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Discussion on the new mode of teaching reform for the specialty of soil and water conservation and desertification control--An innovative strategy to improve the teaching of soil and water conservation planning and design course based on virtual simulation technology

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Abstracts Teaching in the specialty of soil and water conservation and desertification control faces challenges such as limited practical teaching resources, restricted experimental sites, and long observation cycles. This study explores the innovative strategy of applying virtual simulation technology to the teaching reform of soil and water conservation and desertification control specialty. By constructing a virtual laboratory organizational structure with vertical support and horizontal openness, a multifunctional virtual simulation experimental teaching platform is established to optimize the teaching of soil and water conservation and desertification control professional courses. The research adopts coordinate system design, basic transformation, data resource library and illumination technology to construct the virtual scene, and optimizes the experimental scene through the fusion of binary projection image generation and significant feature extraction. The experimental evaluation adopts the method of pre and post-test comparison and independent sample t-test, and the experimental class and control class students are selected to carry out a semester-long teaching experiment. The results show that the average value of students' practical ability posttest score in the experimental class under virtual simulation teaching is 53.19 points, which is 6.43 points higher than that of 46.76 points in the control class (P<0.001); the average score of the course after the teaching reform is increased to 84.63 points, which is 7.26 points higher than that before the reform; the students' enhancement is most significant in the dimension of information and technological literacy, with a difference of 1.7 points (P<0.001). The experiment proves that the teaching mode of soil and water conservation and desertification control specialty based on virtual simulation technology can effectively improve students' practical ability and learning interest, and provides an effective way to solve the problems of limited practical teaching resources and long observation period in traditional teaching.

Index Terms Virtual simulation technology, soil and water conservation, desertification control, teaching reform, practical ability

I. Introduction

In the 20th century resource depletion has been faster, especially the destruction of soil and water resources. Land desertification and soil erosion may be caused by natural factors such as climate change, geological formations, and geomorphological patterns, resulting in the destruction of soil and water resources [1], [2]. Soil erosion and desertification have led to the damage of agricultural production, the reduction of biodiversity, the continuous deterioration of the ecological environment, exacerbated the frequency of natural disasters such as droughts, floods and other natural disasters and the degree of harm, leading to land degradation, water resource pollution and other environmental problems, the deterioration of the human living environment, seriously restricting the sustainable development of the society and the economy, and it is the primary problem of the world's environmental governance [3]-[7]. Soil and water conservation and desertification control is a key link in the construction of ecological civilization and has become a global concern.

Soil and water conservation and desertification control through the protection and improvement of water and soil, strengthen the efficient use of soil and water resources, vegetation planting and protection, improve the ecosystem cycle, optimize the space of the national territory, coordinate the contradiction between man and land, and then create green mountains and green water, and achieve ecological restoration [8]-[10]. Soil and water conservation and desertification control is a comprehensive discipline covering theoretical knowledge of society, economy, engineering, technology, etc., which is based on the governance and restoration of soil erosion and desertification, and serves the sustainable development of society and economy [11]. Based on the urgency of soil erosion and ecological environment restoration, the specialty of soil and water conservation ecological construction and desertification prevention and control has been established as an important basic project for economic and social development in the 21st century. However, the limitations of the current teaching mode of this specialty are highlighted. The design and planning related courses involved in teaching are dominated by two-dimensional design drawings, which are not conducive to the three-dimensional evolution of topographic terrain display [12]. And part of the practice teaching environment is poor, there are safety hazards, and due to seasonal and geographical limitations, practice teaching in the Loess Plateau and karst landscape and other environments can not be observed with other professional courses on a regular basis, the interactivity and the real experience of the opportunity is less, the students are difficult to devote themselves to the teaching [13]. In this context, virtual simulation technology through three-dimensional modeling, human-computer interaction, etc. to build a more realistic practical teaching environment, enhance student interactivity and make immersive experience, thus solving the above problems and enhancing the teaching effect of students [14], [15].

Soil and water conservation and desertification control, as an important specialty for solving ecological environment problems, is of great significance to the construction of ecological civilization in China. However, the teaching of this specialty faces the problems of limited practical teaching resources, restricted experimental sites, and long observation cycles. Traditional teaching methods are difficult to visualize the complex process of soil erosion and desertification formation, and students' understanding of related knowledge stays on the surface, lacking in-depth perception and practical operation ability. As a professional core course, soil and water conservation planning and design course includes the application of soil and water conservation principles and measures, and its teaching quality is directly related to the cultivation effect of students' professional ability. At present, there are problems in the teaching of this course, such as disconnection between theory and practice, abstract teaching content, single teaching method, etc., which restricts the development of students' practical ability and innovative thinking. The development of modern information technology provides new ideas for solving these problems, virtual simulation technology as a new type of teaching means, through the construction of virtual environments and simulation of real scenes, can break the time and space constraints, to provide students with immersive learning experience. How to effectively integrate virtual simulation technology into the teaching of soil and water conservation and desertification control has become an important research direction of the current teaching reform. The status quo that the training system of soil and water conservation and desertification control majors in colleges and universities across the country is not uniform, balanced and perfect requires us to explore the establishment of a cross-regional and multi-school collaborative teaching platform, integrate high-quality teaching resources, and jointly improve the quality of professional teaching. The construction of virtual simulation laboratory can help students break through the geographical restrictions, observe the soil and water conservation situation in different regions, understand the applicable conditions and effect differences of various control measures, so as to improve the ability to comprehensively analyze and solve problems. At the same time, virtual simulation technology can also visualize the slow process of soil and water conservation, show the spatial similarities and differences in the development of soil and water conservation, and help students quickly and accurately grasp the pattern of change in the occurrence and development of desertification.

