



Research on the Development Strategy of Virtual Reality Civic and Political Education Scenes for Cultivating College Students' Values

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SUMMARY: *The research focuses on the use of virtual reality technology to innovate the mode of college students' civic education, and develops a set of VR civic teaching system with both strong interactivity and educational effectiveness. Using Unity3D as the development engine, we introduced an improved QEM mesh simplification algorithm to build the key contours and detailed features in the virtual teaching scene for the complex scene rendering problem. Then Mip-Map texture mapping technology is used to map the model and eliminate visual jaggedness. It is also integrated into the interactive teaching system of the ideology and politics course to design the visualized virtual learning situation. The usability test received positive feedback from 98 students, with more than 85% of users giving ratings that conformed to the above in terms of core indicators such as ease of use and interface friendliness. The experimental class using the VR system scored an average of 90.54 points in the Civics and Political Science Comprehensive, significantly higher than the 81.26 points of the control class with traditional teaching, with an advantage of nearly 10 points. The self-assessed positive rates of the experimental class students in terms of learning interest and self-efficacy also generally exceeded 85%, and the instructors also observed a 20-30% improvement in their classroom concentration, interactive motivation and depth of thought expression. The interactive performance of the system is more than three times that of the traditional system, which explains why it is more effective in attracting students' learning engagement on a behavioral level.*

KEYWORDS: *Unity3D; scene modeling; interactive system; civics teaching; virtual teaching scene*

1 Introduction

In the context of the knowledge economy era, there are higher requirements for the cultivation quality of talents in colleges and universities. Colleges and universities are the main position for practicing socialist core values, and the main goal of Civic and Political Education is to cultivate the values of college students and create builders and successors to meet the cause of national construction [1]. However, Civic and political education in colleges and universities is facing serious challenges in the cultivation of students' values. First of all, Civic and political education is highly theoretical, and under the traditional teacher-led teaching mode, students' interest in learning is low, the learning effect is poor, and the effect of values cultivation is not obvious. With the development of artificial intelligence, virtual reality (VR) technology, as a computer simulation of reality experience, is characterized by immersive, interactive and

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imaginative technology [2, 3], which provides an ideal technological carrier for the cultivation of values in Civic and Political Education in colleges and universities. By developing a multimodal virtual Civic and political education scene with immersion and interactivity with the help of VR, it promotes the essential transformation of teaching [4]. It not only breaks through the physical limitations and transforms abstract theories into perceptible three-dimensional scenes, but also vividly displays the knowledge and theories of civic and political education, completely simulates the elements of the professional environment, and significantly improves the sense of teaching immersion and value recognition [5-7]. In addition, the VR Civic and Political Education scene makes students' participation increase significantly, and the value identity grows significantly [8, 9]. The teaching content is shifted from plane to three-dimensional, the cognitive mode is changed from passive to active, and the value transmission is changed from indoctrination to resonance [10]. Students complete role substitution and value reflection in the virtual scene, forming a complete nurturing closed loop of "cognition-experience-internalization", effectively promoting the transformation of knowledge and action, and injecting new kinetic energy into the cultivation of values [11, 12].

In the context of values cultivation of college students, the application of VR in civic education has received wide attention. Literature [13] examines the value of the application of VR technology in civic education, analyzes its characteristics and existing difficulties, points out the implementation principles and strategies, and emphasizes its role as the basis for research on the innovation of teaching methods and improvement of the quality of education. Literature [14] discusses the application of VR technology in the civic and political education in colleges and universities, analyzes how it can enhance the interest and effectiveness of teaching by creating an immersive environment, and at the same time, emphasizes that the technology can break through the limitations of time and space, highlights the students' subjective position, and provides innovative paths for teachers to optimize the teaching plan and reshape the traditional classroom. Literature [15] analyzes the current situation of the application of VR technology in the civic education of colleges and universities, and through the design of courses and empirical research, it points out that VR can significantly enhance the immersive experience and connotative understanding of students, and emphasizes its important reference value for the popularization and promotion of this technology. Literature [16] discusses the application of immersive media technology in the teaching of Civics and Politics in colleges and universities, and through analyzing its perceptual advantages and interactive characteristics, it proposes a strategy to enhance the effect of theoretical learning and historical research, and provides solution ideas for the implementation problems. Literature [17] for the VR Civics classroom immersion is not enough, through the integration of EEG, eye movement and other biosensors real-time monitoring of the physiological state of students, and the use of machine learning algorithms to dynamically adjust the teaching content and interaction mode, the experimental data show that the technology can effectively improve the attention and emotional resonance, to enhance the teaching experience provides a new path. Literature [18] emphasized that digital intelligence technology empowered ideological education has given rise to intelligent teaching forms, through the use of VR to build a network bionic environment and precision drip irrigation platform, which can effectively enhance the scientific and effective nature of education, and at the same time, to address the challenges of communication obstacles and lagging evaluation, exploring the ecological and intelligent innovative development path to achieve the high-quality transformation of ideological and political education. Literature [19] studied the application of VR in ideological and political education, and evaluated its effectiveness in enhancing students' participation, motivation and understanding by developing an immersive teaching framework and conducting comparative experiments. Literature [20]

explored the application of VR simulation technology in Civic and Political Theory courses in universities, systematically elaborated its integration process and evaluation method, and confirmed through comparative experiments that the technology can significantly improve students' academic performance and learning attitudes, highlighting its practical potential for optimizing teaching effectiveness.

