

Analysis of the Design Elements for the Children's Picture Books Based on VR

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ABSTRACT

The research of combining virtual reality technology with the design elements of children's picture book education is a relatively new topic in virtual reality technology in recent years. Based on the combination of picture book design elements with virtual reality technology and the development of a children's picture book teaching game, this article analyzes the effectiveness of the application of virtual reality technology in children's teaching, and explores the usability of picture book design elements in teaching [1]. Through literature research methods, practical research methods and investigation research methods, this paper lucubrates the application of virtual reality technology in the design elements of children's picture book education so as to provide adequate theoretical and practical support for the research theme. The spatial positioning, vision, sound, and functional requirements of children's picture book games play a leading role in teaching. Practical statistics have proved that it is easier to promote children's mastery of teaching knowledge in a virtual environment. Moreover, use VR's game management function and setting function to solve the boringness of traditional education methods and the limitations of the teaching environment. The feasibility of game operation provides a virtual teaching platform system for children's education, and the teaching effect is remarkable.

Key words: Virtual reality, Children's picture book, Education, Interaction, Design elements

1. INTRODUCTION

1.1 Research background

The advent of the Internet era drives the rapid development of multimedia technology. People's lives are increasingly inseparable from multimedia, which deeply influences our thinking, behavior and spirit. In multimedia education, virtual reality technology is widely used [2]. Driven by multimedia information technology, virtual reality technology has changed the expression form of traditional education, adding interactive animation, game-style animation, and so on. The VR-based picture book education, with the features of authenticity and interactivity, can enhance children's creative think-

ing and cultivate their good learning habits. The use of virtual reality technology in children's picture books can create a virtual computer simulation system that integrates multi-source information together, which forms a three-dimensional dynamic world and an immersive educational environment for children's teaching.

Since childhood is a crucial period to form a thinking pattern, the three-dimensional dynamic scene constructed by virtual reality technology could greatly promote children's IQ. The natural atmosphere created will help raise children's interest in learning science and technology. This subject researches the design elements of children's picture books based on virtual reality technology,

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which has great practical significance in promoting children's picture books' education innovation system as well as the development and exploitation of virtual reality technology.

1.2 Research purposes

The purpose of this research is to change the traditional paper-based teaching of paleontology (Fig. 1) and to research and analyze the structure, vision, sound and functional requirements of picture book games based on VR technology to make up for the shortcomings of traditional children's education and realize virtual [3]. The biological model (Fig. 2) displayed in virtual space could improve children's learning interest and cognition of paleontology, promote children's intellectual development, mobilizes their learning interest and meet their needs for knowledge of paleontology. Malaysian research scholar Joesins once proposed to build a physics laboratory with virtual reality technology to reduce the operating environment limitation in traditional classrooms [4].



Fig. 1. Virtual environment learning.



Fig. 2. Traditional picture book.

There are increasingly deep researches in user experience, interactive animation and inspirational design in exploring interactive education applications. The research on the design elements of picture book game teaching enables children to control the game through hardware devices such as virtual reality helmets, gamepads, tracking sensors, etc. Such interaction enables children to have an intuitive understanding of the picture book content so as to achieve the ultimate teaching goal [5].

1.3 Research process for painting design element

This paper takes literature research, practice research and investigations research as primary methods in the research of picture book design elements (Fig. 3), summarizes and organizes information and materials related to virtual reality and children's picture book teaching, and carries out in-depth analysis. It also studies the feasibility, application advantages and critical development methods of applying virtual reality technology in children's picture book design. At the same time, we made an investigation among children through questionnaires to analyze their needs, and thus have a clear idea of designing children's picture books with virtual reality technology. Through detailed feasibility analysis of the system design by fully referring to available data principles in the literature, we got the final case analysis design.