Based on the above background, this study proposes an innovative strategy to improve the teaching of soil and water conservation and desertification control majors based on virtual simulation technology. By constructing a virtual laboratory and a virtual simulation experimental teaching platform, the study establishes a “vertical and horizontal” organizational structure to realize the four major functions of talent cultivation system construction, curriculum resource sharing, first-class curriculum construction and teachers' teaching ability improvement. The study adopts coordinate system design, basic transformation, data resource library and illumination technology to construct virtual scenes, and optimizes the experimental scenes through the integration of binary projection image generation and salient feature extraction, in order to provide a new mode for teaching soil and water conservation and desertification control. The study selects experimental classes and control classes to carry out teaching experiments for one semester, and evaluates the effect of virtual simulation teaching through pre and post-test comparisons and independent sample t-tests, verifies the influence of this teaching mode on students' practical ability and learning interest, and provides practical basis and theoretical support for the teaching reform of the specialty of soil and water conservation and desertification control.

II. Teaching construction of soil and water conservation simulation course based on virtual simulation technology

II. A. Construction of a virtual classroom in the field of soil and water conservation and desertification control

II. A. 1) Classroom organization

The advantage of the virtual laboratory lies in openness and cooperation, and the platform aims to serve teachers, break through spatial barriers, open fair and open communication channels, and realize efficient collaboration [16]. Soil and water conservation and desertification control professional virtual laboratory under the premise of ensuring normality and rigor, highlighting the word service, and strive to provide a good platform for all teachers in the laboratory to carry out teaching and research work. Therefore, this paper proposes a vertical support, horizontal open "one vertical and one horizontal" type of virtual laboratory organizational structure, as shown in Figure 1.

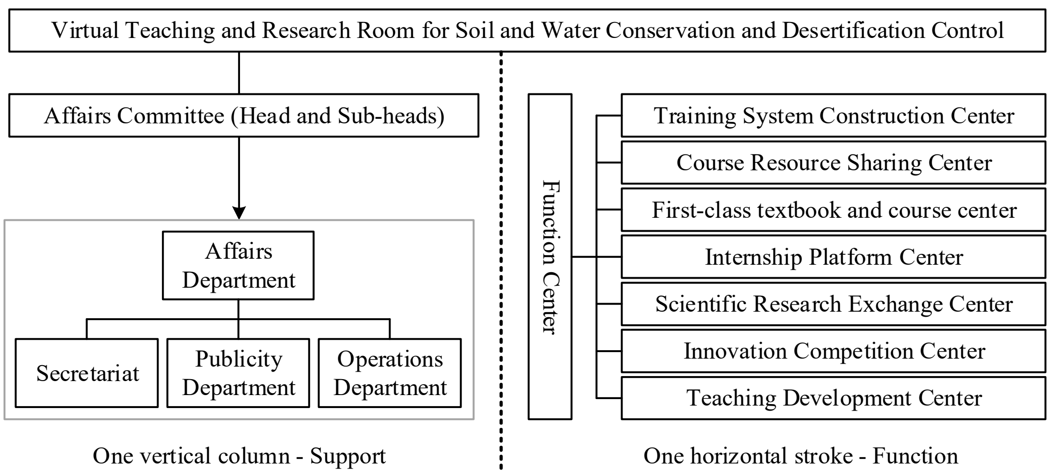

Figure 1: Organizational structure of the Virtual laboratory

II. A. 2) Construction content

In order to achieve the overall construction goal, the following four core teaching and research functions are planned for the virtual laboratory of soil and water conservation and desertification control with seven functional centers [17].

(1) Talent training system construction

Scientific and sound personnel training system is a prerequisite to ensure the effect of educating people, and at the present stage, soil and water conservation and desertification control majors are facing the status quo that the training system of colleges and universities across the country is inconsistent, unbalanced and imperfect, and colleges and universities are in a self-contained and independent state in every aspect of personnel training such as the discipline system, the teaching system, the teaching material system, the management system, etc., which greatly restricts the study of students for further study, internship, employment and cross-regional exchanges. Employment and cross-regional exchanges. Therefore, the virtual laboratory firstly starts from the talent cultivation system, strengthens the communication and discussion on the cultivation of professional talents in soil and water conservation and desertification control among colleges and universities, benchmarks the requirements of national-level discipline construction, revises the professional talent cultivation mode through cross-school cooperation, and sorts out the professional curriculum system, so as to realize the unity of the professional talent cultivation system in the whole country. This part of the work is based on the meeting function of the virtual laboratory platform, which is jointly negotiated by the participating units. At present, nearly 10 colleges and universities have carried out interactive discussions on the talent cultivation system for the specialty of soil and water conservation and desertification control.

(2) Curriculum Resource Sharing Construction

Curriculum resources are the basis for education and teaching. Teachers uphold the concept of "sharing and win-win" and upload course resources into the knowledge base according to the categories of syllabus, teaching design, teaching cases, teaching courseware, teaching videos and electronic teaching materials to realize the sharing and common construction of multiple schools. The virtual lab divides the courses into three major groups: basic theory group, scientific research training group and professional application group. Among them, the basic theory group is divided into 6 modules of water, soil, gas, life, earth and force according to the course content, and the professional application group is divided into 3 modules of technology, engineering and management, thus forming a complete course classification system for the specialty of soil and water conservation and desertification control. Based on the hyperlinks of the course system, faculty members of the virtual laboratory can locate courses, access, upload and share course resources.

(3) Curriculum construction

First-class teaching materials and courses are the direct reflection of professional teaching quality. The Virtual Laboratory of Soil and Water Conservation and Desertification Control strives to integrate advantageous resources, realize inter-university first-class course/teaching material planning, member formation, joint declaration, first-class course sharing across universities, first-class course construction experience sharing and guidance, and jointly improve the construction quality of professional courses through the leadership of famous teachers, multiple people and one course, and displaying their own strengths. Meanwhile, the virtual laboratory has planned a number of inter-university cooperative teaching materials, such as the revised and published teaching materials “Desertification Control” (2021), “Wind and Sand Physics” (2022), etc., which are co-written by a number of universities, such as Beijing Forestry University, Southwest Forestry University, Shandong Agricultural University, Inner Mongolia Agricultural University, etc., and have been generally recognized by the industry, and the acceptance and usage of the cooperative teaching materials have been compared with the previous version The acceptance and utilization rate of the cooperative teaching materials have been greatly improved compared with the previous version. Under the trend of “Internet+” era, the Virtual Laboratory of Soil and Water Conservation and Desertification Control will focus on the innovative construction of three-dimensional teaching materials and digital teaching materials in the future.