In addition, based on VR technology, literature [21] constructed a practical teaching system for Civics and Politics in colleges and universities, developed interactive scenes through 3dsMax modeling and Unity3D engine, combined with SQL Server database and Apache Tomcat server, realized the digitization of the teaching process, and verified the effective promotion of this system for the innovation of Civics and Politics practical teaching mode. Literature [22] analyzes the challenges and opportunities faced by Civic and Political Education in the shaping of college students' values, and proposes strategies such as the use of VR and other information technologies to promote the comprehensive cultivation of values by exploring the issues of information overload and social change. Literature [23] explores how digital technology empowers red cultural resources, analyzes the logic and path of its in-depth integration with the ideological and political courses in colleges and universities with the aim of improving the quality of ideological and political education, and emphasizes the potential of innovative applications of VR and other technologies in it. Literature [24] emphasizes that course ideology and politics is an important mission of contemporary teachers, aiming to cultivate new-age college students with firm beliefs and ideological and political literacy, in order to make clear the fundamental direction of education “for whom to cultivate people and how to cultivate people”, and puts forward the practice of course teaching reform based on VR technology. Literature [25] addresses the problem of choosing IT solutions in Civic and Political Education, and examines the external characteristics such as authenticity and inclusiveness by constructing an evaluation system based on q-ROFS environment and entropy weight WASPAS method, and points out that this paradigm can provide data support and practical paths for institutions such as the Central University, so as to promote the digital transformation of education. Literature [26] focuses on students' online civic education, analyzes the problems of disconnecting its conceptual scope from reality, single method and insufficient assessment, and proposes improvement strategies such as incorporating VR technology, updating content, enriching methods and improving assessment frameworks, in order to enhance the effectiveness of teaching and learning. Literature [27] analyzes the impact of VR and Internet technology on students' ideological education through questionnaires, pointing out that it can provide new concepts and platforms to enhance students' abilities, and reveals the current challenges of lack of personalization and insufficient platform construction, and then proposes innovative paths such as resource digitization, conceptual change and platform reconstruction. Literature [28] discusses the value of VR experiential teaching on ideological education relying on red culture, enhances students' perception and identification of red culture through the path of “learning, thinking, practicing and understanding”, and emphasizes its positive role in enhancing college students' ideological literacy and practical ability.

The construction of virtual reality Civic and political education scene not only involves the processing of the underlying 3D model, but also relates to the logical design of the upper layer of teaching and the integration of multi-sensory interaction. In this regard, the study constructs a strategy for the development of virtual reality Civic and political education scenes that integrates technology and application. Unity3D engine is selected as the cornerstone of the development to help efficiently build the cross-platform Civic and Political Education virtual scene. In the face of fine 3D models that may appear in the scene, such as revolutionary relics and historical buildings, adaptive subdivision and visual effect-based QEM simplification

methods are adopted. By analyzing the degree of curvature (curvature) and local detail density (area) of the model surface, the flat areas are simplified in priority, while key features such as corners and twists and turns are retained and delayed to improve the rendering speed. Meanwhile, Mip-Map texture mapping technology is used to wrap the image material accurately on the surface of the 3D model. It can automatically match different precision textures according to the distance of the object from the observer, effectively eliminating flickering and jaggedness to make the scene visually smoother and more realistic. Finally, all the technologies are integrated into the interactive teaching system of the Civics course based on virtual reality technology. Design the intuitive visualization operation interface, and realize the linkage and display of teaching content and three-dimensional scene, from technology building to educational experience delivery.

2 The realization of the integration system based on virtual reality technology and ideological education

2.1 Virtual reality-based mobile learning platform development tools

Unity3D is a virtual reality, cross-platform application development engine developed by Unity Technologies. Its editor runs under Windows and MacOS and can publish applications to Windows, MacOS, iOS and Android platforms. It has the following features: (1) Visual programming interface, through Unity3D can complete a variety of development work, through efficient scripting language programming, development is more convenient. (2) Easy to import models, Unity supports most of the 3D models, such as FBX, OBJ format animation and bone direct import, and the material mapping is automatically converted to Unity3D usable format. (3) The underlying support for Direct11 and OpenGL, simple and practical physics engine, simulation of physical effects to make the scene more realistic. (4) The development efficiency is outstanding, very cost-effective, and the multi-platform development and deployment of the work can be completed in one click.

The project adopts the common interface of Unity3D engine, which has good cross-platform characteristics, and uses C language for development. The whole system is designed in first-person perspective, and can be operated by virtual joystick on Android and iOS side. On the PC side, users can control it by using keyboard and mouse.

2.2 Generation and drawing of LOD model for virtual scene

When dealing with scene models, providing different levels of LOD models for objects can control the scene complexity and speed up the graphics drawing speed. LOD models are generally generated by mesh simplification algorithms. Mesh simplification is to minimize the number of vertices while maintaining the appearance characteristics of the original mesh model, and represent the original model with an approximate model. Some elements that have little influence on the appearance of the model are removed from the polygon mesh to achieve its simplification purpose.

2.2.1 Mesh simplification algorithm: adaptive subdivision type

The mesh simplification algorithm used in the study is an adaptive subdivision type algorithm, whose basic idea is to first establish its simplest form according to the original model, then subdivide the original model according to certain rules, and then gradually add the detail information of the original model to the simplified model, and finally obtain a finer multi-resolution model, as shown in Figure 1. The algorithm utilizes the error tolerance defined by

the Euler distance to subdivide the grid model several times and generate the simplified model. This type of method is mainly applicable in uniform grid models such as height field, in addition, it is more difficult in constructing the simplest grid model of the grid model, and it is also easy to lose some detail feature information when subdividing the grid.

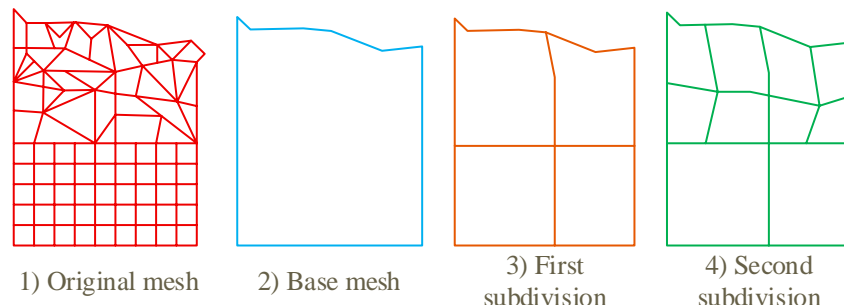


Figure 1: Adaptive subdivision algorithm

2.2.2 Weighted error measures for curvature and area

The study starts from two points, curvature and area, to determine the local features of the geometric model and ensure the quality of the simplified model. Firstly, the curvature of all vertices in the mesh model is sorted, and the order of contraction is delayed for regions with larger curvature, and the edge folding operation is prioritized from regions with smaller curvature, so that the key features of the mesh model can be preserved; then, the feature point is judged based on the magnitude of the curvature and the local area of the region of that feature point is derived; finally, the curvature of each vertex in the mesh and the local area of the corresponding feature point are introduced into the quadratic error matrix to guide the edge folding order of the mesh model. By introducing the two weighting factors of vertex discrete curvature and local area, more detailed features of the model can be retained more effectively, which can produce a visual effect more similar to the original model.

