Eng Int Syst (2025) 6: 701–710

Engineering
Intelligent Systems

Design and Implementation of Red Culture Education experience System Based on VR Technology

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Red culture is an important heritage of Chinese revolutionary history, and contains rich educational value. Traditional modes of red culture education lack interaction and immersion, and therefore cannot fully meet the needs of today's learners. In order to create a more vivid and effective means of conveying red culture, this study combined virtual reality technology to design and achieve an immersive educational experience system. The integration of technology and education enables learners to improve their knowledge mastery, strengthen their emotional identification, and facilitate the communication of red culture. Based on constructionist learning theory, immersion theory and multimedia learning theory, a system architecture is constructed that integrates scenario-immersion experience, dynamic content adaptation and user interaction optimization. The system development involves data collection, scenario modeling and algorithm design, ultimately building a red culture education platform suitable for different learning scenarios. The results show that the system improves the user's knowledge mastery and emotional recognition, and optimizes the learning experience and ease-of-operation. It demonstrates the broad applicability of virtual reality technology in red culture education.

Keywords: virtual reality technology; red culture education; Immersive learning

1. INTRODUCTION

Red culture is an important part of Chinese revolutionary history, carrying the profound connotation of national spirit and revolutionary tradition, and has important educational value in the modern era. The traditional red culture education mode often is often confined to classroom teaching and text reading, which cannot adequately stimulate learners' emotional resonance and motivation to learn. Nowadays, virtual reality technology, which can provide immersion, interaction and visualization, offers a new possibility for innovating the education model, and shows a unique advantage in the experiential learning of red culture. The virtual learning environment constructed with VR technology simulates historical scenes, allowing learners to experience historical events and figures in Red Culture from a unique perspective, thereby enhancing the intuitiveness and authenticity of education. In recent years, education information has been gradually promoted, and the state has issued a series of policies to encourage the deep integration of digital technology and education. In the dissemination and promotion of red culture, the introduction of innovative technology is regarded as an important means of addressing the currently inefficient educational process and single learning experience. As an important tool of digital education, VR technology has great application potential. Red culture education based on VR technology can significantly improve learners' learning outcomes and emotional experience. The research on the combination of red culture education and VR technology is still in its infancy, with systematic deficiencies and limited number of practical cases. How to use virtual reality technology to build efficient and immersive educational experiences is not only a problem in the field of technology, but also the realistic demand of red culture communication.

There is ongoing research on the integration of virtual reality technology and red culture education. Nnamani (2024)

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studied the learning experience of students in mainstream schools and proposed that the ecosystem perspective can effectively determine the influence of different factors on students' learning, providing a reference for analyzing their learning adaptability in a virtual reality environment [1]. Zhang and Yu (2024) discussed the application of virtual reality technology in rehabilitation, pointing out that technology-driven systems can significantly improve learners' participation and motivation, providing a theoretical basis for the promotion of virtual reality technology in educational contexts [2]. Ren (2024) studied the modern expression of Chinese red culture and believes that the innovation of cultural communication needs to be strongly combined with modern technology, providing a cultural perspective for the study of the integration of red culture and virtual reality technology [3]. Bedar et al. (2023) verified the significant impact of virtual reality technology on functional recovery through their study of virtual reality intervention applied to stroke-affected people, indicating that virtual reality technology can be applied to the simulation of special scenarios and provide behavior guidance in educational intervention [4]. Hamad and Jia (2022) comprehensively reviewed the application scenarios of virtual reality technology in life, pointing out its unique advantages in emotional expression and content delivery, and providing ideas for emotional design in the education system [5]. Moore and Blackmon (2022) systematically reviewed the experience of MOOC learners, proposed that the optimization of technical environment is closely related to the improvement of learner experience, and emphasized the importance of interactive optimization for the design of a virtual reality education system [6]. Wang (2022), from the perspective of the creation and reshaping of red culture, emphasizes the need for innovative expression of cultural education and provides inspiration for the modern dissemination of red culture [7]. Zhao and Zhou (2022) analyzed the action mechanism of user experience in an educational live streaming platform and believed that the optimization of user experience could improve the learning effect of an education platform, providing theoretical support for the optimization of user interaction design in virtual reality systems [8]. Hwang and Shim (2021) studied the application of virtual reality technology in home renovation and proposed practical methods of virtual scenario construction, providing important references for scenario immersion design in red culture education [9]. Mittler (2020) studied the combination of politics, aesthetics and popular culture of Chinese red classics and pointed out that red culture education should pay attention to the integration of history and modern narrative, which provided inspiration for the design of course content for virtual reality education [10]. Shafer (2019) analyzed the factors of user experience in virtual reality games, and believed that the fit of technology and content directly affected users' sense of immersion, providing guidance for scenario design and the optimization of interactive experiences in red culture education [11].