(4) Enhancement of Teachers' Teaching Ability

To realize the improvement of teachers' teaching ability and the improvement of teaching quality, high-quality training suitable for professional teachers, regular quality monitoring and information feedback are indispensable. The virtual laboratory of soil and water conservation and desertification control is intended to rely on the platform's collaborative lesson preparation, seminars and other activities, so that teachers can get multifaceted, in-depth and immediate feedback from their peers, and help them to understand their own strengths and shortcomings. At present, the virtual laboratory platform has completed the collaborative construction of knowledge maps for three core courses, namely “desertification control science”, ‘biogeochemistry’ and “wind and sand physics”. At the same time, the virtual laboratory relies on activities such as open demonstration classes, gives full play to the demonstration and leading role of national teaching teams, demonstration centers and master teachers, carries out the training of teaching skills and sharing of innovative teaching methods, and provides references to the updating of the teaching concepts of the teachers of the specialties of soil and water conservation and desertification control, the innovations of teaching methods and the changes of teaching methods, thus comprehensively upgrading the teaching ability and quality of the teachers of the specialties.

II. B.Virtual Simulation Experimental Teaching

Soil and water conservation and desertification control show virtual simulation experimental teaching, in order to comprehensively enhance students' practical and innovative ability, improve the quality of teaching, and provide social services for the purpose of the principle of soil and water conservation based on the specificity of the principle of soil and water conservation and the objectives of experimental teaching, based on the idea of “thick foundation, wide aperture, innovation, high level,” through the process of quantitative analog simulation Based on the idea of “thick foundation, wide aperture, innovation and high level”, through the combination of quantitative process simulation and virtual scene three-dimensional reproduction, the mechanism verification experiment and scientific exploratory experiment, and advanced virtual simulation technology as a carrier, it promotes the students to change from perceptual thinking to rational thinking. The simulation system contains 8 display modules. Through virtual simulation to simulate the mechanism of desertification control, to avoid the dangerous environment of real experiments, with soil and water conservation and desert control as the core, to show the spatial and temporal distribution of soil and water conservation. Through virtual simulation to show different characteristics of soil and water conservation, the slow process of soil and water conservation visualization, soil and water conservation development of spatial similarities and differences, classified to show out, focusing on different time scales and spatial scales in the process, to help students quickly and accurately grasp the desertification occurs in the development of change.

III. Establishment of virtual simulation experimental teaching scenarios

III. A. Virtual Simulation Key Technology

III. A. 1) Coordinate system

Virtual simulation system involves the virtual three-dimensional environment of the object translation rotation collision and other problems, these problems are mainly solved by geometric transformations and coordinate calculations, and other three-dimensional environment related software, the form of the coordinate system and the transformation is very important, excellent coordinate system design can improve the quality of interactive algorithms and save the three-dimensional model transformations of the memory consumption.Virtools in the main coordinate system include: the world coordinate system, local coordinate system, screen coordinate system. World coordinate system, local coordinate system, screen coordinate system. The most basic requirement of computer 3D graphics is to display the 3D model in 2D screen coordinates. In the virtual world there are many objects, each object has its own position, direction and size. In order to express the relationship between these objects in terms of distance, proximity, and size, a world coordinate system is defined as the datum for all references. The world coordinate system is used for the spatial localization of all objects in the interactive environment, and each object uses a three-dimensional vector to determine its position in the interactive environment. The local coordinate system is defined relative to each object, using its own center position as a reference, which represents the position and direction relationship of each vertex of the object. While the world coordinate system determines the position of an object, the local coordinate system determines the orientation of each part of the object. Screen coordinate system with two-dimensional vectors to determine the location of three-dimensional objects or two-dimensional objects in the screen, if the size of the activation window will be different, the coordinate system will be different, Virtools coordinate system to the upper-left corner of the window screen as the origin, horizontally to the right for the direction of the x-axis, vertically down for the direction of the y-axis, the use of the screen coordinate system can be determined and determine the location of the two-dimensional frame.

III. A. 2) Basic transformations

The movement and shape change of the 3D model in the virtual scene is accomplished through the point, line, surface, and coordinate system transformations of the model, and the basic transformations involved in this paper include translation transformations and rotation transformations [18].

(1) Translation transformation

Translational transformation refers to the process of moving any point M in the space in world coordinates from one coordinate position to another along a linear path. Let the initial position coordinate of point M be (x,y,z), and the position coordinate after translation be $(x^{'},y^{'},z^{'})$, and let the translation vector be (T_x,T_y,T_z), which represents the distance moved by point M in X-axis, Y-axis and Z-axis respectively. Then the process of translational transformation is expressed by Eq:

$$\begin{cases} x^{'} = x+T_x \\ y^{'} = y+T_y \\ z^{'} = z+T_z \end{cases} \tag{1}$$

With the introduction of the three-dimensional transformation matrix, if expressed in chi-square coordinates, the equation for the translation transformation can be written as:

$$\begin{aligned} \begin{bmatrix} x^{'} & y^{'} & z^{'} & 1 \end{bmatrix} &= \begin{bmatrix} x & y & z & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ T_x & T_y & T_z & 1 \end{bmatrix} \\ &= \begin{bmatrix} x+T_x & y+T_y & z+T_z & 1 \end{bmatrix} \end{aligned} \tag{2}$$