(1) Discrete normal vector and curvature estimation

The normal vector and curvature of the surface can be used as important metrics to represent the local details of the mesh model, such as creases, inflection points, and other curved areas.

Since the mesh model constructed in this paper is represented by a triangular mesh, the surface formed by the mesh model is a discrete surface representation without continuous normal vector and curvature. The discrete normal vectors and curvatures at the corresponding vertices are usually calculated as the degree of curvature of the mesh surface at the vertices.

1) Discrete normal vector

A triangular mesh is usually represented by the set of vertices $V = (v_1, v_2, \dots, v_n)$, the set of edges $E = (e_1, e_2, \dots, e_t)$, and the set of triangles $T = (t_1, t_2, \dots, t_m)$, where V , E , and T denote the set of all vertices, edges, and triangles, respectively, around vertex v_i .

For any triangular face piece in the mesh can be denoted by (v_{i-1}, v_i, v_{i+1}) , then the unit normal vector of the triangular face piece is:

$$n_i = \frac{(v_{i-1} - v_i) \times (v_{i+1} - v_i)}{|(v_{i-1} - v_i) \times (v_{i+1} - v_i)|} \quad (1)$$

The area of the triangle associated with the vertex v_i is utilized as the weights, and the unit normal vectors on each face are weighted and averaged to obtain the unit normal vector at that point. The expression is as follows:

$$n_i = \frac{\sum_{j=1}^n n_j s_j}{\left\| \sum_{j=1}^n n_j s_j \right\|} \quad (2)$$

where s_j denotes the area of the j th triangle adjacent to the vertex; n is the number of triangles adjacent to the vertex. The unit normal vector at each vertex can be calculated and stored by equation (2).

2) Discrete curvature

The study applies Gaussian curvature to compute the discrete curvature. It defines the two principal curvatures of the surface at any point v as k_1 and k_2 , then the Gaussian discrete curvature k at that point is defined as $k = k_1 \times k_2$. The Gaussian curvature k reflects the degree of curvature of the surface. The Gaussian curvature of each vertex of a triangular mesh is estimated using equation (3).

$$K_v = \frac{2\pi - \sum \theta_v}{S_\Sigma(v)} \quad (3)$$

where θ_v is the neighboring pinch angle of vertex v ; n is the number of triangles associated with vertex v ; and $S_\Sigma(v)$ is the sum of the areas of the triangular meshes neighboring vertex v , i.e., the local region area (LRA). The Gaussian curvature at the vertex is stored as the eigenvalue of the vertex.

(2) Local Region Area

Local region area (LRA) is the area of the local region that changes during the execution of simplification. It will be used as a feature keeping control factor, which can effectively control the model simplification error.

The synthesis will get the edge folding cost, first define the two endpoints of any edge L in the triangular mesh as (v_1, v_2) , and their Gaussian curvatures are K_{v_1} and K_{v_2} , then the Gaussian curvature of the edge L can be expressed by the following expression:

$$K(L) = |K(v_1)| \cdot w_1 + |K(v_2)| \cdot w_2 \quad (4)$$

where w_i is the Gaussian curvature weight coefficient of the vertex, which can be obtained by the following equation:

$$w_i = \frac{S_\Sigma(v_i)}{S_\Sigma(v_1) + S_\Sigma(v_2)}, i = 1, 2 \quad (5)$$

Then the Gaussian curvature of the edge L can be expressed as:

$$\begin{aligned}
 K(L) &= \left| \frac{2\pi - \sum_n \theta_{v_1}}{S_\Sigma(v_1)} \right| \cdot \frac{S_\Sigma(v_1)}{S_\Sigma(v_1) + S_\Sigma(v_2)} \\
 &+ \left| \frac{2\pi - \sum_m \theta_{v_2}}{S_\Sigma(v_2)} \right| \cdot \frac{S_\Sigma(v_2)}{S_\Sigma(v_1) + S_\Sigma(v_2)} \\
 &= \frac{\left| 2\pi - \sum_n \theta_{v_1} \right| + \left| 2\pi - \sum_m \theta_{v_2} \right|}{S_\Sigma(v_1) + S_\Sigma(v_2)}
 \end{aligned} \tag{6}$$

Then the discrete curvature of each vertex in the mesh can be redefined as:

$$K(v) = K(L_v) \cdot K_v \tag{7}$$

where $K(L_v)$ is the Gaussian curvature of the edge containing vertex v and K_v is the Gaussian curvature of vertex v .

The discrete curvature associated with each vertex and the area of the local region of the triangular mesh adjacent to it are obtained according to the above equation, and then according to the principle of the QEM algorithm, the new quadratic error matrix $Q'(v)$ of each vertex is obtained, which is the error matrix obtained after weighting by the above two weighting factors, and it can be expressed by the following equation:

$$Q'_{v_i} = \frac{K(v)}{LRA(v)} \cdot Q_v = \frac{K(v)}{S_\Sigma(v)} \cdot Q_v \tag{8}$$

Then the new folding cost can be expressed as the contraction cost if $(v_1, v_2) \rightarrow \tilde{v}$:

$$\Delta'(\tilde{v}) = \tilde{v}^T (Q'_{v_1} + Q'_{v_2}) \tilde{v} \tag{9}$$

The detailed features of the model can be well preserved using the edge folding cost obtained from the above equation.

2.2.3 QEM Improvement Algorithm Based on Visual Effects

The simplified algorithm used in the study is the visualization-based Quadratic Error Measure (QEM) algorithm, the flow of which is shown in Figure 2.