2. DESIGN ELEMENTS OF GAME

2.1 Design elements of game construction

The game construction framework uses the Unity3D game engine to build the game interaction platform. The design program is mainly developed in C#, and the C# script is used to control the data transfer of virtual objects in Unity 3D. The game scene can be constructed and transformed, or can be directly optimized via similar code [6]. The game scene in this design can virtually create the paleontological scene in the picture book. In the ap-

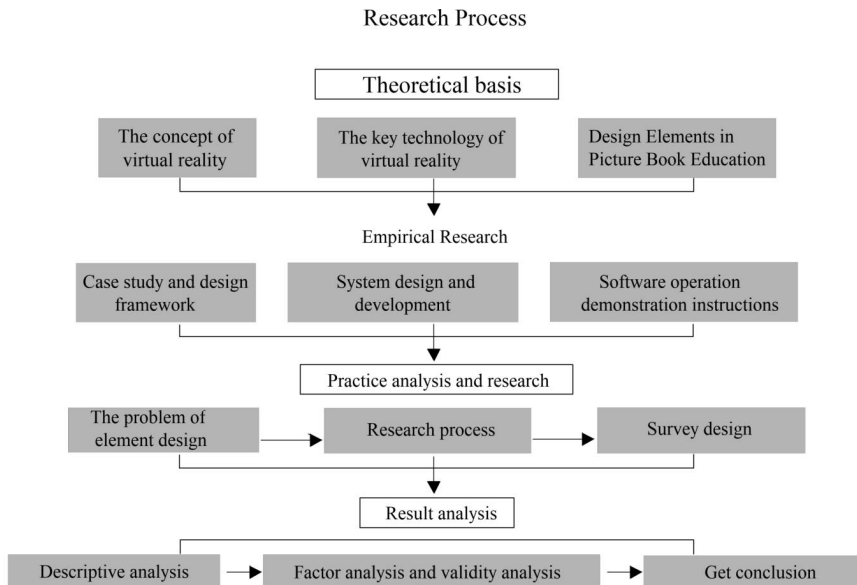


Fig. 3. Research structure.

plication of Unity 3D, we made full use of the interactive environment built in the game, determined the number of menus in the scene construction, and input the coordinates in the scene system [7]. In this way three different 3D virtual reality scenes (as shown in Fig. 4) were constructed, including the origin of paleontology, the living environment of paleontology and the extinction of paleontology.

2.2 Design elements of game sight

In the construction of the game scene, we adopted the three-dimensional method to display the content. When entering the game scene, the player triggered the internal game scene by operating with the gamepad, forming a three-dimensional

sense of simulation vision. The monocular viewing angle of the human eye is 150° horizontally and 120° vertically [8]. The construction of a game stereoscopic display scene needs to fit this data so that the illusion of reality can be formed when observing the scene in the game. While observing, the highest part of the resolution of the human eye, which is the central of the visual field, gradually decreased toward the edge. Knowing this feature, we could focus on the central part of the core vision in the construction of the scene.

Based on the above characteristics, in the construction of the three-dimensional display of virtual reality games, we laid emphasis on simulating human visual changes, and the scene was visually

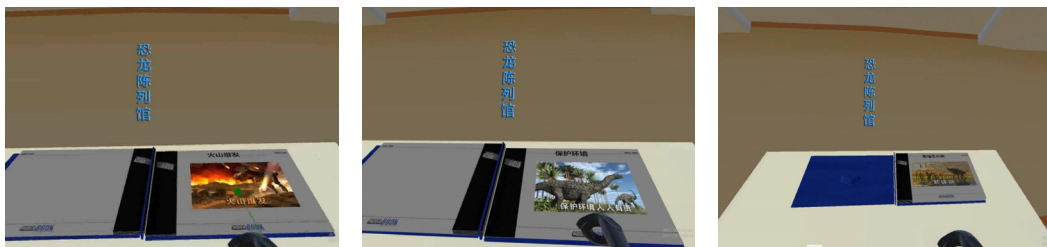


Fig. 4. VR picture book 3D scene.

arranged and constructed. The scene design in the game was completely simulated in accordance with human visual characteristics and resolution. The conventionally observed two-dimensional scenes was achieved by plane reality with no angle tilt in it.

