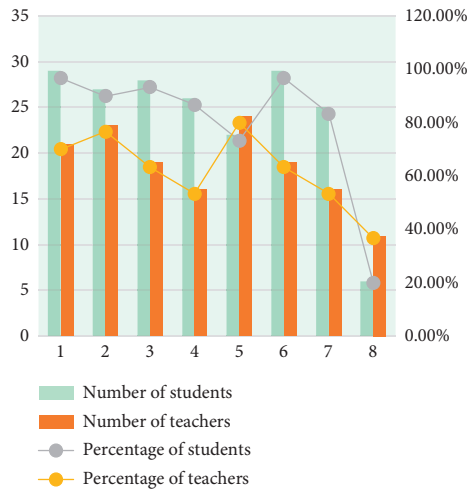


FIGURE 6: Trial feedback.

whole questionnaire survey was reviewed before this experimental survey, and the main reviewers were some famous ski experts. The content of the interview mainly involved how to better improve the ski simulation, as well as related issues that need to be considered in the actual skiing process. Table 5 and Figure 5 show the evaluation of the content of this survey questionnaire by ski experts.

From the data in the figure, it can be concluded that most scholars are satisfied with this survey, and most of them have given high evaluations to the design of the questionnaire.

4.2.2. Questionnaire Reliability Test. This article mainly applies the test-retest reliability analysis method in the questionnaire reliability testing process. Use SPSS17.0 software to further analyze and sort out the results of the questionnaire survey. The test results are shown in Table 6.

According to the data in the table, it can be concluded that the average value of the questionnaire reliability correlation coefficient r is 0.955.

4.3. Trial Analysis of Ski Simulator. With 30 teachers and students as the research objects, the students were divided into two groups. Each lesson included a set of intervention exercises for 20 minutes. The participants wore head-mounted displays and controllers to practice the technical movements of the ski simulator. The teacher observes and corrects errors. The results are shown in Table 7 and Figure 6.

It can be seen from the chart that the skiing teaching and sports training system based on VR designed in this paper has been well received. 96.67% of the students and 70.00% of the teachers think that the system can stimulate the enthusiasm of skiing training; 93.33% of the students think that the system is novel, 96.67% of the students think that the system is exploratory, and 83.33% of the students think that the experience is based on virtual reality. The skiing process of technology is pleasant; a small number of teachers and students think that there is a big gap between the system and the actual skiing experience.

5. Conclusions

In recent years, researchers have increased the promotion of the application of virtual reality in many fields such as virtual design and teaching. The students also greatly improved their cognitive level through virtual reality technology. It is of great significance to continuously optimize and upgrade the virtual skiing teaching mode and learner participation methods, which will play a role in promoting the development of the education industry.

Data Availability

No data were used to support this study.

Conflicts of Interest

The author declares that there are no conflicts of interest.

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