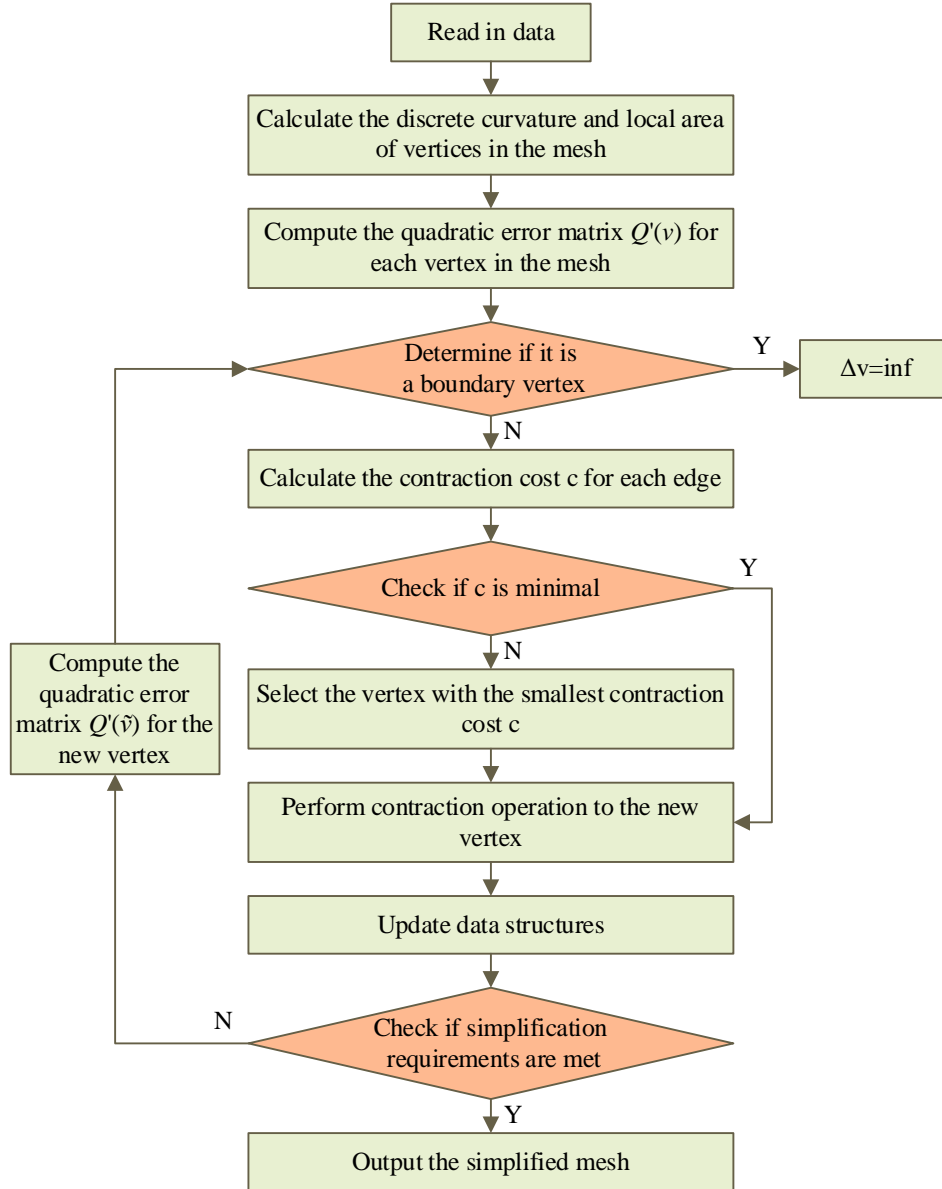


Figure 2: The improved QEM algorithm based on visual effects process

The algorithm is mainly divided into two parts, i.e., the initialization part and the iteration part, and the specific steps are as follows:

(1) Read in the initial mesh data, including the coordinates of the vertices in the mesh and the vertices and sequences of its neighboring triangular face pieces, and other information data;

(2) Calculate the discrete curvature $K(v)$ of each vertex in the mesh (obtained from Eq. (7)) and the local region area $LRA(v)$, and weight these two weighting factors with the matrix $Q(v)$ to obtain the quadratic error matrix $Q'(v)$ of each vertex in the mesh, as shown in Eq. (8);

(3) By inputting a suitable threshold value $w = 0.9$, then determine whether it is a boundary, i.e. $-w \leq \cos(i) \leq w$, and if it is a boundary, set $\Delta(v) = \text{inf}$;

(4) Based on the quadratic error matrix $Q'(v)$ of each vertex obtained in step 2, thus calculate the contraction cost c of each edge, whose expression is (9), and put it into the stack, the larger the value of c the more backward its position in the stack, and vice versa, store it in the top of the stack;

(5) Remove the top of the stack, i.e., the edge with the smallest contraction cost, from the stack to perform the contraction operation, and update the data structure of the lattice to recalculate the new edge folding cost as well as to update the stack sequence;

(6) If the simplification requirement is reached, end the algorithm, otherwise iterate the above process until the simplification requirement is reached.

2.3 Texture Mapping Techniques

After the mesh simplification of the model based on curvature and local area weighting, realistic texture mapping of the model surface is also required to further realize a highly realistic virtual scene. The following section focuses on texture mapping and its anti-alignment technique to enhance the visual realism of the Civic Education scene in the system.

2.3.1 Texture Mapping

Texture mapping can be applied to a surface of an object like a sticker. The texture mapping node of VRML is the Texture node, which has the following three main types: image texture, movie texture, and pixel texture. The more commonly used is image texture, mainly including jpeg, gif, bmp, tiff, png and other formats of the picture, by specifying the URL of the file to display.

2.3.2 Texture Backsampling Technique: Mip-Map Algorithm

As the texture mapping is related to the shape of the object surface, different model polygonal surfaces, a certain range of pixel areas on the screen are mapped to the object texture plane, and the texture is displayed on the screen after taking the average texture color. The exact solution of the average texture color is difficult. The principle of the lookup table technique is to replace curved polygons with regularly shaped circles, squares, and rectangles. Regularly shaped regions are much simpler to solve than complex polygons. Mip-map technology uses a lookup table technique, so-called lookup table, which is a table in which images of different resolutions are stored, and according to the different situations to find the corresponding resolution of the image. Each pixel on the screen is a square, and the mapping region of that one pixel projected on the texture plane is also represented by a square of appropriate size. For each pixel region, there is no need to compute the mapping relationship between image space and scene space and texture space, largely avoiding real-time and repetitive computations. Approximating the pixel texture region with a square is shown in Figure 3, as the projection of each pixel on the texture plane is also a square, the lower level of image resolution to take the higher level of image resolution of half, that is, to take the high-level image of the two sides of the length of the mid-point, connecting the four points that is the formation of the lower level of resolution image, and so on will be different resolutions of the image to form the texture array, the formation of the texture lookup table.