2.3 Design elements of game sound

Game immersion perception was realized through sound sensory stimulation. This study, designing children's picture books with virtual display technology, uses rendering methods to enhance the authenticity of the virtual scenes in the game, which optimizes the design of light energy transmission and spot effect in the background. Game immersion perception in this research is mainly created by two major perception systems of vision and hearing. In picture book games, the three-dimensional sense of space was formed visually with corresponding stereo surround sound, rendering children to feel to be in it [9]. We used the 3.1 stereos in Cubase to optimize the sound in different scenes to form a coordinated playback of surround sound and stereo generation [10].

3. STRUCTURAL RESEARCH

3.1 System design feasibility

Virtual reality technology uses three-dimensional models to visualize children's picture books, or so-called, immersion. Children can experience scene objects in virtual reality through virtual equipment, and can observe things from different angles to achieve the effective teaching purpose. In teaching, children can use virtual 3D models and virtual reality spaces to learn about restored pre-historic creatures [11]. The display of children's picture book games focuses on the diversification of interactive forms, which can enrich children's knowledge and bring them a sense of interest at different levels. Picture book design can stimulate children's participation and interaction through the

display of three-dimensional virtual things, while children's picture books based on virtual reality technology have greater advantages in this regard [12].

According to relevant studies, the children's science education system with immersive interaction can effectively display learning materials and results, which enhance learners' learning willingness, stimulate their learning interest and enthusiasm, as well as consolidate the long-term memory and condensing of knowledge [13].

Through the research and analysis of traditional picture book teaching, combined with the immersive, interactive, and conceptual characteristics of virtual reality, the preliminary design framework is shown in Fig. 5.

3.2 Functional requirements analysis

3.2.1 Analysis of game management function elements

The general reading class is usually categorized by subjects, such as 'Palaeontological Origin Picture Book Reading', 'Paleontological Extinction Picture Book Reading' and 'Paleontological Environment Picture Book Reading', etc. These picture books are stored in a file package, which can be imported into the picture book game.

(1) Reading tasks include adding, modifying and deleting reading picture books. In addition to inputting picture book information in C# language, we can import the information with the picture book data package.

(2) Reading task query. Since entering the picture book game scene, we can browse through the game scene by pressing the HTC VIVE handle button. The picture book game scene can be read and learned by players themselves.

3.2.2 Analysis of functional elements of game settings

After the picture book data model is imported into U3D software, children set the picture book

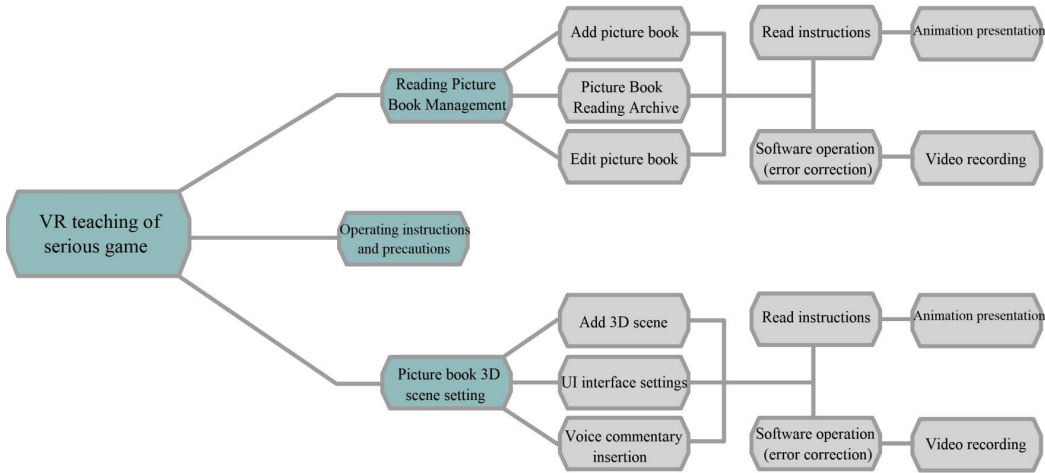


Fig. 5. Software design framework.

content in different 3D scenes when learning each subject. They can construct the stage and picture book text according to their interests and choose different 3D scenes to experience different learning results. There are two types of settings in the virtual scene: virtual scene management and text management.

