Interactive Game Design Based on Situational Cognition Theory--Taking Harbin Industrial Factory as an Example

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Abstract. Harbin is an essential part of the industrial base in Northeast China and carries a rich industrial history. The area has many representative industrial buildings; however, these factories have gradually been abandoned due to changes in historical processes. However, it is undeniable that they are still precious witnesses of Harbin's industrial development and contain immeasurable humanistic and historical value. In recent years, serious games, which are both "educational" and "entertaining," are beneficial for the protection and inheritance of industrial heritage, as they allow the public to feel the precious value of industrial heritage in an immersive way. Based on the above background, we designed an interactive contextual game. In particular, based on the theory of contextual cognition, we retained the historical characteristics of the Welding Research Institute in Harbin. We constructed a new Ice City Industrial Culture Exhibition Hall on this basis. The game is divided into two levels: "Rebirth of the Old Site" and "Historical Exploration," with rich game mechanisms, including element collection, the eye of fire, process simulation, speed paving, etc. The game is "educational and entertaining," which enables players to understand the rich historical heritage of the Harbin Industry in a more comprehensive and in-depth manner. The contextualized game interaction experience design provides a new way of thinking for developing serious games.

Keywords: Situated Cognition Theory, Industrial Heritage, Serious Games, Unity

1 Introduction

Harbin, integral to China's Northeast industrial base, boasts a rich industrial history. Initially burgeoning in the early 20th century, its heavy industry flourished in the 1950s, fostering a good industrial landscape [1]. However, growth decelerated post-1980s. In the 21st century, China initiated strategies to revitalize old industrial bases, prompting Harbin's industrial evolution. As China's urbanization accelerated, Harbin's urban structure changed, and several old industrial zones ceased production, creating industrial wastelands. However, it is undeniable that these old industrial areas have witnessed the development of Harbin's industrial history and contain much valuable industrial heritage.

In today's context, industrial heritage holds significant historical, cultural, and educational value [2,3]. Innovative architectural renovations can blend modern design concepts with preserving industrial structures, revitalizing urban spaces, and promoting sustainable local economies. Additionally, engaging activities such as historical exhibitions, popular science education, and

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interactive games [4-6] foster public interest and awareness, promoting the cultural inheritance and innovation of industrial heritage.

Based on the above background and problems, this study focuses on: 1. how to innovatively remodel the original old factory buildings in Harbin according to their characteristics;2. how to better popularize Harbin's industrial history and culture and play the educational significance;3. how to design fun and challenging game interaction mechanisms to engage users more.

Based on the theory of situational cognition, this study designs an interactive situational game using the welding research institute in Harbin as an actual building model for innovative design. The game constructs an exhibition hall of industrial culture in Ice City, utilizing virtual reality technology to inherit Harbin's industrial history and culture. The game has various tasks and challenges, such as deciphering historical documents, identifying classic industrial scenes, and simulating craft production. Participants can get rewards and achievements by completing the tasks, stimulating their interest and desire for exploration. This study aims to dig deeper into the connotation of Harbin's industrial culture through this game so that players can learn knowledge, experience fun, and feel the power of industrial spirit in entertainment.

2 Related work

In recent years, serious games have been widely used in industrial heritage and history education. The distinctive feature of serious games is the combination of "entertainment" and "education." By providing a game experience, it vividly reproduces and restores historical events to educate, train, and enlighten the users and achieve the purpose of "edutainment" [7]. Two factors need to be considered in designing serious games: motivational and educational [8].

Motivational factors refer primarily to the interactive and immersive nature of the game [9]. Seale (2023) explores how digital technology can enhance engagement in museum games. The author points out that modern audiences are less interested in traditional museums, but through interactive technology, museums can create more engaging and educational experiences [10]. Ferdani et al. (2020) note that with the rapidly growing field of virtual archaeology, more and more attention is being devoted to virtual museums and interactive applications. The article describes how a more serious gaming experience can be achieved by creating accurate 3D assets and incorporating interactive design [11].