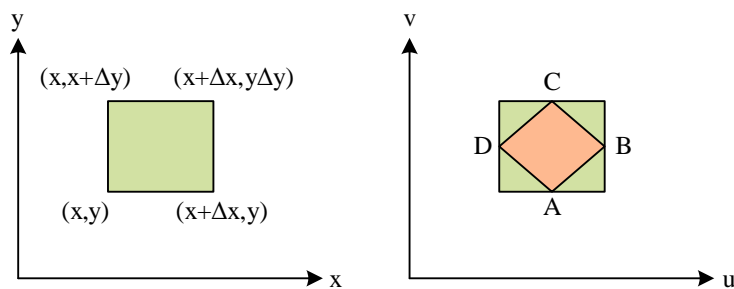


Figure 3: Approximate the pixel texture area with a square shape

Figure 4 shows how a standard Mip-map lookup table is stored. The resolution of the lower level image is half the resolution of the higher level image, i.e., one-half of each of the two sides of the upper level image is taken as the size of the lower level image. The image texture array of a particular level consists of three color components: red, green and blue. The texture color values of the same texture region displayed on the screen at different resolutions are stored in a table, which is a lookup table.

B		G	
B	G	R	
	R		

Figure 4: The storage method of the mip-map table

Mip-map technology is combined with texture mapping to represent the same material image as multiple images depending on the viewer's proximity and distance, depending on the resolution of the material: the largest sized images are placed close to the point of view, while relatively small images are set back into the background area. A Mip-map level is defined for each different size class.

Mip-map improves the quality of texture mapping, but has some drawbacks. The lookup table can be generated in advance, and only the texture values are directly fetched when needed, requiring very little computation time and providing greater real-time performance. If you need good visual effect, you need to store multi-level texture images, which will occupy a large storage space. Generally, in order to reduce the storage space occupied by the texture, the original texture can only be graded a limited number of times.

2.4 Interactive Teaching System for Civics Course Based on Virtual Reality Technology

After completing the geometric and texture optimization of the scene model, the above technologies are integrated into the specific interactive system of Civic and Political Education to realize the linkage between the teaching content and the virtual scene.

2.4.1 Developing a visual interactive interface for teaching Civics courses

Using Unity3D tools, build the system interactive interface and integrate each function module program in the terminal in an embedded way. Write software program scripts to control the logical sequence of some animation models in the educational resources and the sequence of PLC communication data processing. The interactive functions in the interface are divided into two categories: manual control and automatic control. When using manual control interaction, the terminal will actively simulate the signal control of PLC, participate in the students' learning of each chapter and module, and realize the debugging of programming. While the automatic control is mainly a preview of the entire workflow, you can operate the reset button to control the initialization of the teaching animation during the preview process. The script program is imported into the Unity3D processing tool to optimize the comprehensive display of the visual interactive interface by adjusting the material and animation effect of the object model in the user interface (UI). Control the corresponding animation of mouse clicking the button through the script, realize the change of input/output (I/O) point key and light in the interface, bind the button and animation on the user interface, and control the UI animation in the interface by

operating the mouse. The whole project is packaged into EXE format and embedded in the system personal computer (PC) terminal.

2.4.2 Linked display of teaching content based on virtual reality technology

In order to meet the interactivity of the system interface in use, virtual reality technology is introduced to transmit the signals generated during the communication process using a transmitter device, so that the communication signals are presented in a discrete state in space. The spatial distance of the discrete points in the virtual reality display interface is calculated with the formula

$$L = (t - t_0)v \quad (10)$$

where: L is the spatial distance of discrete points in the virtual reality display interface; t is the signal transmitting time; t_0 is the signal receiving time; v is the transmission speed of the signal in the virtual reality space. Considering that independent signals cannot be in the interface, the linkage between the audio feedback signal and image feedback signal in the virtual reality interface is established, and the process is as follows

$$w(x, y) = (2u_x u_y + G) / (u_x^2 + u_y^2 + G) \quad (11)$$

where: w is the linkage display 3D sound effect; u_x is the positioning image row frame; u_y is the positioning image column frame; G is the recognition coefficient. In order to avoid visual color difference in the display process, it is necessary to design the virtual reality interface color difference matching. The process is

$$M = \sum_{r>1}^t \sum_{p>1}^k (x - x')^T K_{(rp)} \quad (12)$$

where: M is the chromatic aberration segmentation threshold; K is the matching chromatic aberration usage change rate; x' is the original color recognition rate; T is each angle of the interface; r is the matching color recognition rate; and p is the color coefficient.

3 Test, application and interactive efficacy empirical evidence of VR Civics teaching system

3.1 Experimental Analysis of System Usability Testing

Firstly, the above constructed interactive teaching system for Civics courses based on virtual reality technology is analyzed for usability testing. Usability testing is a method of evaluating the ease of use of a product or system, aiming to understand the difficulties and experience felt by users in the actual operation process. Usability is a measure of a system's ability to function properly and provide services for a specific period of time. In this study, usability testing was used to ensure that the interactive teaching system for the Civics course has usability, to assess the intuitiveness and convenience of its operation, and to understand the student users' overall feelings and satisfaction with the program.

A total of 98 college students from the classes of 2021-2024 of a university were invited as subjects to apply the interactive teaching system for Civics and Politics courses constructed in

this paper. The subjects came from all grades and majors, including 47 male students and 51 female students. The usability test mainly focuses on the three aspects of system usability metrics, information and interface metrics, and overall ratings. The questionnaire was based on a five-point Likert scale of 1-very non-compliant, 2-comparatively non-compliant; 3-fairly compliant, 4-comparatively compliant, and 5-very non-compliant.

3.1.1 System availability metrics

The system usability metric includes Q1: Overall, satisfied with how easy this product is to use; Q2: It is easy to use this system; Q3: Comfortable to use; Q4: It is easy to learn this system; Q5: Civic education courses can be better conducted through this system; Q6: It is not easy to make mistakes in using it totaling 6 questions. 98 subjects after applying the interactive teaching system for Civic Education courses The results of the evaluation of the system usability metric are shown in Figure 5.