(1) Reading picture book management: Children can select picture book theme, preset picture book in the virtual game scene, and save picture book file at any time, so that they can continue reading when entering the scene next time.

(2) Three-dimensional scene selection: Children can add certain scenes during reading, which are displayed as game interface in the picture book. They only need to click to select and then add them to the picture book. The 3D scene can be changed in the picture book, that is, the scenes can be modified and deleted if unwanted.

4. EMPIRICAL RESEARCH

4.1.1 Game platform structure construction

The children’s picture book game is designed to visualize the picture book’s contents and present the three-dimensional model in a virtual scene for children to watch. To solve some children’s ob-

stacles in text, a voice function is added to read the detailed science information automatically [14]. It provides a place for children to learn and enjoy and arouse their strong interest in knowledge. It has changed the traditional way of teaching communication, cultivated children’s creative thinking, and achieved the goal of disseminating teaching content. The game design mainly uses U3D software, and is developed in the Windows10 system (Fig. 6).

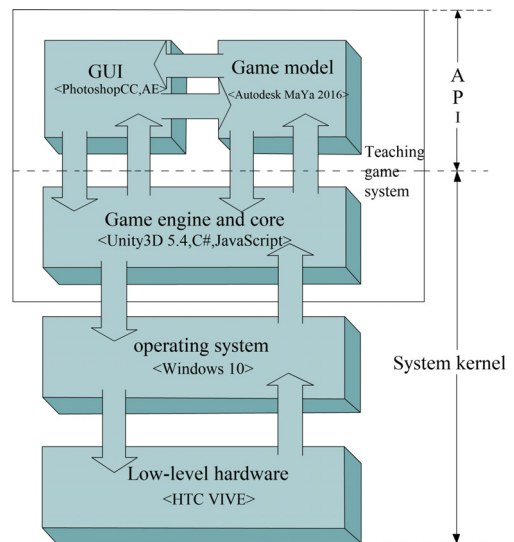


Fig. 6. Hardware and development platform.

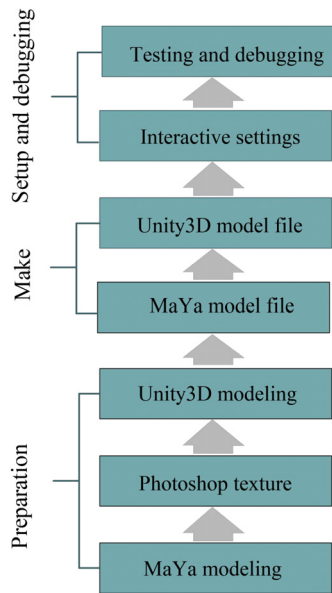


Fig. 7. Game design process.

(1) We used the Unity3D platform to build a virtual reality picture book education platform to simulate teaching content scenes.

(2) We explored how to use artistic methods to best represent the virtual reality picture book education and its production process from four aspects of model, sound, material and sight (Fig. 7).

(3) We simulated 3D effects with the HTC VIVE as a virtual reality helmet to improve children’s sense of immersion in virtual reality.

(4) We explored how to use peripherals such as Arduino and Leap Motion to carry out related designs to increase children’s immersive experience and realize the interaction of children’s learning responses.