Educational factors mainly refer to the historical, cultural, and pedagogical values behind the game [12]. In their study, Lazarinis et al. (2022) designed a lightweight game engine for cultural heritage education. Two application examples are the educational program of ancient Amphipolis and the educational setup of Lake Korkeni. Through multi-user interaction, students can earn scores, badges, and certificates. Studies have shown that this leads to favorable educational outcomes [13]. Pletcher et al. (2020) designed a serious game that aims to enhance learners' acquisition of the language of Middle and Ancient Egypt. Utilizing the immersive context of cultural heritage, players learn basic and advanced knowledge of hieroglyphics while being immersed in the storyline [14].

It can be seen that to make a serious game, both motivational and educational factors need to be considered. This study considers both motivational and educational aspects in its design, aiming

to provide users with a good experience while viewing the educational significance behind the game.

3 Actual process

3.1 Scenography

Situated cognition theory is a psychological theory that emphasizes that individuals' behaviors and thinking occur in specific contexts and that these contexts significantly impact individuals' cognition and understanding. According to this theory, individuals' behaviors and thinking are shaped according to the situations in which they find themselves, and the various factors include the physical, social, and cultural environments [15].

This study emphasizes the importance of the environment to user perception and experience. It creates a specific context to stimulate visitors' interest and inspire thinking by designing the physical environment and displaying the venue's content. To promote user interaction and learning in the context, we chose the Harbin Welding Research Institute as a base. It was built in 1956, as shown in Figure 1, and is a national scientific research institution with comprehensive scientific and technological strength. We utilized its existing site, retained some of the original facilities, and innovatively remodeled it to pass on the industrial cultural history of the Welding Institute.

Fig. 1. Former site of Harbin Welding Research Institute.

Among the demolished buildings, we have preserved some of the structures and integrated them with the site's functions, such as converting the foundation of the office building into a public recreational platform. At the same time, we conserved and restored the site facilities, making them into vignette units and installing signage to facilitate understanding of the history. In converting the industrial building, the intact truss structure and red brick wall exterior were preserved and landscaped in three dimensions. Figure 2 summarizes the entire process of extracting historical and cultural elements from the old factory. These initiatives were designed to showcase the industrial site's history and culture and fulfill the pedagogical goals of the game interaction.

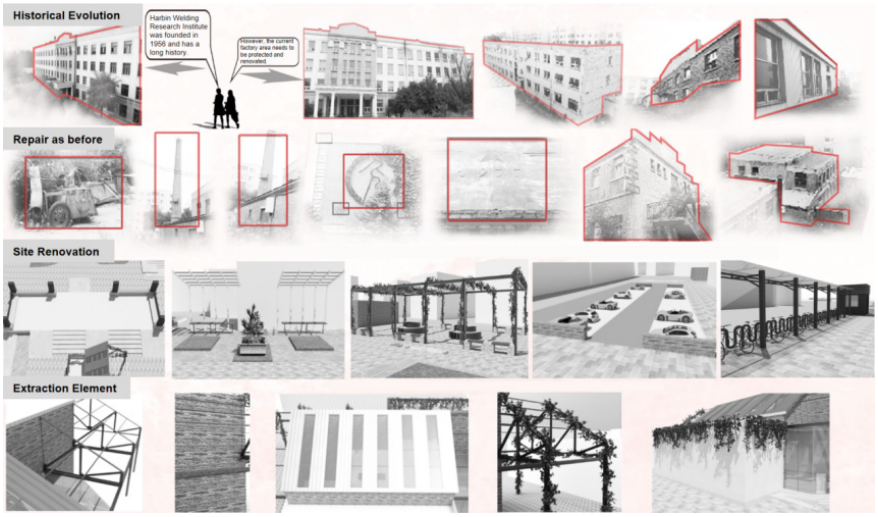

Fig. 2. Extraction of historical and cultural elements of the old factory.

In the design of the venue, as in **Figure 3**, we retained the structure of the old factory building and combined it with the newly built blocks to form a staggered landscape. Subsequently, we carried out structural remodeling and functional zoning by decreasing the original blocks and building additional trusses. Finally, we designed a brand-new Ice City Industrial Culture Exhibition Hall as the game scene.