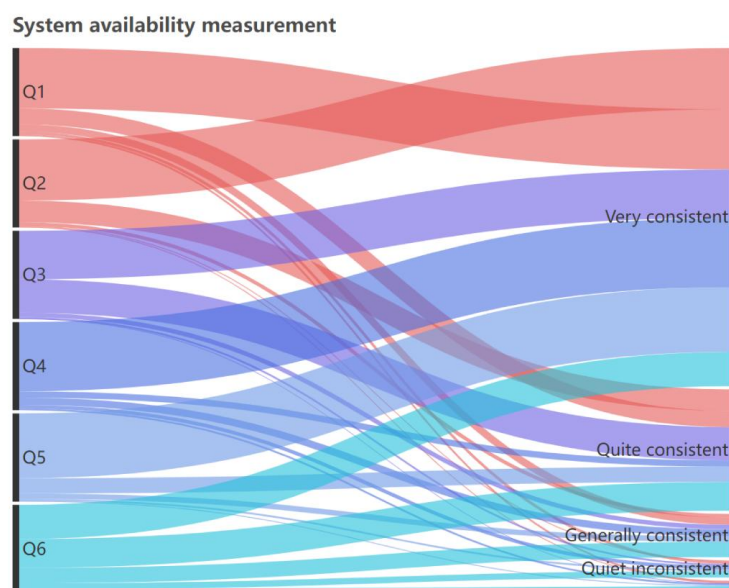


Figure 5: Evaluation results of system availability measurement

Overall, users highly recognized the core usability of the system. The vast majority of participants felt that the system was easy to use, simple to operate, and had a low learning threshold, with more than 85 people rating the system as “very compliant” and “more compliant” for questions Q1-Q5. However, for Q6: It is not easy to make mistakes when using the system, although there are still 70 positive ratings (Very Compliant + Comparatively Compliant), 28 users chose Generally Compliant or below. This reveals that the system still has room for improvement in terms of operational tolerance and guidance. There may be a need for clearer operational feedback to make it easier for student users to operate.

3.1.2 Information and Interface Metrics

The questions in the questionnaire about information and interface metrics include Q7: It is easy to find the information I want to know about Civics; Q8: The information provided is clearly hierarchical; Q9: The interface is well laid out; and Q10: The visualization of the virtual scenarios, models, and interfaces is clear and aesthetically pleasing. The findings of the system information and interface metrics are shown in Figure 6.

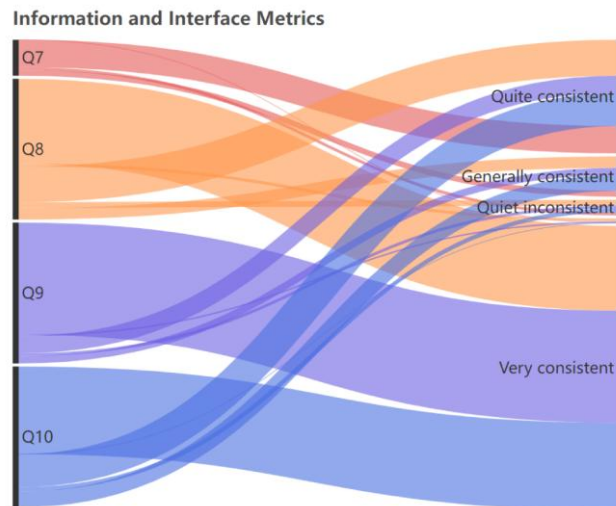


Figure 6: Evaluation results of system information and interface metrics

In terms of information presentation and visual interface, the system's performance also received positive feedback, with almost all ratings flowing to “very compliant” and “fairly compliant”. In terms of Q7's information findability, 92 users recognized that the system was successful in laying out the information points in the Civics virtual scenario. Users also bought the system's clarity, aesthetics and organization. This is due to the application of model optimization and texture mapping techniques discussed in the previous sections, indicating that the technical inputs are directly translated into a good user experience.

3.1.3 Overall rating

The overall rating dimensions include Q11: The system provides sufficient functionality; Q12: I am satisfied with the layout and style of the Civics teaching virtual scene; Q13 I do not feel any discomfort caused by VR; Q14: The design and presentation of the content of the Civics course within the system is appealing enough to me to stimulate my interest in learning; and Q15: Overall, I am satisfied with the virtual teaching system.98 subjects The findings for the overall ratings are shown in Figure 7.

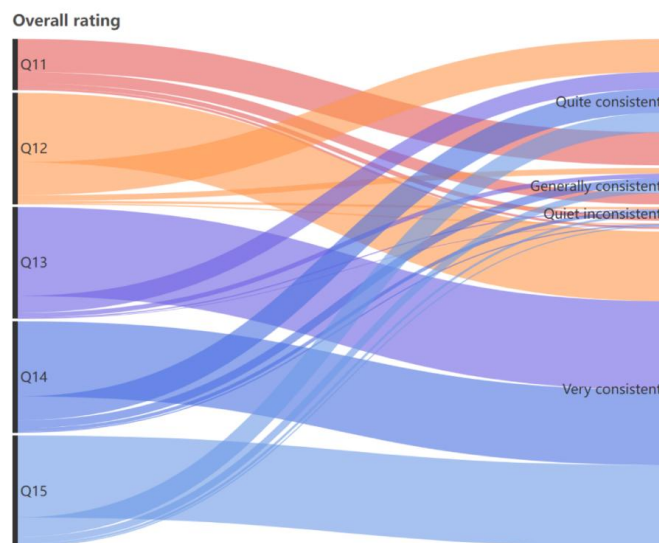


Figure 7: Evaluation result of the overall score of the system

From the macro evaluation of the overall experience, the system has once again been confirmed in all aspects. The overall rating of the five items in 67.35% and 22.65% flowed to “very consistent” and “more consistent”, generally consistent with only 6.53%, “less consistent” “Comparatively non-compliant” and “Completely non-compliant” are only 2.45% and 1.02% respectively. This shows that users are more satisfied with the system functionality, scene art style, technical experience, content design and overall satisfaction.