In practical applications, how to use VR technology to efficiently integrate red cultural resources, how to faithfully reproduce red cultural scenarios in virtual environments, and enhance learners' sense of participation and learning effect through interactive design, are issues that need to be resolved. Hence, this study focuses on the problems existing in the design and implementation of the red culture education experience system, and proposes a systematic solution to optimize the communication mode of red culture education and enhance the education effect [12, 13]. Focusing on the deep integration of virtual reality technology and red culture education, this study explored effective education models and provides innovative ideas for the dissemination of red culture in the modern era. The purpose of this study was to design and implement a red culture education experience system based on virtual reality technology, improve the communication effect of red culture through innovative education methods, and enhance learners' understanding and identity of red culture. Relevant literature published at home and abroad was collected and reviewed to clarify the research status and development trend and form the theoretical basis of the research. The demand research method, utilizing questionnaires and interviews, was adopted to analyze the demand of different learner groups for the content and experience of red culture education. For the system development, the technology realization method was adopted to construct the red culture education experience system based on virtual reality technology [14]. The experimental verification method was adopted to conduct user tests on the designed VR education system, collect feedback data from the learners using the system, analyze the system's performance in terms of learning outcomes and user experience, and propose optimization schemes. At the theoretical level, this study enriches the theoretical basis for the application of virtual reality technology in the field of education, and provides a new research perspective for the combination of red culture education and emerging technologies. At the practical level, this study designed and implemented a red culture education experience system based on virtual reality technology, with faithfully-restored historical scenarios and an immersive interactive design, providing learners with a new way of acquiring knowledge [15].

According to constructivism learning theory, learners are active constructors of knowledge, and knowledge acquisition is accomplished through the interaction between learners and the environment, others and their own experience. In the process of education, learners integrate the new learning content with the existing knowledge structure through exploration and practice to construct knowledge and meaning. Constructivism learning theory is in line with red culture education. In the virtual reality environment, learners can perceive historical events, experience revolutionary scenarios and deeply understand the spiritual core of red culture through simulation and interaction. In the VR education system, in order to quantify the effect of learners' knowledge construction, the following formula is used (1).

$$E_k = \sum_{i=1}^{n}(C_i \cdot I_i) \tag{1}$$

E_k represents the efficiency of knowledge construction, C_i represents the content relevance of the first i learning resource, I_i represents the interactive weight of the resource, and n represents the quantity of the resource. Immersion theory is the basis of the application of virtual reality technology,

Table 1 Classification of red cultural and educational resources.

Resource Type	Description	Source
Revolutionary Events	Text, images, and audio of key events	Museum databases, archives
Red Culture scenarios	Images of revolutionary sites and simulations	National Heritage Bureau, cultural research centers
Revolutionary Figures	Biographies and video records	Authoritative documents, red-themed films
Classic Historical Documents	Revolutionary documents, speeches, and literary works	Central Archives, Ministry of Education

Table 2 Analysis of user requirements.

Target Group	Sample Size	Type of Demand	Data Collection Method
Primary & Secondary Students	200	Content visualization and engagement	Surveys and interviews
University Students	150	scenario immersion and interaction design	Surveys and interviews
Young Party Members	100	Historical depth and seriousness	Surveys and interviews

emphasizing that users can fully focus on the psychological state of the scenario in a specific virtual environment. A high level of immersion can enable learners to form a strong sense of connection with the scenario environment, and enhance their learning experience and emotional resonance. In red culture education, immersion theory is used to build realistic revolutionary historical scenarios, in which learners can deeply participate and better understand the historical background and spiritual value of red culture. The quantitative model is as follows (2).

$$I = \frac{(S_v + S_a + S_i)}{N} \tag{2}$$

I is the immersion index, S_v represents the intensity of visual stimuli, S_a represents the intensity of auditory stimuli, S_i represents the interactivity index, and N represents the total number of stimulus types (such as visual, auditory, and tactile).

2. MATERIALS AND METHODS

2.1 Data Collection and Sample Selection

2.1.1 Collection of Red Culture and Education Related Resources

The content of a VR education system is based on red cultural and educational resources. As shown in Table 1 below, the collected resources were in relation to: revolutionary historical events, red cultural scenarios, revolutionary characters' deeds and classic historical documents. In order to ensure the comprehensiveness and accuracy of the content, most of the data were obtained from the red culture exhibition hall and museum database sponsored by the national and local governments, the research results of authoritative academic institutions, the film and audio materials on the theme of red culture, and the red culture teaching syllabus formulated by the education department.

In the process of collection, the focus is on screening representative red cultural and educational resources to ensure the balance of historical background, content breadth and educational value of resources. Resources were classified according to the age, geographical region and event type, so as to facilitate the content matching and application in the subsequent system development. Following the collection process, the relevant resources were sorted into standardized data formats, providing a foundation for virtual scenario modeling and the development of educational content.