(2) Rotational transformation

Rotational transformation refers to the process of reorienting a 3D model by rotating it around a coordinate axis, thus rotation changes the orientation of the model. Equation (3) a (5) is the transformation matrix, where α,β,θ is the rotation angle of the 3D model around the X-axis, Y-axis and Z-axis respectively:

$$T = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos\alpha & \sin\alpha & 0 \\ 0 & -\sin\alpha & \cos\alpha & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \tag{3}$$

$$T=\begin{bmatrix}\cos\beta & 0 & -\sin\beta & 0\\ 0 & 1 & 0 & 0\\ \sin\beta & 0 & \cos\beta & 0\\ 0 & 0 & 0 & 1\end{bmatrix} \tag{4}$$

$$\mathrm{T}=\begin{bmatrix}\cos\theta & \sin\theta & 0 & 0\\ -\sin\theta & \cos\theta & 0 & 0\\ 0 & 0 & 1 & 0\\ 0 & 0 & 0 & 1\end{bmatrix} \tag{5}$$

III. A. 3) Data repository

A large number of data resources through the logic statement control to build a complete virtual simulation system, these data resources include: 2D frames, 3D models, arrays, materials, textures, mapping, cameras, animation, groups, lighting and so on. In order to efficiently manage these resources, in the virtual system design before the start, first of all in the Virtools environment to build a folder called DataResourees as a data resource library, and then all the resources that need to be used into the DataResourees in the corresponding sub-folder. During the design process, you can add the needed resources to the 3D Layout at any time.

III. A. 4) Illumination

In the real world, all kinds of light strikes an object, some of it is absorbed by the object, some of it is reflected by the object, and some of it is picked up by the eye, so that things can be seen clearly. There are three types of light available in Virtools to simulate the effects of natural light: directional light, point light, and spot light. Figure 2 shows a schematic diagram of the lighting types. Figures (a)-(c) represent directional light, point light, and spot light, respectively.

(1) Directional Light. Consists of a set of parallel rays of light traveling through the scene in parallel and in the same direction. Directional light is not attenuated and affected by distance. The system is minimally burdened by this light relative to the other two forms of light, as shown in Figure 2(a).

(2) Point light source. With the location of the light source as the center, light is emitted in all directions, and this light attenuates with the distance from the object, as shown in Figure 2(b).

(3) Spot light. A light that forms a conical area of light from the light source position. Spotlight will increase with the distance, the irradiation range also becomes larger, the brightness will also be attenuated, and only in the light formed within the conical area of the object can be illuminated, as shown in Figure 2 (c).

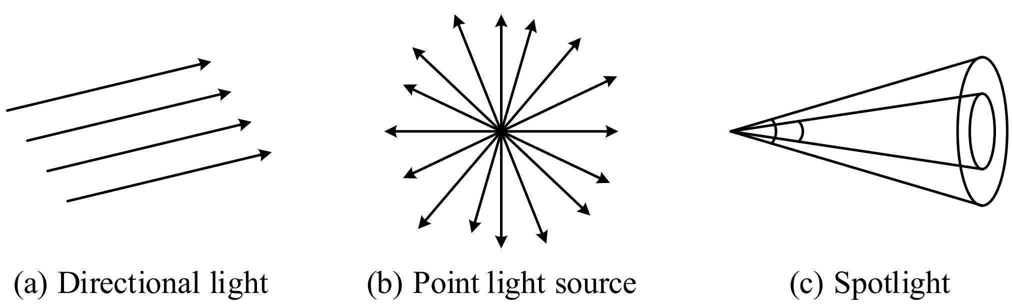

Figure 2: Schematic diagram of lighting types

Since no self-luminous attribute was added to the 3D model during the modeling and optimization process, it appears completely black after importing the Virtook scene. Only after adding a suitable light source and setting the parameters, the 3D model will be able to show the original color in the virtual environment. Click the Add Light button in the left panel of 3DLayout to create a new light source, create an appropriate number of new light sources, select the type of light in the Light Properties tab and adjust the parameters, respectively, adjust the position of the new light source and the direction of illumination to the model of all the surfaces can be covered by the light and illuminate.

In this paper, parallel light source is used as the main light type of the light module, parallel light source can make the light effect of any position in the virtual scene is the same, this design makes the user to switch the viewpoint will not be affected by the change of light, which is conducive to the realization of the real-time control of the model.

III. B. Virtual Simulation Experiment Scene Optimization

III. B. 1) Binary Projection Image Generation

The virtual simulation laboratory is equipped with specialized facilities such as computers, projection equipment, scanners, virtual reality all-in-one machines and interactive equipment. In order to present the 3D model of the lab in parallel projection, the model needs to be processed. Although the 3D model can distinguish and strip out the information of points and surfaces for storage, the data is usually randomly distributed when mapped to the plane, which results in only randomly distributed points on the plane, and many important information may be lost due to the inability to be efficiently categorized and extracted. In order to realize the integrity of the mapped image, the blank positions between the various vertices of the mapped face sheet must be completed against the original face sheet. The pre-processed 3D model of the virtual simulation laboratory is mapped on plane XOY, which is mapped against the set of point data $3D_p$ and the set of facet data $3D_f$. A prototype language model (Proto-lm) is introduced as follows: Input: $3D_p, 3D_f$, Output: binary projected image of the virtual simulation laboratory layout.

Step 1: Obtain $x_{\max}, x_{\min}$ of X axes and $y_{\min}, y_{\max}$ of Y axes in $3D_p$.

Step 2: Obtain the difference between the X, Y random 2 points, respectively, the minimum value of the difference is not 0 $\Delta x, \Delta y$

Step 3: Get the height and width of the virtual simulation lab layout map and the space for storing $M(w,h)$

$$w = x_{\max} / \Delta x - x_{\min} / \Delta x \tag{6}$$

$$h = y_{\max} / \Delta y - y_{\min} / \Delta y \tag{7}$$

Step 4: If no $3D_f$ global is searched, perform the following steps:

(1) Obtain the number of points $q_1(x_1, y_1), q_2(x_2, y_2), q_3(x_3, y_3)$ of the control.

