Research of Electronic Building Blocks VR Tutorial System

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Abstract. China's market for children's education informatization is booming, and the government, schools, and families are increasingly concerned about extra-class education for primary and secondary school students. Electronic building blocks, also known as electrical building blocks or electrical models, are a type of physics extra-class education tool. They are also popular educational toys that can be assembled by elementary school students and even kindergarten children. Through electronic building blocks, children can learn about physical and electrical knowledge while enjoying educational entertainment. As a result, these building blocks have received praise from both parents and children. However, currently, there are issues such as the significant homogenization of electronic building block products, challenges in assembling for younger children, and a lack of learning guidance for specific user segments. Especially during the assembly process, various factors such as the limited spatial imagination ability of younger children, the inability to read and understand block tutorials, and the lack of guidance from some parents can lead to incorrect assembly, resulting in the electronic building blocks being unable to function properly. At the same time, parents of older children also want to acquire more knowledge through entertainment. Therefore, it is necessary to provide a visual interface and voice prompts for the aforementioned child users of electronic block virtual reality tutorials. This will assist the users in learning independently and help them develop a passion for physics and electricity. Ultimately, this approach will achieve the goal of making education enjoyable. To this end, this paper briefly introduces the user research, competitive analysis, overall design, and user experience of the electronic building blocks virtual tutorial system. The system includes a PC version and an applet of WeChat version. Experimental results demonstrate that the tutorials successfully meet the design requirements. This tutorial combines virtual reality with electronic building blocks to help children develop hand-eye coordination, enhance their intelligence, and cultivate independent learning and study skills. At the same time, it lays a solid foundation for younger children to develop math, physics, and spatial imagination skills in the future. In the future, deep learning algorithms in artificial intelligence will be applied to develop intelligent recognition tutorials for the next generation of electronic block building.

Keywords: Educational toys; Virtual Reality Tutorial; Electrophysics; Applet of WeChat.

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1 Introduction

At present, the market size of the global educational toys industry continues to grow, and the per capita ownership of children's toys is increasing. At the same time, China's early childhood education informatization market is also booming, and the government's financial investment in extra-class education funding for primary and secondary schools is substantial[1][2].

In 2018, the Ministry of Education released ‘the Education Informatization 2.0 Action Plan’, which emphasizes the development of students' specific abilities and shifts the focus of education from enhancing students' information technology application skills to promoting information technology literacy in the 2.0 Plan.

In terms of national education strategic objectives, the 2.0 Plan focuses on promoting the integration and innovative development of "Internet + education", comprehensively modernizing education, and building a smart education ecosystem.

In provinces and cities such as Jiangsu, Guangdong, Tianjin, and Anhui, the implementation of extra-class '15:30 classrooms' in primary and secondary schools has been widespread. These classrooms aim to provide students with additional education in information technology, physics, and biology.

With the wide application of new-generation information technology such as 5G, AI, and Extended Reality (XR for short, which is an umbrella term for three types of technology: Virtual Reality, Augmented Reality, and ,Mixed Reality), the market for information technology in compulsory education will usher in new growth opportunities[3][4]. These opportunities include hardware upgrades, comprehensive software services, and increased payment scenarios. Electronic building blocks (also known as electrical building blocks or models) are popular teaching tools and educational toys in the physics extra-class educational products market. These building blocks are designed with wires and electronic parts integrated into plastic modules[5]. They present electrical circuits in a simple and interesting way, making it easier for children to learn about electrical knowledge. For example, by connecting circuits, electronic building blocks can produce various animal sounds, simulate traffic lights, and even rotate a helicopter's propeller. However, currently, there are issues such as the significant homogenization of electronic building block products, low user awareness, and a lack of learning guidance for specific user segments. Therefore, it is necessary to provide a virtual reality tutorial of electronic building blocks with a visual interface and voice prompts for younger children. This will assist users in learning independently and help children develop a love for physics and electricity. The goal is to achieve both educational and entertainment purposes.