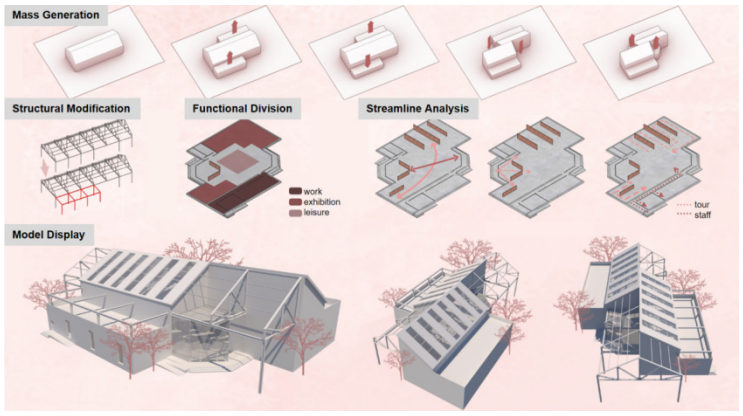

Fig. 3. Game scene construction and pavilion appearance.

3.2 Game design

To let players feel the precious industrial heritage and Harbin industrial history and culture of the long, in the game, the player will play a Harbin industrial history research expert through the " Rebirth of the Old Site " and " History Exploration " two levels.

In Level 1, "Rebirth of the Old Site," the game interface is framed by an old TV set, as in **Figure 4**, showing players the old site of Harbin Welding Research, which gives players the experience

of traveling through time and space with a sense of immersion and fun. The lower left corner of the screen shows players' collected old industrial elements, which prompt the game's progress. The final exhibition hall retains the original industrial design of the Harbin Welding Research Institute and is decorated with models related to the history of industrial culture. This design allows players to immerse themselves in the game scenario and feel the heaviness of history through visual experience, thus stimulating interest and curiosity in industrial heritage.

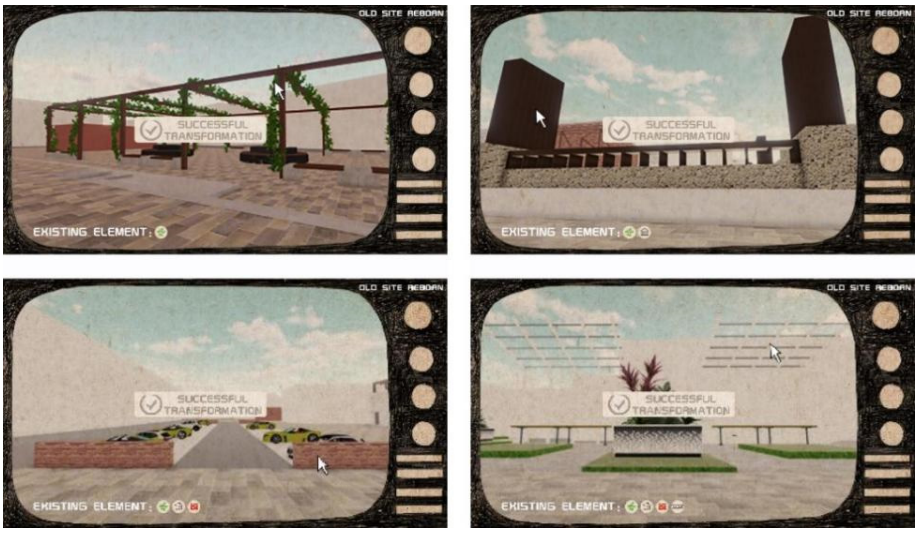

Fig. 4. "Rebirth of the Old Site" user experience perspective.

Specifically, the player needs to explore the historical and cultural elements of the old factory in the Harbin Welding Research Institute to preserve and carry out innovative remodeling. Players can use the WSAD keys on the keyboard to move back and forth in the game scene and the left mouse button to click on objects. First, Players must collect industrial relics from the old site, including trusses, skylights, and red bricks. Then, follow the prompts to make innovative alterations to the site, which include the public recreation platform, the parking lot enclosure, the rear plaza of the factory, and the seat canopy. Only after all of them have been explored and correctly remodeled can the player get the admission ticket to the interior of the Ice City Industrial Culture Exhibition Hall, thus entering the second level. This mechanism not only brings into play players' subjective initiative and allows them to reap the joy of creation but also prompts them to think about the protection and inheritance of industrial heritage, deepening their understanding and awareness of the history and culture of Harbin's industrial heritage.