4.1.2 Game 3D modeling production

This game utilizes Unity3D game engine to build an interactive platform. Unity3D supports visual editing with a rich element inspector that makes real-time preview available. Debugging in this game design can be done in the visual programming interface, which is efficient and convenient for game development. Most of the game models in the scene ‘Picture Book’ are finished in MAYA. The model maps are made with PhotoShop, and a few simple models are directly modeled with Unity3D. MAYA-made designs can be automatically imported in Unity3D. External game production changes will also be updated in real-time in the project. Unity3D software is supported in multi platforms, whose works can be directly exported to files suitable for Windows, IOS, Linux, and other systems, and the multi-platform development can be completed with one click. Unity3D supports multiple programming languages, such as JavaScript, C#, Boo scripting language [15]. It also supports various video and audio formats and can compress, some types of media files. In the establishment of the 3D scene model [16] (Fig. 8(a), (b), (c)), we used hardware devices such as HTC VIVE, virtual reality helmets, game-pads and tracking sensors to create a sense of immersion for users. This technology uses lasers and photo-sensitive sensors to build an interactive experience among different scenes by capturing users’ movement within a specific range. In three-dimensional modeling, we used this device to realize the interactive capture of physical gestures and update the

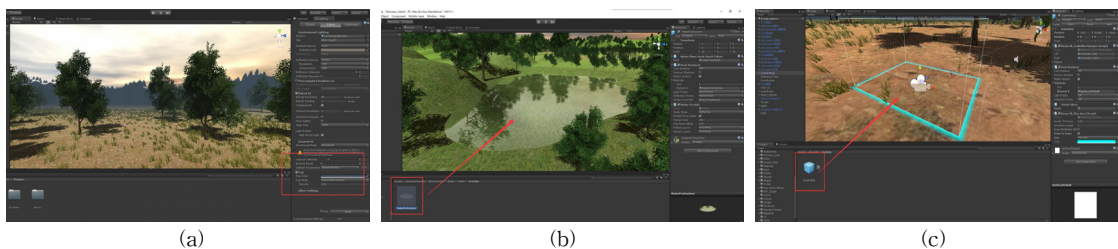


Fig. 8. VR 3D modeling production. (a) Forest scene, (b) Greenland scene, and (c) Plain scene.

gesture movement into the game scene. The game scene's natural environment is brought in through the HTC VIVE to form an interactive scene under the first-person perspective. Game 3D modeling is an integral part of a successful children's picture books design [17]. During the modeling process, independent program codes are designed for different scenes.

4.1.3 Game space positioning

The spatial positioning method used in this research design is to convert the spatial positioning into a specific positioning point, quickly determine the horizontal and vertical directions, and give the feedback to the display area. For the spatial scene in the game, this positioning method can meet the demand. In the design, affected by the technical principle of this spatial positioning, the virtual reality scene can only be viewed by the operator, otherwise more game-pads and receivers need to be added [18].

The scene in the game can be divided into three modules. The first part is paleontology, which is movable in the virtual scene. The second part is a natural scene, which includes movable and non-movable parts. For example, flames and acid rain are movable parts and we need to determine the accurate spatial position of the particulates. The third part is supporting facilities. For example, items can be picked up and placed according to different rules in a virtual reality scene. For different common design constructions, the spatial position

are further determined by using static and dynamic methods separately.

We used gamepads to control the game and triggered various scenes in the game. For example, when the corresponding UI interface is activated in the acid rain game environment and the volcanic eruption game environment, the text will be first displayed to show the hazards of acid rain and volcanoes as well as the reason of the paleontological extinction, accompanied by corresponding audio commentary [19]. Children can both experience the vivid virtual scenes in a specific space, and acquire new knowledge (Fig. 9(a), (b), (c)).

4.1.4 Game programing

For the construction of the scene in 3D modeling, particle effect analysis is used to form a realistic special effect scene [20]. For example, the flame special effects in the scene. In the special effects production, the particle technology is used to construct countless particles to form a whole, and the single or the whole movement is controlled through scripts. In this way, the special effects are constructed. The visual effect is more realistic. The content of children's picture book games is very diverse. In such a scene construction, the development and construction of the game content is carried out from the most basic frame composition, and on this basis, different types of control color filling are carried out to form a more realistic scene closer to the real scene. The overall scene of the game adopts a 360-degree panoramic free move-