2.1.2 User Demand Survey and Sample Design

The main purpose of the user demand research was to understand the target learning group's demand for red culture education content and VR learning style, and ensure that the system design met user expectations. As shown in Table 2 below, the research samples comprised three groups: primary and secondary school students, college students and young Party members. These groups have their own characteristics in terms of educational background and cognitive level. The difference in demand for red culture education provides a basis for the diversified design of system content.

Questionnaire survey and in-depth interview are used, and the contents of the questionnaire cover users' cognition status of red culture education, preference for educational content forms, and acceptance of the VR technology application. Questionnaires were distributed to schools and Party branches. After collecting the questionnaires, statistical analysis was carried out to form a demand portrait. At the same time, the emotional experience and expectation of users in the learning process were collected via in-depth interviews to provide data for interactive design.

2.1.3 Description of the Data Collection Tool and Platform

In order to complete the data collection work efficiently, combined with different types of data requirements, a variety of acquisition tools and platforms were adopted. For the collection of resources related to red culture and education, document analysis software (NVivo) was used to organize text resources, and a geographic information system (GIS) was used to collect and manage spatial data related to revolutionary sites. Audio and video data were extracted and classified

Table 3 VR system architecture and module division.

Module Name	Function Description	Implementation Method
scenario Management	scenario loading, switching, and resource scheduling	Unity engine, resource management algorithms
Interaction Control	Real-time user interaction and feedback	Controller input, physics engine
Educational Content	Dynamic display of red culture knowledge and tasks	Database, real-time rendering
Data Collection	Collection and analysis of learning behavior and system performance	Database, analytics algorithms

using professional editing tools such as Adobe Premiere. For the research on user demand, online research platforms (such as questionnaire star or Google Forms) were used for the questionnaire design and statistical analysis. Recording equipment and transcription software (Otter) were used during in-depth interviews to record user feedback. All collected data was stored and managed by specialized database management tools (MySQL) to ensure data integrity and availability, providing reliable data support for subsequent VR system development.

2.2 Model Construction

2.2.1 Selection and Analysis of Virtual Reality Technology

When selecting a virtual reality technology, the focus is on its performance, stability and adaptability. According to the high requirements of the red culture education system for scenario immersion and interactivity, we built a virtual environment based on the Unity engine. Unity has cross-platform support, powerful 3D rendering capabilities, and a wealth of development tools to enable efficient construction and real-time rendering of complex scenarios. Considering the hardware requirements of the system, a solution compatible with mainstream VR devices in the market (such as HTC Vive and Oculus Quest) should be chosen to ensure the balance between device availability and user experience. In order to quantify the scenario-rendering performance of the VR system, formula (3) was designed to evaluate the real-time rendering effect of the scenario at runtime.

$$R = \frac{P_d \times N_v}{T_f} \tag{3}$$

R is the rendering performance index, P_d is the number of pixels drawn per second, N_v is the number of vertices in the scene, and T_f is the interval between frames.

2.2.2 VR System Architecture Design

The design of the VR system architecture is based on the principle of modularity to ensure that the system has good scalability and maintainability. The system designed in this study comprises four modules: scenario management module, interactive control module, education content module and data acquisition module. As shown in Table 3 below, the scenario management module is responsible for loading and switching different red culture scenarios. The interactive control module realizes the user's operation and feedback in the virtual environment; the educational content module undertakes the dynamic display of knowledge points and the release of tasks; and the data acquisition module is used to record learning behavior and system operation data.

2.2.3 Scenario Modeling and Technical Implementation

Scenario modeling is the core of system development, which directly affects the immersive experience of learners. In this study, actual historical scenarios were taken as reference, and through the combination of GIS data and historical documents, several typical red cultural scenarios were constructed in three dimensions. The Maya and Blender modeling tools were used to ensure the precision and authenticity of the model. In order to improve rendering efficiency, LOD (Level of Detail) technology was used to dynamically adjust the detail level of the model according to the user's perspective distance.

For material processing, PBR (physics-based rendering) technology was used to simulate light and shadow effects to make the scenario more realistic. Texture resources were seamlessly mapped to avoid obvious splicing marks on the surface of the model. Sound effects were integrated with background music to create an immersive audio-visual experience for users. Dynamic objects in the scenario, such as flags fluttering and light changing, were implemented through the Unity physics engine to create a more realistic environment.