3.2 Application of Interactive System of Civics Course in Teaching and Learning

Based on the results of the above system usability testing and analysis, for the slightly insufficient fault tolerance of the system, then improve the operation, add more clear operation feedback, and increase the anti-mistake touch design on the key steps. Further, the improved Civics Virtual Scene Interaction System is applied to actual Civics classroom teaching, and differentiated teaching is conducted in experimental and control classes, and the teaching effect is understood according to the self-assessment of students' learning attitudes, the teachers' assessment of their participation in the course, and the comprehensive grade of Civics.

The object of the study is two parallel classes of students in the 2024 session of a university majoring in public administration. 1 class has 54 students as control class, which is taught by traditional teaching methods, and 2 experimental class has 53 students in total, which is taught by the optimized interactive teaching system of Civics course based on virtual reality technology. The learning conditions of the two selected classes are basically the same, the cognitive level before learning new knowledge is basically the same, the same content is taught by the same teacher in the process of Civics teaching, the same teaching materials are used, and the same set of evaluation criteria are used to evaluate the students in a unified way after the teaching is finished, so as to ensure that the final results of the teaching are fair and accurate.

3.2.1 Analysis of Students' Civic and Political Achievements

The students' final Civic and Political Sciences grades include both final theoretical test grades and usual performance grades, both of which are weighted in the ratio of 6:4 to get the final Civic and Political Sciences grades. The Civics and Politics grades of the students in the two classes are shown in Table 1.

Table 1: The ideological and political scores of the two classes of students

		Experimental class (N=53)		Control class (N=54)	
		Number of people	Percentage	Number of people	Percentage
Final theoretical test score	Excellent: 90 - 100	35	66.04%	19	35.19%
	Good: 80 - 89	16	30.19%	21	38.89%
	Pass: 60 - 79	2	3.77%	11	20.37%
	Fail: 0 - 60	0	0	3	5.56%
	Total score	92.05±7.33		84.03±12.39	
Regular performance results	Excellent: 90 - 100	27	50.94%	13	24.07%
	Good: 80 - 89	16	30.19%	16	29.63%
	Pass: 60 - 79	9	16.98%	20	37.04%
	Fail: 0 - 60	1	1.89%	5	9.26%
	Total score	86.94±10.97		77.30±12.84	
Overall score		90.54±8.38		81.26±12.45	

After one semester of differentiated teaching, the experimental class had significantly more students with high scores of “excellent” (90-100 points) in the Civics course, accounting for 66% of the students, which is almost twice as much as the control class. And all the students in the experimental class successfully passed the exam, while three students in the control class failed. The experimental class scored 92.05 points ahead of the control class's 84.03 points, and the difference between the two classes' final theoretical test scores was more than 8 points.

The experimental class has an equally solid advantage in the usual performance scores that reflect the learning process. Its overall average score is 86.94 ± 10.97 , while the control class's usual performance score is only 77.30 ± 12.94 . The experimental class continues to have more than twice as many high-performing students as the control class, with 27 and 13 students respectively. Through the use of VR system for Civics teaching, the overall performance of students in classroom interaction, homework completion, practical participation and other aspects is more outstanding.

The experimental class received an overall score of 90.54 points after the two scores were combined and weighted, surpassing the 81.26 points of the control class by nearly 10 points. It confirms the effectiveness of VR technology-enabled Civics teaching, and the system translates into better academic results.

3.2.2 Results of self-assessment of students' learning attitudes

At the end of the semester teaching, questionnaires were distributed to the students of the two classes respectively, so that the students could self-assess themselves in five aspects, namely, learning motivation, interest in learning, learning ability, self-efficacy and teaching effectiveness. The results of the self-assessment evaluation of students' learning attitudes in the two classes are shown in Table 2.

Table 2: Self-assessment results of learning attitudes of the two classes of students

		Strongly Agree	Quiet agree	Generally Agree	Quiet disagree	Strongly Disagree
Learning enthusiasm	Experimental Class	31	11	7	3	1
	Control class	10	14	17	9	4
Learning interest	Experimental Class	35	12	4	2	0
	Control class	12	7	22	10	3
Learning ability	Experimental Class	40	8	4	1	0
	Control class	16	15	16	5	2
Self-efficacy	Experimental Class	27	18	4	3	1
	Control class	8	12	19	11	4
Teaching effect	Experimental Class	42	5	4	2	0
	Control class	22	16	11	4	1

On the five core self-assessment dimensions, the vast majority of the students in the experimental class voted in favor, indicating that the changes brought by the VR Civics classroom were profound and positive. The most prominent feedback centered on learning effect and learning ability. Forty-seven (42+5) and 48 (40+8) students agreed “strongly” or “fairly” with the improvement of these two items respectively. In contrast, only 38 (22+16) and 31 (16+15) students in the control class of the traditional teaching method were late satisfied with these two items. Meanwhile, the immersion and interactivity of the virtual interactive system also translated into strong learning drivers for the students in the experimental class. A whopping 47 of them indicated that their interest was enhanced, compared to only 19 in the

control class, and more students were indifferent to the enhancement of their interest in Civics and Politics learning.

3.2.3 Analysis of teacher evaluation results

For teacher evaluation, the Civics teachers involved in teaching rated the students of the two classes on a scale of 1-10 in the four aspects of Civics classroom attentiveness, interactive positivity, uniqueness of student expression and depth of thought. The results of the teacher evaluation of the experimental and teaching classes are shown in Figure 8.