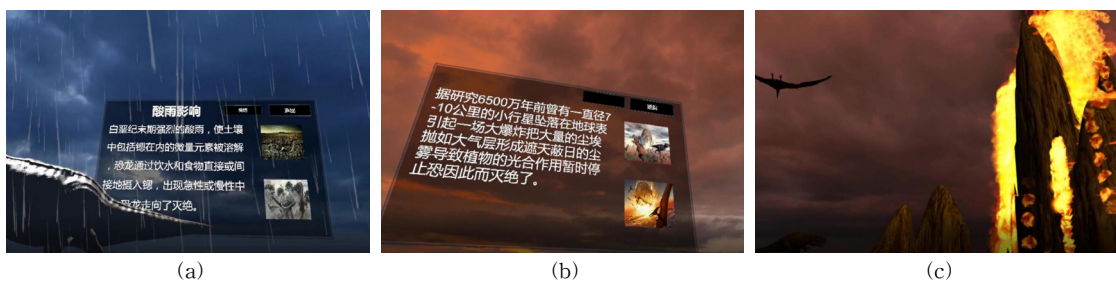


Fig. 9. UI interfaces, (a) Acid rain interface, (b) Meteorite interface, and (c) Volcano interface.

ment method [21]. In the content of the construction, the three-dimensional construction of the virtual reality scene is controlled by C# program code.

```
void tossObject(Rigidbodyrigidbody){
    Transform orgin=trackedObj.origin? tracked
    Obj.origin:
    trackedObj. transform. parent;
    if(orgin!=null){
        rigidbody.velocity=orgin.TransformVector
        ((device.velocity));
        rigidbody.angularVelocity=orgin.Transform
        Vector(device.angularVelocity);
    }else{
        rigidbody.velocity=device.velocity;
        rigidbody.angularVelocity=device.angular
        Velocity;
    }
    // rigidbody.velocity=device.velocity;
    // rigidbody.angularVelocity=device.angular
    Velocity;
    }
}
```

4.2 Game instructions

(1) We clicked to enter the picture book display interface, as shown in (Fig. 10(a)), and introduced the picture book interface one by one. There are 3 scene modules in the picture book interface. To quickly switch pages, the scene will always remain the initial state. The player can come to the front of the display stand in no time (Fig. 10(b)), and roam around in different positions by pressing the

trigger button on the left game-pads to emit rays.

(2) If a player selects the Biological Origin module interface (Fig. 10(c)), he or she will enter this virtual scene. He can watch the animation display, which demonstrates paleontology's movement habits (Fig. 10(d)), and listen to the voice commentary on the UI interface by emitting rays on the right game-pads. Voice commentary and the animation in the scene can be stopped by clicking the cancel button.

(3) The player can choose a volcano scene. He can regulate the height and power of the volcano eruption according to his needs.

(4) The hands-on operation requires participants to learn according to voice instructions. Interaction and transmission are involved during the operation, such as identifying and classifying the name and type of paleontology. The process can be archived and recorded to evaluate the learning effect afterwards.

(5) The operation instruction module is mainly present with videos and dynamic figure demonstration. The player can control the movement with the Bazier curve in the left gamepad, and the interaction with the rays in the right gamepad. In the virtual scene, the player could flip over the pages of all kinds of paleontological pictures, each showing a different scene, all by clicking the trigger button on the right gamepad. Once the learning is completed, the player can click the 'exit' button through the gamepad ray to exit and enter the next module.



Fig. 10. Picture book operation display. (a) Game interface, (b) Game home, (c) Game scene, and (d) Game introduction.

5. PRACTICE ANALYSIS AND RESEARCH

5.1 Research question

This research focuses on whether virtual reality teaching technology has a significant impact or assistance on children’s picture books teaching.

5.2 Research procedure

This research procedure determines objects for verifying the research question. Secondly, based on the empirical investigation, we designed, distributed and collected the questionnaire. Through extracting the factors of virtual reality teaching technology’s impact on children’s picture books teaching, we made main factors analysis. To prove the rationality of the extracted elements, we made credibility analysis. Based on the results’ study, a correlation analysis between the virtual reality teaching technology and the teaching of children’s

picture books is carried out to verify the significant relationship between the two.