2 Product Competitive Analysis

A comparative analysis of the leading electronic building block brands in the market (refer to Table 1) reveals that currently, most domestic electronic building block products suffer from homogenization. The toys available in the market lack differentiation, and brand recognition is weak. These products are still in the early stages of development, primarily focusing on selling individual building units or separate toy sets as the main source of profit. As a result, they have

failed to establish a comprehensive product system centered around the gaming experience. Moreover, most products only provide a graphical version of the manual, lacking a more intuitive form of instruction or an introduction to circuit knowledge and principles for older children.

The building blocks and other construction toys launched by the foreign company LEGO form an experiential system for young children's construction play. This system includes the sale of basic building units (primary products), themed toy sets (products), apps for use with the toys (services), and themed offline activities (experiences). However, there are currently no products related to physics and electricity.

Table 1. Product Comparison of Major Electronic Building Block Brands

Brand	Product picture	Feature	Weakness
Dipole		1) A variety of series of themed electronic building block products, with a variety of spelling methods and excellent craftsmanship. 2) The products of second generation includes voice control and other intelligent modules to be suitable for older children.	1) Hardware products only. 2) With graphic instructions, without any video tutorials, etc. 3) The products of second generation is expensive.
Electricity Guy		1) A variety of series of themed electronic building block products, offering a range of spelling methods and competitive prices. 2) With the "Physics Big Bang" series of science videos. 3) The products are distributed by several stores, each offering different services.	1)Mainly relying on the sale of complete sets of hardware products, popular science videos are given as gifts without any explanation of the principles. 2) Multiple dealers, after-sales cannot be unified.
Rainbow		1) A high level of modularity, making them easier to assemble for 5-6 years old children. 2) With graphical programming software which can be used to control the hardware by connecting via Bluetooth. 3) With the Children's Programming series of courses.	1) Accessed by enrolling in the offline courses "Programming Space" only. 2) It is primarily used for children's programming enlightenment, rather than for electrical education.
Lego		1) Exquisite workmanship, thematic set of products, almost like a puzzle-themed product. 2) The product combines an app with strong gameplay, high playability, well-made app design, and animation. 3) With LEGO building instructions in video format. 4) With high-quality toy products and an immersive experience system, as well as develop tailored LEGO education programs for children of various age groups.	1) Expensive. 2) LEGO educational aids and courses are only available at physical LEGO activity centers. 3) There are no electricity-related products available.

3 Overall design of the electronic building block VR tutorial system

Because the development process of cell phone applications (apps) is complex, requiring separate development for Android and Apple phones, the cost of development and maintenance is high. In contrast, applet of WeChats offer simple development, low cost, compatibility across different phone platforms, no need for individual installation, on-the-go installation and usage, small installation files, and easy maintenance [2]. Therefore, the system adopt a combination of the applet of WeChat version and the PC-base version to meet the demand for a user-friendly virtual tutorial experience. To facilitate children's independent learning and parental guidance, use WeChat to scan the QR code on the E-Block and access this tutorial. Its specific functions are divided as shown below Figure 1.