(2) Find the most value $x_{q\min}, y_{q\min}, x_{q\max}, y_{q\max}$ in each of the 3 points

(3) Determine whether the points within the rectangle formed with $(x_{q\max}, y_{q\max}), (x_{q\min}, y_{q\min})$ as the diagonal points exist among the original triangular facets. If it exists, $I(w,h) = 1$, and $w \in [x_{q\min}, x_{q\max}], h \in [y_{q\min}, y_{q\max}]$.

Step 5: Save the converted image and the conversion is finished.

Proto-lm model can get the appropriate length and width of the binary projection image of the virtual simulation lab layout according to the level of detail of the 3D model of the virtual simulation lab layout.

III. B. 2) Significant feature extraction for experimental scene images

(1) Global significant feature extraction

The binary projection image of the above virtual simulation laboratory layout is decomposed into an image block matrix and its significant features are extracted using principal component analysis (PCA). Find the mean $\bar{h} = \frac{\sum_{i=1}^{L} h_i}{L}$ of each image block vector h_i in the image block matrix $H = [h_1, h_2, \cdots, h_L]$, the image block mean matrix $\hat{H} = [h_1 - \bar{h}, h_2 - \bar{h}, \cdots, h_L - \bar{h}]$, H against the covariance matrix A is:

$$A = \frac{(\hat{H}^T \hat{H})}{L^2} \tag{8}$$

where L is the total number of image blocks. Significant eigenvalue decomposition of Eq. (8) is done using the eigenvector U against which the previous d largest eigenvalues are compared, and the dimension of $U = [u_1, u_2, \cdots, u_d]^T$, U is $d \times L$.

Mapping the feature extractions within the lab layout image blocks to the high-dimensional space: most of the image blocks have consistent features, e.g., color shading, stripe veins, etc., and after the mapping occurs, they are grouped together because of their consistency.

With p_x representing the N features within the high-dimensional space, the center point p_A within the L_1 range is:

$$p_A = \frac{\sum_{h=1}^{N} p_h}{N} \tag{9}$$

In the formula, it is assumed that feature point p_h is far away from p_A. The probability of not including p_h in the clustering centered on p_A is high, as is the probability of significant features. Therefore, the distance of each feature point from the center point p_A is found, and the top 30% of feature points that are farthest from the center point are determined by ordering the distances from the farthest to the nearest. Since the salient feature image does not have a priori information about the scale size, it needs to be solved in multiple sizes in order to improve the accuracy, so the image is scaled to 30%, 60% and 90% of the original size for processing, and the global salient feature map of the virtual simulation laboratory layout image is obtained by averaging S_G.

(2) Local significant feature extraction

Assume that the center image block of the locally significant features of the binary projection image block of the virtual simulation laboratory layout is represented by i, and the mean value of the dissimilarity between i and $K(K=48)$ image blocks in its adjacent rectangle is represented by S_L. The locally significant features are:

$$S_L(h_i)=\frac{\sum_{j=1}^{K}W_{ij}^{-1}d(h_i,h_j)}{K}。 \tag{10}$$

where, W_{ij} is the length between the image blocks h_i,h_j and $d(h_i,h_j)$ is h_i,h_j the non-similarity between the two. Color is the most important salient feature, with color as the salient feature, many images can find their salient region based on the color they have. Assuming that the image pixels are determined as M_a and M_b, the non-similarity is defined as:

$$d(M_a,M_b)=D(M_a,M_b)\eta \tag{11}$$

where, η is the product of the length and width of the space,space $L\times a\times b$ contains pixels M_a and M_b, and $D(M_a,M_b)$ is the color distance between the two. If $M_a\in h_i,h_j$, is a block of neighboring pixels, then the non-similarity of M_a and h_j is expressed as:

$$d(M_a,h_j)=\frac{\sum_{M_b\in h_j}D(M_a,M_b)}{|h_j|\eta}=\frac{\sum_{M_b\in h_j}D(M_a,M_b)}{n^2\eta} \tag{12}$$

where $|h_j|$ is the number of pixels present in pixel block h_j, excluding spatial relationships, and non-similar values are present through pixels with consistent color values. Therefore, the term in Eq. (8) where consistent color values c_j exist is unified:

$$d(M_a,h_j)=d(c_a)\eta=\sum_{b=1}^{n_j}p_b\times D(c_a,c_b)\eta \tag{13}$$

where, c_a is the color value of pixel M_a, n_j is the number of regions h_j containing inconsistent colors, p_b is the probability of occurrence of color c_b in region h_j.

If $M_a\in h_i$, then the non-similarity of both region h_j and region h_i can be expressed as:

$$\begin{aligned}d(h_i,h_j)&=\sum_{I_a\in h_i I_b\in h_j}D(M_a,M_b)\eta\\&=\sum_{a=1}^{n_j}\sum_{b=1}^{n_j}p(c_{i,a})p(c_{i,b})D(c_{i,a},c_{i,b})\eta\end{aligned} \tag{14}$$

where $p(c_{i,a})$ is the probability that the s rd region corresponds to the a th color within n_s colors, $s=\{i,j\}$. Because color histograms are more robust than other feature representation algorithms, combining Eq. (13) allows for the application of color histograms to represent regions h_j and h_i, with the non-similarity between the two being determined by the dissimilarity in the color histograms. Therefore, combining Eq. (9) yields a locally significant feature map S_L of the virtual simulation laboratory layout image.