5.3 Questionnaire design (Form 1)

Participants were asked to fill out the questionnaire online after using the model for 10 to 20 minutes. A total of 150 questionnaires were distributed and 130 questionnaires were effectively collected. Except for basic personal information, other questions were set in the form of a Likert five-level scale (5 represents strongly agree while 1 represents strongly disagree), which include the convenience of the picture book game, the display effect, the understanding of the picture book and its help to teaching, etc.

6. RESULT ANALYSIS

Children of different ages were selected to par-

Table 1. Questionnaire.

Survey topic	Question options
1. The display effect of virtual picture book game content	Strongly agree [1] [2][3][4][5] Strongly disagree
2. The usefulness of virtual picture book education	Strongly agree [1] [2][3][4][5] Strongly disagree
3. The effect of virtual picture book games on children’s concentration	Strongly agree [1] [2][3][4][5] Strongly disagree
4. The setting of the learning level of the content of the picture book	Strongly agree [1] [2][3][4][5] Strongly disagree
5. Convenience setting situation of virtual picture book game operation	Strongly agree [1] [2][3][4][5] Strongly disagree
6. The effect of reading time of game content on children’s patience	Strongly agree [1] [2][3][4][5] Strongly disagree
7. The effect of virtual picture book game education on children’s vertigo	Strongly agree [1] [2][3][4][5] Strongly disagree
8. The influence of content module division on children’s understanding and knowledge	Strongly agree [1] [2][3][4][5] Strongly disagree
9. The Influence of Educational Interaction of Picture Book Games on Children’s Senses	Strongly agree [1] [2][3][4][5] Strongly disagree
10. The effect of virtual picture book game education form relative to traditional education form on children’s memory	Strongly agree [1] [2][3][4][5] Strongly disagree
11. The influence of reading picture book management function on children	Strongly agree [1] [2][3][4][5] Strongly disagree
12. Children’s Dependence on the Teaching Mode of Virtual Picture Book Games	Strongly agree [1] [2][3][4][5] Strongly disagree

ticipate in this experiment. A total of 150 questionnaires were sent out and 130 questionnaires were collected. Among the participants, 32 were aged 4 to 7, accounting for 24.6%, 41 aged 8 to 11, accounting for 31.5%, and 47 aged 12 to 15, accounting for 36.1%.

6.1 Factor and validity analysis

The influencing factors were extracted for this study, and factor analysis and reliability analysis were carried out. (Table 2). According to the SPSS analysis and data compiled in EXCEL, the KMO and Bartlet verification results of virtual reality picture book games on children’s education influence factors showed that, the KMO value is 0.760, which is more than 0.5, and the P-value is less than

0.05, indicating that it is suitable for factor analysis.

We extracted three factors. As shown in the table below, the accumulation based on the feature value greater than 1 is 56.188%, which is greater than 50%, indicating that the three dimensions currently explored can better represent the real data. Considering the questionnaire items, the three extracted factors are named: (factor 1) effectiveness, that is, the display effect of the contents of the virtual reality picture book, which fully represents the practicality on children’s education; (factor 2) memorability, that is, virtual reality picture books promote children’s memory of knowledge; (factor 3) easy to learn, that is, the division of virtual reality picture book game modules promotes children’s learning.

In the result analysis, the data shows that KMO=

Table 2. Factor analysis and reliability analysis results.

Factor	Number	Survey topic	Component		
			Factor1	Factor2	Factor3
Factor1 Effectiveness	11	11. The influence of reading picture book management function on children	.818		
	5	5. Convenience setting situation of virtual picture book game operation	.806		
	4	4. The setting of the learning level of the content of the picture book	.802		
	9	9. The Influence of Educational Interaction of Picture Book Games on Children’s Senses	.742		
Factor2 Easytoremember	2	2. The usefulness of virtual picture book education		.782	
	12	12. Children’s Dependence on the Teaching Mode of Virtual Picture Book Games		.687	
	3	3. The effect of virtual picture book games on children’s concentration		.673	
Factor3 Easytolearn	8	8. The influence of content module division on children’s understanding and knowledge			.754
	7	7. The effect of virtual picture book game education on children’s vertigo			.709
	6	6. The effect of reading time of game content on children’s patience			.553
Eigenvalue			2.738	2.203	1.802
Cumulative variance			22.813	41.174	56.188
KMO (Kaiser-Meyer-Olkin)			0.760		

Table 3. Results of reliability statistics.