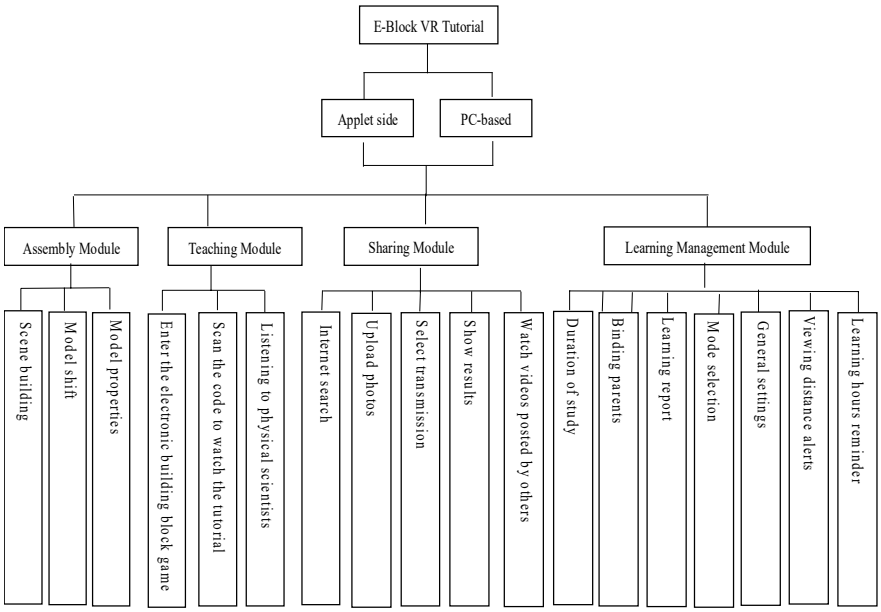

Figure 1. Architecture of E-Block VR Tutorial.

Both applet side and PC side system include the following key module:

1. Assembly Module: This module allows for the independent selection of desired electronic components to be placed. It also enables the user to freely change the perspective and observe the placement of electronic components from multiple angles. When the components are placed correctly, corresponding electrical phenomena will occur. The free assembly function allows users to simulate the building process of electronic building blocks online in real time, eliminating the need for physical electronic building blocks. This feature is particularly convenient for users who are on the go or traveling.

2. Teaching Module: This module aims to popularize children's knowledge of electricity through pictures, text, voice, and video. It includes physics interesting short stories, electrical trivia, introduction to electronic components, and education on the safe use of electricity. The

main purpose of this module is to provide users with the necessary physical knowledge before they start building electronic blocks.

3. Sharing Module: Children can share photos or videos of their own satisfactory block building to increase their sense of achievement, thereby improving user engagement.

4. Learning Management Module: Additionally, with the user's permission, the system will analyze and provide feedback on the collected user data to the manufacturer, facilitating further hardware upgrades.

4 Electronic building blocks VR tutorial system show

Figure 2. User Interface

Figure 2 Shows the user interface (UI) of the applet version for the E-Block VR tutorials.According to the target users (children aged 2 to 14 years old) and considering their physical and mental development characteristics, the design of the user interface and virtual scene should prioritize a balance between fun, ease of use, and error tolerance during user interaction.

Figure 3 and Figure 4 are the VR teaching module interface and Free building block interface. The overall scene uses bright colors to create a vibrant environmental atmosphere, and incorporates simple small toys as decorative elements. The lively and adorable interface style is filled with children's curiosity and can engage their interest in using the software.

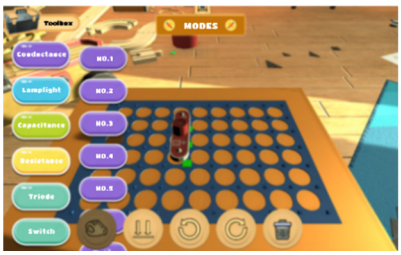

Figure 3. VR Tutorial Module Interface

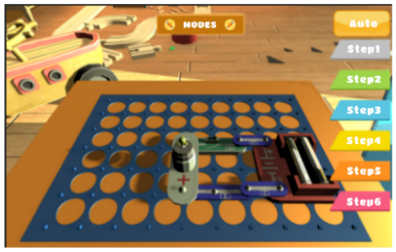

Figure 4. Free Build Module Interface

5 User assessment

User assessment test method: five-level Likert scale (Table 2 shows the scale setup, and Table 3 shows the result statistics). In order to obtain targeted and accurate user assessment results, the questionnaire was primarily distributed to parents of children aged 2-14 years old. The test group for children was aged 8-14 years old, with a total of 50 test users.

The statistical results were analyzed using principal component analysis to extract the common factors and perform variance-maximizing orthogonal rotation. It can be observed that the majority of user feedback for positive questions is focused on responses indicating a moderate level of satisfaction, whereas the user feedback for negative questions primarily revolves around responses indicating a lower level of satisfaction. In general, most of the functions of this system can meet the user's needs for using electronic building blocks. However, the sharing function module needs improvement as it fails to effectively increase user engagement.