2.2.4 Development of Interactive Function Modules

Interactive function is the core design of the VR education system, the purpose of which is to improve user participation and learning outcomes. Based on VR controller and gesture recognition technology, this research developed a variety of interaction methods, including touch selection, object grasping and task manipulation. In the scenario, users can select educational content, participate in task challenges, and interact with virtual objects by means of virtual controllers. In one scenario, for example, users can "light" a virtual bonfire and watch the reenactment of a revolutionary speech. In order to strengthen the interest and challenge of learning tasks, the system designed a dynamic task generation mechanism to adjust the difficulty and content of tasks in real time according to the learning progress and behavior data of users. The system supports multi-person online collaborative learning,

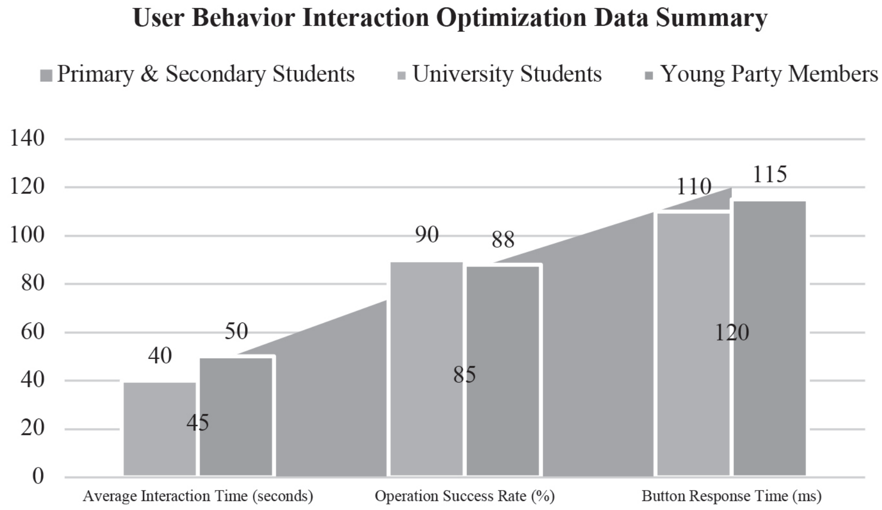

Figure 1 User behavior interaction optimization data summary table.

and users can complete educational tasks together with other learners through voice communication, which improves social interaction during the learning process.

2.3 System Function Implementation and Optimization Path

2.3.1 Scenario Immersive Experience Design

The scenario immersion experience enables learners to integrate into the virtual environment in an all-round way and get immersive feelings. This study focuses on the restoration of details and the enhancement of dynamic elements in the design of virtual scenarios. Taking red culture and education as the theme, the system selected a number of representative revolutionary historical scenarios, such as the Jinggangshan army meeting, the Long March Road and Yan 'an cave dwellings during the Anti-Japanese War, and carried out three-dimensional modeling and texture rendering through historical data and GIS data to make the scenarios highly realistic. The immersion aspect of the scenario is achieved through visual, auditory and tactile multi-dimensional stimuli. In terms of vision, PBR rendering technology is used to reconstruct the light and shadow effect of the scenario, and the continuity of the environment is enhanced through the smooth switching of the panoramic image. In terms of auditory stimulation, high-quality environmental sound effects, such as wind, character dialogue and historical background music, are introduced to enhance the historical atmosphere of the scenario. Haptic interaction is enabled by VR devices that simulate real touch through vibration feedback, such as the vibration effect when clicking on revolutionary objects. The introduction of dynamic elements, such as waving flags, changing the lighting, and scenario interaction, enhances the immersion experience of learners.

2.3.2 User Interaction Design and Optimization

The focus of user interaction design is to improve learners' operation convenience and sense of participation. Based on virtual controller and gesture recognition technology, in this study, a variety of interaction modes was constructed, including object picking, scenario navigation and task operation. In the scenario, users can use the controller to select educational content, complete interactive tasks, or scroll through virtual history books by means of gestures, strengthening their engagement in the learning process. The optimization of interactive experience is realized through the collection and analysis of user behavior data. In this study, a behavioral interaction model was designed to analyze the user's operational behavior and optimize feedback. The optimization can be achieved by shortening the scenario-loading time, enhancing the response speed of buttons, and simplifying the steps of complex operations. As shown in Figure 1 below, when users are undertaking educational tasks, the system dynamically adjusts the display mode of operation instructions to reduce the learners' cognitive burden.

2.3.3 Dynamic Adaptation of Educational Content

The dynamic adaptation of educational content aims to meet the individual needs of different learners and achieve the flexible presentation of educational content. The system adjusts the difficulty and presentation of educational content in real time utilizing user behavior data, learning preferences and task completion. For example, for users with weak basic knowledge, the system gives priority to displaying intuitive pictures and videos, while for users with some basic knowledge, the system presents more in-depth text and situational tasks. The dynamic content adaptation is based on the behavioral interaction model formula (4).

$$U_e = \frac{\sum_{i=1}^{n}(P_i \times L_i)}{T} \tag{4}$$

U_e represents the user's educational effect score, P_i represents the user's participation in the first i task, L_i represents the task difficulty coefficient, and T represents the total number of tasks. Through real-time calculation of the user's participation effect, the system dynamically adjusts the learning content to ensure that the content difficulty matches the user's ability.

Table 4 Promotion path analysis.