In Level 2, "History Exploration," i.e., in the Ice City Industrial Culture Exhibition Hall, a flat map of the hall is set up in the upper right corner of the game interface so that players can clearly understand the layout of the hall. As the player explores each area, the corresponding serial number on the map will be automatically ticked, guiding the player to visit each scene in an orderly manner, as shown in Figure 5. In roaming, players can not only experience the fun of exploring unknown venues but also gradually understand the knowledge of Harbin's industrial culture.

Fig. 5. "History Exploration " map logo.

We designed several scenarios, including a history gallery, an introduction gallery, and a cultural heritage gallery. The exhibition hall roaming player experience perspective is shown in Figure 6. Players can click on the exhibits in the exhibition hall one by one to learn about the history and culture of the Harbin industry. In addition, the selling area and conversation area provide a place for players to transition and communicate with each other and acquire more knowledge through conversations with the game characters. This communication mechanism enriches the players' overall interactive experience and further deepens their understanding and knowledge of Harbin's industrial history and culture.

Fig. 6. Exhibition hall roaming player experience perspective.

In addition to the exhibition itself, the pavilion also features three hidden mini-games in which players can obtain small fragments of the Harbin map after unlocking and clearing each level. After completing all the games and collecting enough fragments, players can put them together to form a complete medallion of the pavilion as a reward and souvenir of the game's victory, as shown in Figure 7. Such a design can stimulate the players' sense of achievement and satisfaction and motivate them to understand Harbin's industrial culture completely.

Fig. 7. Map fragments and pass medal designs.

Specifically, each mini-game will be triggered after the player has navigated through the corresponding pavilion division (History, Introduction, and Cultural Heritage Halls), with the respective rules and gameplay as follows:

Game 1, "Fire Eyes," aims to show Harbin's industrial development through old posters to help players understand the past development and use of industrial elements. As shown in **Figure 8**, we designed the game interface with posters on the red brick wall, echoing the original red brick wall in the 3D exhibition hall. Regarding the game elements, we adopted gears closely related to the industry as hints after clicking. The game interface is set up with four pictures, and each image will show one industrial element that does not fit the period scene shown in that picture. A timer is shown in the upper left corner of the interface, and the number of resurrections is shown in the upper right corner. Players must find unreasonable places within 30 seconds to pass the game and get the "Map Piece 1"; otherwise, it is a failure, and each player has three resurrection chances. Players can choose to consume one resurrection chance and restart the current game, and the picture will be automatically updated to the scene picture of another era.

Fig. 8. Game 1 "Fire Eyes" user experience perspective.

In a specific single operation, the player needs to visit the exhibition hall to understand the industrial development of Harbin in various eras and, at the same time, accept the test to consolidate the mastery of industrial knowledge. Players use the left mouse button to click on the picture of the game page in the unreasonable place to complete the game operation. When the mouse is clicked, the industrial element in the mouse position is selected. When clicking on the wrong place on the picture, a "wrong choice" prompt will appear and explain the application of the industrial element at that time; when clicking on the correct place on the image, a "correct choice" prompt will appear. This kind of instant feedback and explanation makes the players learn and deepen their understanding of the history of Harbin's industrial development in entertainment, thus enhancing the game's entertainment and education.

Game 2, "Crafting," is designed to help players better understand the production process of the extractive, raw material, and processing industries. As shown in Figure 9, the game's initial layout adopts a top-down structure, with the upper half divided into the extraction scene and the lower half into the toolset. The advanced part of the game leads the player to the extraction scene and guides the player to the correct extraction process through textual hints. Regarding the game elements, we chose industrial elements closely related to industrial development, such as excavators, shovels, and helmets. The game interface is set up with three scenarios (extraction industry, raw material industry, processing industry) that a production line needs to go through. Players need to find the tools corresponding to the industrial scenes shown in the picture below within 30 seconds and complete the corresponding industrial generation process operation according to the prompts within 2 minutes, that is, to pass the level successfully; otherwise, it is to pass the level failed. The number of resurrections will be displayed in the lower-left corner of the game page. When all three resurrections are used up, and the player fails to pass the game, the player will not be able to get the map pieces of the introductory exhibition hall; on the

contrary, the player who passes the game will get the game rewards "Map Pieces 2." The design of this time-limited task and simulation operation increases the challenge and tension of the game, making players full of anticipation and passion.

Fig. 9. Game 2 "Crafting" user experience perspective.