Table 1. User assessment 1

Items	Strong Agree	Relatively agree	Normal	Disagree	Strong Disagree
1. I would like to use this VR tutorial system.	5	4	3	2	1
2. I find the system overly complicated.	1	2	3	4	5
3. The virtual tutorial feature can be very helpful for me in using the electronic blocks.	5	4	3	2	1
4. The free-assembly feature allows me to construct without physical objects.	5	4	3	2	1
5. The function of electrical knowledge can help me gain a better understanding of electrical concepts and promote its popularization.	5	4	3	2	1
6. The sharing function setting is not necessary.	1	2	3	4	5
7. The learning management functionality does not accurately transmit data to vendors.	1	2	3	4	5

Table 2. User assessment 2

Items	Strong Agree	Relatively agree	Normal	Disagree	Strong Disagree	Average value	Standard deviation
1. I would like to use this VR tutorial system.	20.6%	56.5%	12.5%	8.0%	2.4%	3.85%	0.92%
2. I find the system overly complicated.	2.0%	8.1%	15.7%	54.8%	19.5%	3.82%	0.91%
3. The virtual tutorial feature can be very helpful for me in using the electronic blocks.	19.5%	54.8%	15.7%	8.1%	2.0%	3.82%	0.91%
4. The free-assembly feature allows me to construct without physical objects.	15.7%	57.7%	14.9%	9.3%	2.5%	3.75%	0.92%
5. The function of electrical knowledge can help me gain a better understanding of electrical concepts and promote its popularization.	15.5%	57.8%	14.6%	9.3%	2.8%	3.74%	0.92%
6. The sharing function setting is not necessary.	6.5%	35.9%	22.5%	28.2%	6.8%	3.07%	1.08%
7. The learning management functionality does not accurately transmit data to vendors.	4.0%	28.6%	14.3%	37.5%	15.7%	2.68%	1.16%

6 Conclusions

This system incorporates virtual simulation technology into extra-class education for electronic building blocks. It utilizes the user-friendly features of WeChat applets to create comprehensive guidance tutorials that are intuitive and convenient to use. The system offers various functions,

allowing users to freely explore and learn through the virtual tutorial system for electronic building blocks. This addresses the issues of product homogenization, low user awareness, and the lack of learning and parental guidance associated with existing electronic building block products. This system facilitates the development of intelligence, hand-eye coordination, spatial imagination, and independent learning and problem-solving abilities through virtual tutorials, free assembly and sharing, learning management, and other functional modules. Deep learning algorithms in artificial intelligence will be applied in the future to develop the next generation of electronic building block assemblies with intelligent recognition and guided virtual tutorials.

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References

[1] Kong Qian. Research on CUBI model-based e-block experience design driven by big data[D]. Guilin University of Electronic Science and Technology, (2021)

[2] Xiang Wu, Design and implementation of virtual electronic building blocks teaching system based on VR [D], Xibei Normal University, (2022)

[3] Chuyu Fang, Yuxiang Kuang, Kunkun Car —Concept Design of Educational Toys based on VR Technolgoy [J].Design, Vol.36, No.14, pp94-95, (2023)

[4] Shuhai Liu, Development and application of VR experimental project of educational intervention for children with mental retardation [D]. Nanning Normal University, (2022)

[5] Haoran Yang, Jing Shen, Tufeng Chen, Haodong Lai, Jie Chen, Computer Knowledge and Technology [J], Vol.17, No.24, pp126-128, (2021)

[6] Viola P,Jones M.Rapid Object Detection using a Boosted Cascade of Simple Features[C], null.IEEE Computer Society,2001

[7] Krizhevsky A, Sutskever I, Hinton G E. ImageNet classification with deep convolutional neural networks[C], International Conference on Neural Information Processing Systems. Curran Associates Inc. 2012:1097-1105.

[8] Girshick R , Donahue J , Darrell T , et al. Rich Feature Hierarchies for Accurate Object Detection and Semantic Segmentation[C], CVPR. IEEE, 2014.