ReliabilityStatistics	
Cronbach’sAlpha	NoffItems
.817	12

0.760, which is greater than 0.7, indicates a specific connection between the structural design elements, visual design elements, and sound design elements in the picture book game in the questionnaire design. Sig.<0.001, it can be seen that the independent variables and The dependent variables are correlated, which proves that the design elements of the picture book have substantive use-value for children’s teaching comprehension and application expansion methods.

6.2 Reliability Statistics and Correlation analysis

Generally speaking, the reliability of the questionnaire mainly depends on Alpha (a coefficient). $a < 0.7$ indicates that the questionnaire is unreliable, $0.7 < a < 0.8$ suggests that the questionnaire has a certain degree of reliability, $0.8 < a < 0.9$ indicates that the questionnaire is reliable. It can be seen from (Table 3) that $a = 0.817$, showing that the design elements of picture book games is of high credibility in this research.

To further study the influence of picture book game design elements in traditional children’s teaching, relevant analysis is carried out. The results showed that the effectiveness and memorability of (Table 4) are closely related ($=0.403^{**}$), and the memorability and easy to learn are also

closely related ($=0.274^{**}$). Even if the relationship between effectiveness and easy to learn is ($r = -0.265^{**}$), there is a correlation between the two to a certain extent. In the meanwhile, the corresponding P values are all less than 0.05, so there is no null hypothesis, and there is a positive correlation between the independent and dependent variables.

7. CONCLUSION

Through empirical research, this paper designs children’s picture book teaching software based on virtual technology. We conducted questionnaire surveys on users’ experience after using this software and raised the verification question. First, factor analysis and validity analysis were carried out. The analysis results showed that the extracted factors can better represent questionnaire items and have good credibility. Then, factor correlation analysis was carried out, and the analysis results showed that the software’s effectiveness and practicability are closely related to the operability, which also verifies the question, that is, virtual reality technology impacts children’s picture books teaching, and the design structure of children’s picture books has obvious relevance to the knowledge concept and the teaching effect. Studies have shown that the system, vision, sound and functional requirements in picture book games in the design elements of children’s picture books play a leading role in teaching. An immersive and interactive virtual environment can better promote chil-

Table 4. Results of correlation analysis.

		Factor1 Effectiveness	Factor2 Easy to remember	Factor3 Easy to learn
Factor1 Effectiveness	Pearson Correlation	1		
	Sig. (2-tailed)			
Factor2 Easy to remember	Pearson Correlation	0.403**	1	
	Sig. (2-tailed)	.000		
Factor3 Easy to learn	Pearson Correlation	-0.265**	0.274**	1
	Sig. (2-tailed)	.002	.002	

dren to master knowledge. At the same time, the AR-based practical design raises the interest and exceeds the limited teaching environment compared with traditional education, therefore provides a virtual teaching platform system for children's education, and improves children's creative thinking and learning ability.

8. FUTURE RESEARCH

Through practical and empirical analysis, future design on children's virtual reality picture book education will pay more attention to the connection between virtual combination and human-computer interaction technology, as well as to children's healthy growth and psychological needs, in order to improve the quality of children's learning and life. Virtualized picture book education will be more humane and intelligent. There are still many shortcomings in this research. Due to hardware equipment limitations, users will feel dizzy after long-term use, which will reduce the learning effect. The future picture book education will study how to avoid dizziness by adopting 'virtual touch' technology in AR, and how to improve learning efficiency by enhancing virtual learning environment.

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