III. B. 3) Fusion of salient features of experimental scene images

The global and local salient feature map S_G,S_L of the virtual simulation laboratory image is decomposed into low and high frequency sub-band coefficients at position (o,v) by multi-scale multidirectional transform, which are $S_G^{j0}(o,v),S_L^{j0}(o,v)$ and $S_G^{jl}(o,v),S_L^{jl}(o,v)$, respectively, with j indicating the number of layers and l indicating the direction of decomposition. In the j th layer of high-frequency subbands, the low and high-frequency subband coefficients of the fused image are $S_F^{j0}(o,v)$ and $S_F^{jl}(o,v)$, respectively. when fusing the low-frequency subbands, the salient feature maps need to enhance the target saliency, and the background region needs to be eliminated if there is any obstruction, so as to better fuse the indicative features of the global salient feature map and the detailed features of the local salient feature maps. The low-frequency fusion subband coefficients for the virtual simulation laboratory layout are:

$$S_F^{j0}(o,v)=\left[S_G^{j0}(o,v)\alpha_G(o,v)+S_L^{j0}(o,v)\alpha_L(o,v)\right]\eta \tag{15}$$

where $\alpha_G(o,v),\alpha_L(o,v)$ is the significance coefficient of the global significant feature map and local significant feature map at position (o,v), respectively.

The high-frequency sub-band aspect includes most of the detailed information of the laboratory layout, and if only one fusion method is used, it will make the fusion results have errors. Therefore, in the high-frequency aspect, the localized feature area coefficient method is applied for the final fusion.

For the high-frequency subbands in the region of clear detail information, the significant feature region coefficient method is calculated as:

$$C_G^{jl}(o,v) = S_G^{jl}(o,v)\times\eta\times\alpha_G(o,v) \tag{16}$$

For the high-frequency subband fusion process in the region of poor detail information clarity, the local variance contrast is applied to fuse the local variance $\delta_Y^{jl}(o,v)$ of an image Y as:

$$\delta_Y^{il}(o,v) = \frac{\sum_{m=1}^{M}\sum_{n=1}^{N}\left[S_Y^{il}(o+m,v+n) - \frac{\sum_{m=1}^{M}\sum_{n=1}^{N}S_Y^{il}(o,v)}{M\times N}\right]^2}{M\times N} \tag{17}$$

where the window $M\times N$ is taken to be 6 × 6 and the local variance $\delta_Y^{jl}(o,v)$ obtained by using the regionalized conversion is:

$$\delta_Y^{il}(o,v) = \frac{\sum_{m=1}^{M}\sum_{n=1}^{N}\left[\delta^{jl}(o,v)\right]}{M\times N} \tag{18}$$

The local variance contrast is:

$$R^{jl}(o,v) = \frac{\delta_G^{jl}(o,v)\delta_L^{jl}(o,v)}{\delta_G^{jl}(o,v)\delta_L^{jl}(o,v)} \tag{19}$$

and exists:

$$S_F^{jl}(o,v) = \begin{cases} C_G^{jl}(o,v), R^{jl}(o,v)\geq 1 \\ S_L^{jl}(o,v), R^{jl}(o,v)<1 \end{cases} \tag{20}$$

That is, if $R^{jl}(o,v)\geq 1$ then the high-frequency subband coefficient $S_F^{jl}(o,v)$ is $C_G^{jl}(o,v)$, otherwise, $S_F^{jl}(o,v)$ is $S_L^{jl}(o,v)$.

In summary, obtaining the low and high frequency subband coefficients of the fused image, combined with the multi-scale multidirectional inverse transformation, the final fusion result of the salient features of the virtual simulation laboratory layout image can be obtained.

IV. Analysis of the effectiveness of teaching innovations in courses under virtual simulation

IV. A. Assessment of the effectiveness of teaching and learning in the field of soil and water conservation and desertification control

IV. A. 1) Purpose of the experiment

The purpose of this experiment is to implement and verify the practical effect of the design framework of the practical training course of the professional course on soil and water conservation and desertification control based on virtual simulation technology, in order to assess the effectiveness of this teaching mode for cultivating students' practical ability and its operability. Through this experiment, we aim to further optimize the design and teaching methods of the virtual simulation technology practical training course, so that it can more effectively cultivate students' practical ability, and provide reference and reference for teachers of soil and water conservation and desertification control and related majors in teaching soil and water conservation planning and related fields.

IV. A. 2) Experimental methods

Before conducting the study on the design and teaching effectiveness assessment of the practical training course on soil and water conservation and desertification control based on virtual simulation technology, an initial quiz was first given to the students participating in the study. The aim was to use the results of this quiz as a source of data to find out whether there was a significant difference between the experimental class and the control class in terms of practical skills. After confirming that there was no significant difference between the experimental and control classes at the baseline level, a one-semester teaching experiment was launched. The experimental class utilized a virtual simulation-based soil and water conservation and desertification control hands-on training course design, while the control class used a traditional soil and water conservation and desertification control hands-on training course. At the end of the semester, a comprehensive analysis of the course design and its teaching effectiveness was conducted by means of post-evaluation through tests and student interviews.

IV. A. 3) Experimental methods

The independent variable of this experiment is the soil and water conservation and desertification control practical training course design, which was implemented in Jinan L School's map drawing and GIS 1 class (experimental class) based on the virtual simulation of soil and water conservation and desertification control practical training course design, and in the map drawing and GIS 2 class (control class), which continues to use the traditional soil and water conservation and desertification control practical training course, with no special emphasis on the comprehensive Training. The dependent variable is the level of students' practical ability, which is designed to test the difference in the effectiveness of the virtual simulation-based soil and water conservation and desertification control practical training course and the traditional soil and water conservation and desertification control practical training course in enhancing students' practical ability.

IV. A. 4) Experimental procedures

The implementation of this teaching experiment was from September 2023 to January 2024, and the experimental process was divided into three phases: September 2023 was the preparation phase of the experiment, and the pre-test was carried out on the class in charge of this paper by means of the item test, and the data obtained were used as the basis for the selection of the experimental subjects as well as the pre-test data of the experiment. September 2023-January 2024 is the stage of experimental implementation, with two different teaching modes in the experimental class and the control class, February 2024 is the stage of analyzing the experimental results, the post-test is conducted by means of project tests and student interviews, and the pre and post-test scores of the students of the two classes are analyzed by independent sample t-tests using SPSS 26.0, comparing the differences in the pre and post-test scores of the experimental class with those of the control class, so as to check the effectiveness of the practical training course in virtual simulation technology in teaching effect of the virtual simulation technology practical training course in soil and water conservation and desertification control.