Promotion Path	Target Group	Implementation Method	Expected Outcome
School Education	Primary & Secondary Students, University Students	Classroom support, educational activities	Enhance red culture education outcomes
Social Education	General Visitors	Introduce VR in museums, public events	Strengthen public understanding of red culture
Online Education	General Public	Develop mobile apps, social media promotion	Expand the coverage of red culture education

2.3.4 System Test and Function Optimization Suggestions

The test of system function takes the performance index and user experience as the core, which is divided into two parts: technical performance test and user behavior test. In the technical performance test, the rendering speed, scenario switching delay and the system's resource consumption are evaluated to ensure smooth operation of the system on different hardware platforms. For example, tests on mid-range VR devices show that the scenario switching delay is no more than 2 seconds, meeting the basic requirements of an immersive experience. The user behavior test was conducted through questionnaires and data records to analyze the user's difficulties in operation and shortcomings in experience. The test results show that most users were satisfied with their immersion in the scenario and the dynamic adaptation of the content presentation, although some users believed it was necessary to improve the complexity of the interaction. Accordingly, the following optimization suggestions are put forward:

(1) Simplify operation logic, and reduce learners' operation difficulty through gesture guidance and visual markers.

(2) Enhance the coherence of the scenario by, for instance, optimizing the natural degree of the scenario transition animation.

(3) Improve the accuracy of dynamic task generation to make educational tasks more suitable for learners' actual needs.

2.4 System Promotion Suggestions

2.4.1 Promotion Path of Red Culture Education

The promotion path of red culture education should be combined with the existing education system and technological development environment, from three aspects: school education, social education and online education. As shown in Table 4 below, in school education, the education system based on VR technology can be used as an auxiliary tool for classroom teaching using the existing red culture courses in primary and secondary schools and colleges. The combination of traditional classroom teaching methods with immersive virtual reality experience helps students learn red culture knowledge in a more realistic environment and improves the teaching and learning outcomes. In terms of social education, the VR education system could be introduced into red culture sites such as museums and memorials, so that visitors can understand the historical background and spiritual connotation of red culture through virtual reality technology. Local governments and cultural departments could organize red culture experience activities, provide VR equipment in public places for public use, and promote the popularization and dissemination of red culture. Online education can be acquired via the Internet platform and mobile devices, and allows users to access red cultural education content anytime and anywhere through the development of VR education applications suitable for mobile phones and PCS. Social media and online education platforms can be integrated to improve the efficiency of content dissemination and expand the scope of coverage.

2.4.2 Application Value Analysis of VR Education System

The value of the VR education system is evident in its educational effect, cultural communication capability, and technological innovation. From the perspective of educational effect, VR technology enhances the intuitiveness and attractiveness of red culture education by offering strong immersion and interactivity, and solves the problems of lack of learning interest and students' poor participation when in a traditional teaching environment. Because of the restoration of virtual scenarios and the display of dynamic content, students can more deeply understand the background and significance of historical events, and improve the learning outcomes. In terms of cultural communication, VR technology transcends the limitations of time and space, extends red culture from offline communication to online platforms, and provides a new means of cultural protection and communication. The establishment of a digital red cultural resource library can preserve revolutionary historical relics and documents, and also provides rich materials for future education and research. Technological innovation is a highlight of the VR education system. By integrating 3D modeling, interaction design and data analysis techniques, the system development process promotes the development of educational informatization. Its application practice provides valuable experience for the promotion of VR technology in other education fields, and also opens up a new direction for the integration of interdisciplinary technology.

2.4.3 The Prospect of the Integration of Red Culture Education and VR Technology

The integration of red culture education and VR technology provides a broad space for cultural communication and

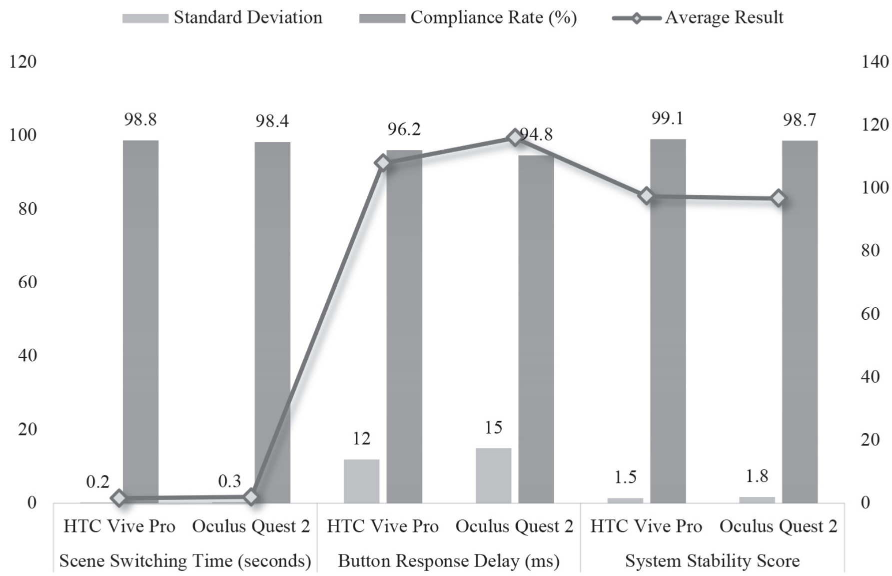

Figure 2 Results of system function evaluation.