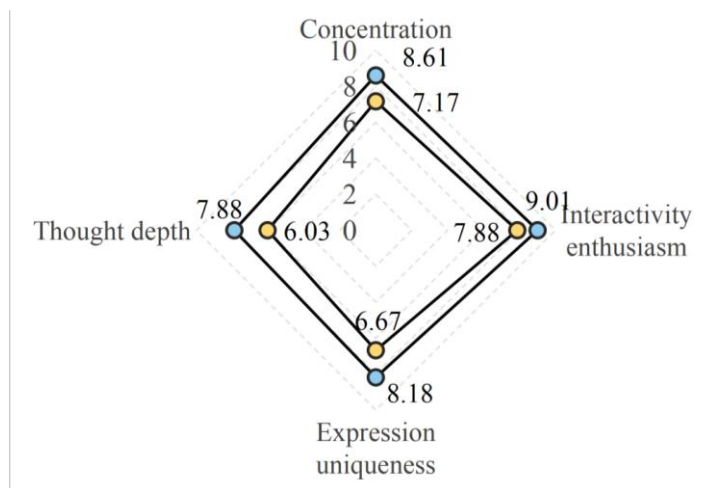


Figure 8: The evaluation results of teachers in the experimental and control class

Teachers' evaluation confirms from a professional perspective that VR Civics teaching not only enhances students' interaction and concentration, but also significantly improves the depth of classroom ideas and expressions. Teachers' concentration score for the experimental class applying the virtual interactive performance teaching system is 8.61, while the control class is only 7.17, the former is 20.08% better, which indicates that the interactive system can attract students more, and keep students' attention on the teaching content for a longer period of time. The interactive system is also significantly better in terms of interactivity, with scores of 9.01 and 7.88 respectively, and the advantages in terms of uniqueness of expression and depth of thought are also present. VR teaching may be able to lead students to deeper thinking and connotative exploration. When abstract theories are transformed into touchable and interactive scenes, students are more likely to feel a sense of immersion, thus stimulating more insightful views. This fits perfectly with the original intent of the system design, which emphasizes the linkage of content and scenes.

3.3 Quantitative Comparative Analysis of System Interaction Performance

Further, this section shifts the perspective from the macro instructional effects to the micro level of the system interaction behavior. Compare the interaction data flow between the system in this paper and the traditional system under the same task. By tracking and quantifying students' information submission and system information feedback, the abstract interactivity is transformed into observable curves and values, revealing the advantages of this paper's system in terms of response mechanism and feedback initiative.

Continuing to select 98 college student subjects in the experiment in section 3.1 above as the research subjects, applying this paper's system and the traditional system, respectively, to

record the students' information submission and information feedback, which are divided into active and passive paths, and if the two paths intersect, then it is an interactive behavior. Fig. 9 and Fig. 10 show the comparison of interactivity under this paper's system and the traditional system, respectively.

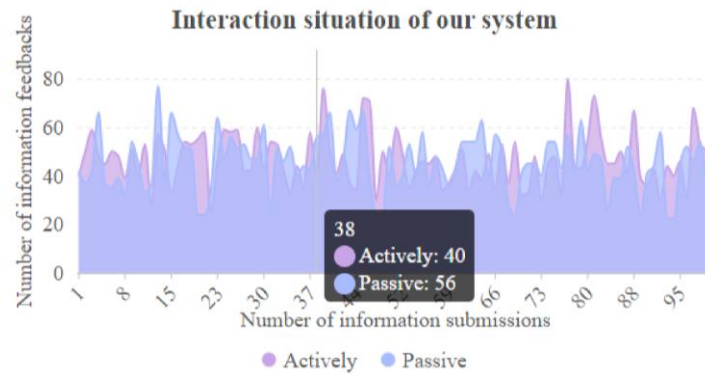


Figure 9: The test results of our system's interaction situation

The horizontal axis is the number of information submissions from 98 students, and the vertical axis is the number of information feedbacks from students, and it can be seen that the number of active and passive feedbacks from students in this paper's system is generally around 40-60 times, and the active and passive curves intersect frequently. It shows that the virtual scene-based Civics teaching system constructed in this paper provides real-time active feedback of teaching information to students, and provides timely explanations of the problems when the users ask questions at the same time. Thanks to LOD model optimization and efficient rendering, the system is able to carry frequent scene switching and object interaction without lagging. The interaction logic built on Unity ensures that the link from user operation to system feedback is extremely short, thus realizing the smooth experience of almost synchronized question-explanation.

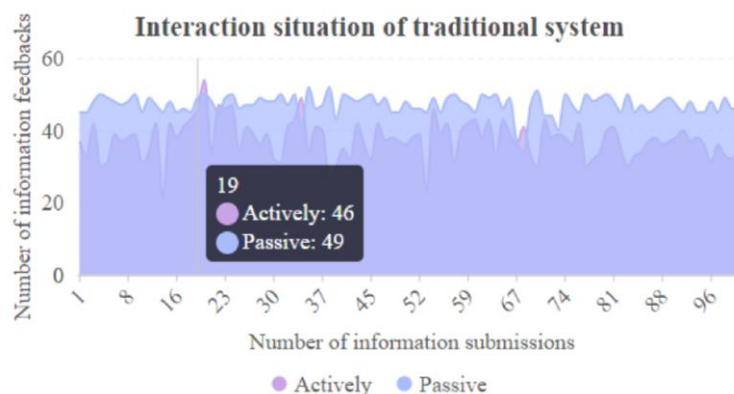


Figure 10: The test results of traditional system's interaction situation

As for the test results under the traditional system, it can be seen that the active and passive interaction curves of the system do not fluctuate drastically with the same information data submission. The number of passive feedbacks from learners under the system is almost always below 40, and the number of active feedbacks is slightly higher, but again, almost no more than 50. This indicates that the users' motivation and interactivity in using the system are not high, the system's ability to provide active feedback on teaching information is poor, and the feedback on the users' questions is also not active. The comparison shows that the traditional teaching

system has poor interactivity, which affects students' interest in learning.

4 Conclusion

Using Unity3D as a hub, the study combines LOD model optimization and intelligent texture mapping to build a cross-platform, high-fidelity, smooth-running virtual Civics teaching scenario. More than 85% of positive user evaluations in the usability test, and nearly 90% of users think that it is “easy to learn” and “improves the learning effect”, which verifies the user-friendliness and acceptance of this technical solution from the experience side. The experimental class using the VR system demonstrated all-round advantages, with an average composite score of 90.54, significantly higher than the 81.26 of the traditional teaching control class, an advantage of 11.42%. At the same time, more than 87% of the students in the experimental class self-reported that their learning interests and effects were improved, and the teachers' ratings of their classroom concentration, interactive enthusiasm and depth of thought were 8.61, 9.01 and 7.88. It confirms that this paper's virtual system of Civic and Political Education based on virtual reality is feasible and efficient, and that it integrates the cultivation of values into the virtual context of high-frequency interaction and stimulates the endogenous motivation and vitality of learning in the meantime, while improving students' grasp of Civic and Political Knowledge. The virtual system of Civic and Political Education based on virtual reality in this paper is feasible and efficient.

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