IV. B. Comparison of the effect of teaching reform

Using the simulation laboratory constructed by virtual simulation technology, teaching reform was carried out for the course of soil and water conservation and desertification control, and 61 students of the class of 2021 from the University of P were selected to assess the effect of the teaching reform by means of pre- and post-tests. Figure 3 shows the comparison between before and after the teaching reform of soil and water conservation and desertification, the basic geology course of 2021 grade soil and water conservation and desertification control majored in the theory, practical teaching content and method of reform and exploration, the test scores are as follows: 90 points and more than 90 points, 19 people, accounting for 31.15%. 80~89 points, 28 people, accounting for 45.9%, 70~79 points, 10 people, accounting for 16.39%, 60~69 points, 3 people, accounting for 4.92%, less than 60 points, 1 person, accounting for 1.64%, the mean square deviation is 9.49, the average score is 84.63. As a control class, the results of the students of the class of 2021 before the reform: the mean square deviation is 12.4, and the average score is 77.37. It can be seen that the results of the reform have been improved significantly, and the failure rate has been reduced significantly.

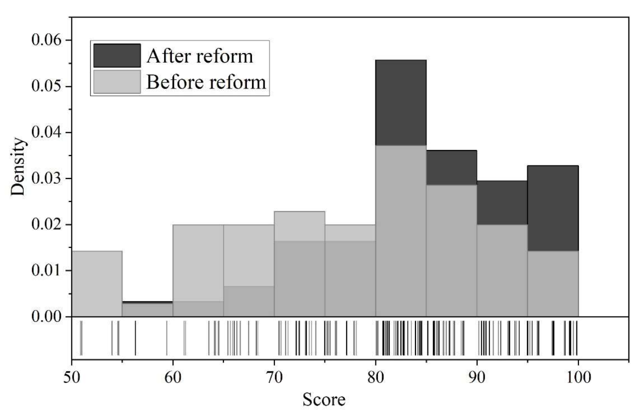

Figure 3: The reform of soil and water conservation and desertification

IV. C. Assessment of teaching effectiveness

IV. C. 1) Pre-testing

Table 1 shows the analysis of the students' pre-test results, in order to ensure that there is no significant difference between the overall geography level of the experimental class and the control class before the experiment, the independent samples t-test was conducted on the pre-test scores of the two classes before the experiment using SPSS 26.0. The average score of the experimental class is 49.82 points, and the average score of the control class is 50.26 points, and the difference between the two classes is only 0.44 points, with a P-value of 0.3498>0.05 No significant difference, i.e., the two classes have a similar level of practical ability, and the experiment can be launched. Sub-specific virtual simulation technology dimensions, in terms of the impact of learning and innovation literacy, the difference between the average score of the experimental class and the control class is 0.29, P value is 0.2415>0.05, no significant difference, in terms of the impact of vocational character and cultivation, the difference between the average score of the experimental class and the control class is 0.1, P value is 0.3845>0.05, no significant difference, and in terms of life and career literacy. The mean score difference between the experimental and control classes is 0.14 with a p-value of 0.4168> 0.05 no significant difference, and in Information and Technology Literacy, the mean score difference between the experimental and control classes is 0.18 with a p-value of 0.5789> 0.05 no significant difference.

Table 1: Student analysis

Dimension	Group	Sample	M	SD	MD	P-Value	Results
Learning and innovation	Experimental Class	61	12.3485	0.9852	-0.2928	0.2415	Difference is not significant
	Control class	60	12.6413	0.8487			
Professional character and cultivation	Experimental Class	61	12.4684	0.9469	-0.1013	0.3845	Difference is not significant
	Control class	60	12.5697	0.8485			
Life and career accomplishment	Experimental Class	61	12.4879	0.9248	0.1411	0.4168	Difference is not significant
	Control class	60	12.3468	0.8439			
Information and technical literacy	Experimental Class	61	12.5154	0.8894	-0.1831	0.5789	Difference is not significant
	Control class	60	12.6985	0.9488			
Practical ability	Experimental Class	61	49.8202	1.7648	-0.4361	0.3498	Difference is not significant
	Control class	60	50.2563	1.7065			

IV. C. 2) Post-testing

By analyzing the results of the posttest conducted on the experimental and control classes, the experimental results are shown in Table 2. The mean value of students' scores in the post-test of practical ability in the experimental class is 53.19 points, and 46.76 points in the control class, and the difference between the two reaches 6.43 points, and the P-value is less than 0.001, which indicates that there is a significant difference in the level of practical ability between the two classes, and the experimental class is better than the control class, which reflects that the teaching effect of the practical training course in virtual simulation technology is significantly improved. Second, when further subdivided into the four dimensions of practical ability, this study found that the virtual simulation technology practical training course had a significant positive impact on students' information and technology literacy, professional character and cultivation, learning and innovation literacy, and life and career literacy. Among them, the difference in the impact of information and technology literacy is the most significant, and the mean difference between the experimental class and the control class reaches 1.7 points, with a p-value < 0.001, indicating that the experimental class and the control class show significant differences in the impact of information and technology literacy, and the mean difference between the vocational character and cultivation, the learning and innovation literacy, and the life and career literacy is 1.62, 1.561, and 1.55 in that order, with p-values all <0.001, indicating that the experimental class and the control class show significant differences in these three indicators.