education development in the modern era. With the continuous progress of technology, the popularity of VR equipment has gradually increased, and the use cost has been reduced, creating favorable conditions for the promotion and application of the system. In the future, based on the support of 5G network and cloud computing technology, the content of VR education system will be richer, and the user experience will be smoother. The future development of integration is also reflected in the diversification and intelligence of content. By combining artificial intelligence technology, the system will be able to generate personalized educational content in real time based on users' learning behaviors and preferences, enhancing the user experience. With the continuous expansion of the content of red culture education, virtual reality will be able to cover more historical scenarios and cultural details, providing a more complete educational experience for learners. The combination of red cultural education and VR technology also provides new ideas for the promotion of cultural soft power. At home, this education model helps to strengthen the revolutionary spirit and identity of the youth. Internationally, the digitization and global dissemination of red culture can enhance the international community's understanding of Chinese culture and history, and strengthen the international influence of Chinese culture. Through continuous technology optimization and content development, the integration of red culture education and VR technology will play a more important role in the future education and culture field.

3. RESULTS AND DISCUSSION

3.1 Results

3.1.1 Effect Evaluation of System Function Implementation

The evaluation of the implementation effect of the system functions focuses on three core indexes: scenario rendering performance, interactive response speed and system stability. The performance of the system was tested in different hardware environments and quantitatively analyzed. Testing data shows that the system's performance meets expectations on both high-end devices (such as the HTC Vive Pro) and mid-range devices (such as the Oculus Quest 2). As shown in Figure 2 below, in terms of scenario- switching speed, the average delay is 1.8 seconds, and the success rate of resource loading is 98.6%. In the interactive response speed test, the average button response delay is 112 milliseconds, and the operation success rate reaches more than 95%. There were no crashes or significant performance fluctuations during operation, and the system achieved a stability score of 97.

3.1.2 User Experience Data Analysis

The feedback statistics of different user groups are used for the analysis of user experience data covering three dimensions: learning immersion, operation convenience and content satisfaction. As shown in Figure 3 below, most users rated the system highly in terms of immersion and content design. The average learning immersion score is 8.7 out of 10, the ease of operation score is 8.4, and the content satisfaction score is 8.9. The feedback of primary and secondary school students on the interestingness of the content is better than that of other groups, and young party members pay more attention to the historical depth of the content.

3.1.3 Preliminary Evaluation of Educational Effect

The initial evaluation of the educational effect was measured by the changes in the user's knowledge mastery and emotional recognition before and after the experiment. The red culture knowledge test and learner attitude questionnaire were designed and compared before and after the system was used. As shown in Figure 4 below, after the use of the system, the average scores for the users' knowledge test increased from 63 points before the use to 82 points, an increase of 30%. Emotional recognition increased from 3.5 points out of 5 to 4.3 points, a significant improvement.

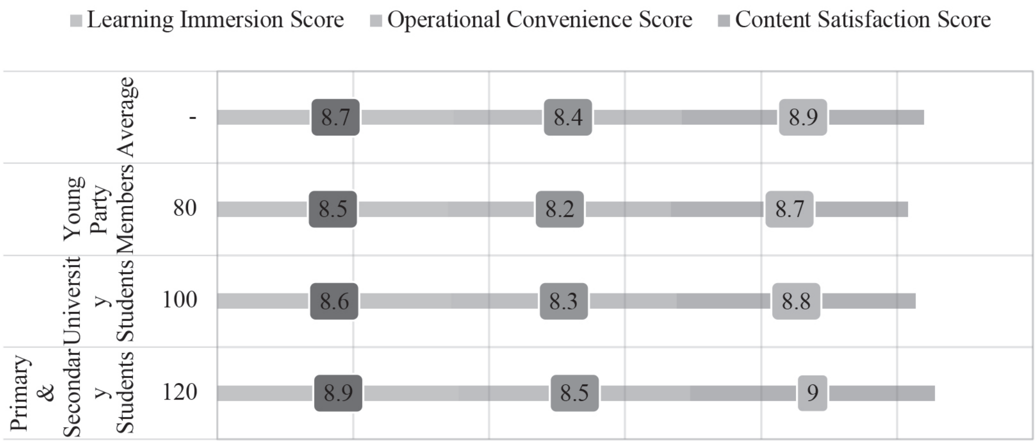

Figure 3 User experience feedback.

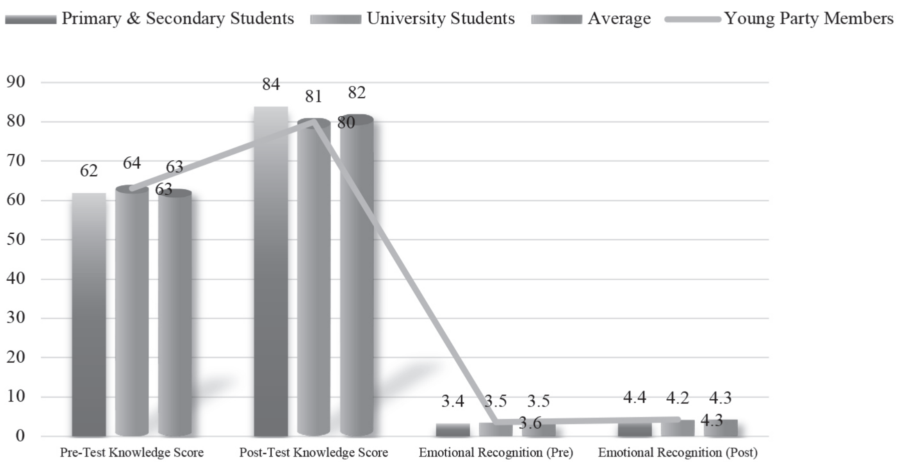

Figure 4 Preliminary evaluation results of educational outcomes.

3.2 Discussion

3.2.1 Problem Summary

When implemented, the system had a high level of user acceptance, and demonstrated that it can improve learning outcomes. However, the testing of the system and the user feedback also exposed several problems that need to be solved. Some users reported that the loading time of scenarios is slightly longer. When complex scenarios are loaded on a mid-range device, a temporary stutter-like phenomenon may occur. To some extent, this affects the immersion experience of users, and there is still room for improvement in scenario resource optimization. Although the interaction design meets the convenience of basic operation, there is still a learning threshold for some users who encounter VR devices for the first time. Some users rely heavily on guidance when completing complex tasks, and the system still needs to be optimized in terms of intuitiveness and guidance friendliness. The effect of content dynamic adaptation is different for different groups. Primary and secondary school students generally show a greater interest in dynamic tasks, but they are slow to adapt to content that is more detailed and difficult. The young party members require a greater depth of knowledge, and want the content to be more systematic and organized. Moreover, the system needs more targeted adjustments to the dynamic adaptation algorithm. Although the emotional recognition has improved significantly, the effect of emotional resonance in the experience scenario is still insufficient. Some users felt that some scenarios lacked a more creative and engaging design. For instance, the interaction of important historical figures and the details of specific events were not vivid enough. On the whole, there is still room for improvement in presenting nuances of emotional expression, which directly affects the depth and appeal of red culture.

3.2.2 Improvement Suggestions

In response to the above problems, this research puts forward the following suggestions to improve the system performance and user experience.

First, in terms of scenario resource optimization, it is suggested that a more efficient resource management mechanism be included, such as a dynamic load-based scenario optimization algorithm. Resources within the user's field of vision are rendered with high precision, while distant or unused resources are loaded in low-precision mode, reducing the burden on device performance. With texture compression and polygon simplification techniques, the effort involved in creating complex scenarios can be reduced. Second, in terms of optimizing the interaction design, multi-mode operation guidance can be included by, for example, combining visual animation and voice prompts, to reduce users' dependence on text guidance. For the primary and secondary school user groups, more guided and interesting interactive tasks can be designed to simplify the operation steps while ensuring that the learning process is fun. It is recommended to add "novice mode" at the beginning of the task to help users become familiar with the interaction process through step-by-step guidance. Third, dynamic adaptation algorithms can enhance intelligence through deep learning models. After collecting the user's operational behavior data and learning preferences, the system can adjust the task content and difficulty based on big data analysis. For example, for users with strong learning ability, it is appropriate to increase the display of more challenging knowledge points; for less capable users, simple and easy-to-understand content modules should be recommended. This dynamic adjustment will improve learning outcomes and meet the individual needs of different user groups. Fourth, in terms of emotional design, the interaction with and detailed performance of the scenario are enhanced to improve the effect of emotional expression. For example, in the restoration of important historical events, the actions and language expressions of virtual historical figures are added to simulate real historical scenarios and dialogues to deepen the emotional resonance of users. Situational tasks can also be designed, such as allowing users to participate in event decision-making as historical figures. This immersive experience can effectively enhance learners' identification with the spiritual connotation of red culture. Fifth, the improvement of system testing and feedback mechanism is also very important. In the development of subsequent versions, function design and content presentation should be optimized continuously through the ongoing collection of user feedback data and behavior analysis results. Also, the following are recommended: establish user communication groups, collect opinions and suggestions regularly, respond to user needs quickly, and iterate versions.