Table 2: Significance analysis of the post-test scores of the experimental class and the control class

Dimension	Group	Sample	M	SD	MD	P-Value	Results
Learning and innovation	Experimental Class	61	13.2458	0.4988	1.5613	<0.001	The difference is significant
	Control class	60	11.6845	0.3478			
Professional character and cultivation	Experimental Class	61	13.2485	0.4985	1.624	<0.001	The difference is significant
	Control class	60	11.6245	0.3895			
Life and career accomplishment	Experimental Class	61	13.3458	0.4798	1.547	<0.001	The difference is significant
	Control class	60	11.7988	0.4369			
Information and technical literacy	Experimental Class	61	13.3455	0.4539	1.6977	<0.001	The difference is significant
	Control class	60	11.6478	0.4249			
Practical ability	Experimental Class	61	53.1856	0.8899	6.43	<0.001	The difference is significant
	Control class	60	46.7556	0.8648			

IV. C. 3) Degree of mission accomplishment

Figure 4 shows the degree of task completion of different teaching methods, statistics during the period of 2023-2024, the use of virtual simulation training teaching classes, compared with traditional teaching, from online independent learning, pre-course pre-study, post-course extension training, physical training and other aspects of comparative analysis. The statistics show that the experimental group of students after joining the virtual simulation of real training, the enthusiasm and completion of the students' independent learning and pre-course pre-study is significantly improved, and the average assessment score is improved by 13.64 points, and the proportion of the training effect is increased by 15.04% in the process of the physical training, and there is a significant increase in the post-course extension training, and the motivation for independent learning has always been a difficult problem encountered by the teachers in the teaching process in the school's open Virtual laboratory, join the virtual simulation of independent practical training, after-school expansion to stimulate students' desire for knowledge, the spirit of exploration, craftsmanship, to achieve a good soil and water conservation and desertification control practical training teaching effect.

IV. C. 4) Independent samples t-test for learning interest

Table 3 shows the independent sample t-test of learning interest pre- and post-test, in the learning interest dimension, the mean score of the experimental group is 17.55, and the control group is 17.85, and the independent t-test significance level P-value is 0.6248 (>0.05), which indicates that there is no significant difference between the two groups of students in their interest in learning about the course of soil and water conservation and desertification control and the application of virtual simulation.

The mean value of the experimental group was 17.55 before the experiment and 22.62 after the experiment, and the paired samples t-test significance level P-value was 0.00 (<0.05), which indicated that there was a significant difference between the students in the experimental group's interest in the course of soil and water conservation and desertification control and the application of the virtual simulation after the experiment, and that the interest in learning was significantly increased.

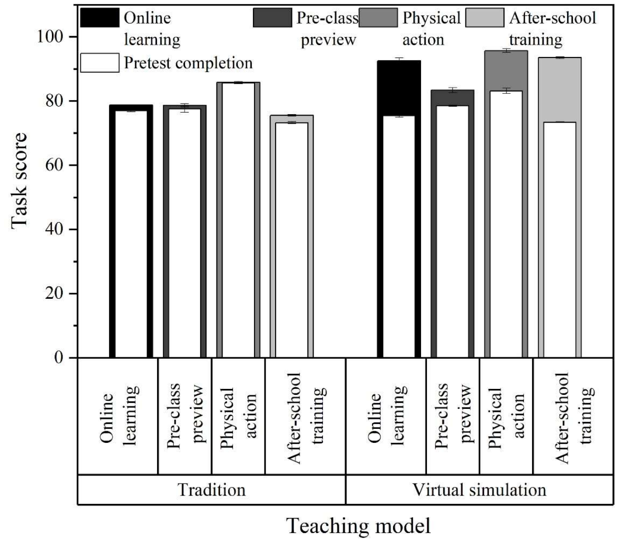

Figure 4: Different teaching methods task completion

The mean value of the control group was 17.85 before the experiment and 17.25 after the experiment. paired samples t-test significance level p-value was 0.13 (p > 0.05), which indicates that there is no significant difference between the control group's interest in learning about the course on soil and water conservation and desertification control and the application of virtual simulation before and after the experiment.

The mean value of the experimental group after the experiment is 22.62, and the control group is 17.25 Independent samples T-test significance level P-value is 0.000 (<0.05), which indicates that after the experiment, there is a significant difference between the two groups in their interest in learning about the course of Soil and Water Conservation and Desertification Control and the virtual simulation, and that the experimental group's effect is significantly better than the control group.

Table 3: Test the independent sample t test before and after the interest

/	Group	N	Mean	F	P
Study interest Premeasurement	Experimental Class	61	17.5468	0.4598	0.6248
	Control class	60	17.8488		
/		Mean	N	T	P
Pair 1	Pre-interest in experimental group	17.5468	61	-11.7895	0.0000
	Post-interest in experimental group	22.6248	61		
Pair 2	Pre-interest in control group	17.8488	60	1.5945	0.1348
	Post-interest in control group	17.2488	60		
/	Group	N	Mean	F	P
Study interest posttest	Experimental Class	61	22.6248	4.8875	0.0000
	Control class	60	17.2488		

V. Conclusion

The application of virtual simulation technology in the teaching of soil and water conservation and desertification control has achieved remarkable results. Through the establishment of “one vertical and one horizontal” virtual laboratory organizational structure, it realizes the four functions of talent training system construction, curriculum resources sharing, curriculum construction and teachers' teaching ability improvement, and solves many problems in traditional teaching. The experimental data show that after the adoption of virtual simulation technology teaching, the students in the experimental class have the most significant improvement in information and technology literacy, and the difference between the average value of the experimental class and the control class reaches 1.7 points (P<0.001). The distribution of course exam scores was significantly optimized after the teaching reform, with the percentage of 90 points and above reaching 31.15% and the failure rate dropping to 1.64%. The average value of students' post-test scores of practical ability reaches 53.19 points, which is 6.43 points higher than that of the control class, indicating that the virtual simulation technology has a significant effect on improving students' practical ability. In terms of task completion, the average assessment score of the class that adopts virtual simulation training teaching is 13.64 points higher, and the proportion of physical practical training effect is 15.04% higher. Learning interest survey shows that the experimental group students' interest in the course increased from 17.55 points before the experiment to 22.62 points ($P<0.001$), while the control group had no significant change. The above data fully proved that the teaching mode of soil and water conservation and desertification control based on virtual simulation technology can effectively improve teaching quality, stimulate students' learning interest, cultivate practical innovation ability, and provide a feasible path for the professional teaching reform.

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