4. CONCLUSION

4.1 Summary of Research Results

In this study, red culture education is combined with virtual reality technology in order to design and implement an immersive and interactive educational experience system. For the system development, through multi-dimensional theoretical exploration and practical verification, a functional architecture integrating scenario-immersive experiences, user interaction optimization and dynamic content adaptation is built. The system achieves the expected goals in terms of scenario realism, interactive fluency and flexibility of educational content. Improved learning outcomes and stronger emotional identity are verified by testing. The research results show that the red culture education experience system based on VR technology can significantly improve users' knowledge mastery and motivation to learn, and enhance users' emotional recognition of red culture. This educational model overcomes the restrictions of traditional teaching and offers a new approach for the dissemination of red culture.

4.2 Research Limitations and Future Prospects

Although this study has made several contributions, it has several limitations. The number of user test samples of the system is relatively limited and therefore does not fully cover all potential user groups, and the suitability between different regions and age levels needs to be further verified. There is still room for improvement in the breadth and depth of the content of the system. At present, it covers several representative red cultural scenarios but does not include more abundant historical events and cultural content. The intelligence of the dynamic adaptation algorithm is still in the basic stage, and more data are needed to accurately analyze user behavior and learning outcomes. Future research could: expand the scope of user testing and explore the different needs of various groups who are using the system; enrich the content library of the system to cover more red cultural resources and revolutionary history details; combined with artificial intelligence technology, optimize the accuracy of the dynamic adaptation algorithm to achieve deep matching between content generation and user behavior; at the technical level, explore the combination of 5G and cloud computing technology, improve system operation efficiency and equipment compatibility, and provide more powerful technical support for the popularization of red culture and education in the future.

REFERENCES

1. Nnamani G. An ecosystemic perspective of the factors affecting the learning experiences of learners with dyslexia in mainstream schools in England. Dyslexia. 2024 Aug; 30(3):e1768. doi: 10.1002/dys.1768.
2. Zhang CJ, Yu SR. The technology to enhance patient motivation in virtual reality rehabilitation: a review. Games for Health Journal. 2024 Aug 1; 13(4):215–233. doi: 10.1089/g4h.2023.0069.
3. Ren HT. RED CREATIVE: culture and modernity in China. Pacific Affairs. 2024 Jun;97(2):433-435.
4. Bedar K, Bubanovich C, Rosemore J, Radford K, Taylor KL. Virtual reality intervention and its impact on upper extremity function in the stroke population: a scoping review. Games for Health Journal. 2023 Dec 1; 12(6):429–439. doi: 10.1089/g4h.2022.0239.
5. Hamad A, Jia B. How virtual reality technology has changed our lives: an overview of the current and potential applications and limitations. International Journal of Environmental Research and Public Health. 2022 Sep; 19(18):11278. doi: 10.3390/ijerph191811278.
6. Moore RL, Blackmon SJ. From the learner's perspective: A systematic review of MOOC learner experiences (2008–2021). Computers & Education. 2022 Dec; 190:104596. doi: 10.1016/j.compedu.2022.104596.
7. Wang J. Red Creative: Culture and modernity in China. China Journal. 2022 Jul 1; 88(1):139–140. doi: 10.1086/720243.
8. Zhao H, Zhou YJ. Understanding the mechanism of user experience role in educational livestreaming platform. Frontiers in Psychology. 2022 May 26; 13:907929. doi: 10.3389/fpsyg.2022.907929.
9. Hwang NK, Shim SH. Use of virtual reality technology to support the home modification process: a scoping review.

International Journal of Environmental Research and Public Health. 2021 Nov; 18(21):11096. doi: 10.3390/ijerph182111096.

10. Mittler B. The making and remaking of china's "red classics": politics, aesthetics, and mass culture. China Journal. 2020 Jan 1; 83:202–203.
11. Shafer DM, Carbonara CP, Korpi MF. Factors affecting enjoyment of virtual reality games: a comparison involving consumer-grade virtual reality technology. Games for Health Journal. 2019 Feb 1; 8(1):15–23. doi: 10.1089/g4h.2017.0190.
12. Alhazmi AA, Kaufmann A. Phenomenological qualitative methods applied to the analysis of cross-cultural experience in novel educational social contexts. Frontiers in Psychology. 2022 Apr 25; 13:785134. doi: 10.3389/fpsyg.2022.785134.
13. Rockers PC, Zuilkowski SS, Fink G. Childhood adversity and educational attainment: Evidence from Zambia on the role of personality. Frontiers in Psychology. 2023 Jan 27; 14:995343. doi: 10.3389/fpsyg.2023.995343.
14. Hamvai K. Red creative: culture and modernity in China. International Journal of Cultural Policy. 2021 Nov 10; 27(7):984–986. doi: 10.1080/10286632.2021.1981888.
15. Townsend IM, Berger EP, Reupert AE. Systematic review of the educational experiences of children in care: Children's perspectives. Children and Youth Services Review. 2020 Apr; 111:104835. doi: 10.1016/j.childyouth.2020.104835.