Specifically, the player must use the left mouse button to select the industrial production tool on the game page to complete the game operation. When the mouse is clicked, the industrial production tool where the mouse is located is selected. According to the current display of the industrial production scene to choose the corresponding production tools, when the correct production tools are, there will be a "selection of correct" prompt; when the wrong tool is selected, there will be a "selection of wrong" fast, when selected three times wrongly will be If the wrong tool is nominated three times, it will be regarded as a failure to start again. After selecting all the production tools, an animation of the past industrial production process will appear, showing the order and use of the tools. If players fail to select all the correct tools within the time limit, they will be considered to have failed, and the right tools will automatically pop up. The only way to restart the current game is to expend a resurrection opportunity, and the tools are disrupted. This random disruption mechanism increases the game's challenge and tension and the player's impression of the industrial tools.

Game 3, "Race to Pave," is designed to help players better understand the industrial situation and historical development of essential factories in Harbin and deepen their impression by answering questions. As shown in Figure 10, we designed two scenarios, one large and one small. The large scenario offers players the traveling condition of the train they are traveling on, while the small scenario is an interface for workers in the old factories that the train passes through to ask questions. Regarding the game elements, we designed a green train image consistent with the old Harbin and a small green train at the bottom of the interface to remind the player of the game's progress. The train will pass by the three old sites shown in the pavilion (Vehicle Factory, Railway General Factory, and Bearing Factory), but the train railroad still needs to be completed. The conductor needs to drive the train to the factory, complete the conversation with the workers, and answer the questions asked by the workers in the old factory within 30 seconds to get the track parts needed to go to the following factory and complete the construction work. After answering the questions and completing the railroad construction, you will reach the end of the level and obtain "Map Piece 3". Otherwise, the player will fail, return to the starting point, and recover the built railroad section, and each player has three chances to resurrect.

Fig. 10. Game 3 "Race to Pave" user experience perspective.

Specifically, the player needs to use the WSAD key to control the train to go forward, backward, left turn, and right turn, use the space bar to control the train to stop moving forward and use the left mouse button to click to select the answer to the corresponding question to complete the game operation. When the mouse is clicked, the answer to the question where the mouse is located is selected. The player assumes the role of a conductor and drives the train to visit three critical factories in Harbin's industrial development. This role-playing design increases the game's interest and sense of immersion, enabling the player to experience the course of industrial development in an immersive environment. Afterward, the player will have a conversation with the factory workers, who will ask the player industrial questions about the corresponding factories based on the content of the conversation. When choosing the wrong answer to a question, a "wrong choice" prompt will appear, giving the correct answer and knowledge explanation; the player needs to return to the starting point to start again; when choosing the correct answer to a question, the worker will give the railroad track to the following factory, the conductor needs to continue to drive the train to the next factory. Failure to provide the correct answer to each question within the allotted time is also considered a wrong answer. The correct answer and explanation of the knowledge point will automatically pop up, and the player will have to return to the starting point and start again. This mechanism of role-playing and simulated train maneuvering allows players to feel more immersed while consolidating their understanding of industrial knowledge in the race to answer the questions.

To summarize, Level 1, "Rebirth of the Old Site," gives full play to the player's initiative to learn about the Harbin Industry through innovative transformation mechanisms. Level 2, "History Exploration," stimulates players' curiosity and desire to explore by collecting map fragments and three hidden mini-games. Among them, the timely feedback mechanism of Game 1 helps players consolidate their knowledge of Harbin's industrial history, the random disruption mechanism of Game 2 helps players exercise their reaction ability and deepen their impression of the industrial culture, and the role-playing and simulation manipulation mechanism of Game 3 allows players feel the railroad culture of Harbin in an immersive way. Through the above levels and mini-games, players can gain an in-depth understanding of heavy industry's development history and cultural connotation, feel the significant contribution made by the Northeast heavy industry to the country's development, and realize the importance of the protection and inheritance of industrial culture.

3.3 Game development

The game chooses Unity as the development engine and c# as the programming language. Firstly, we use Unity's scene editor to create the game scene according to the game design and add various elements such as terrain, buildings, and props. We set their attributes and collision bodies to realize the interaction between the player and the objects. In the UI design phase, the game's user interface is designed using Unity's UI system, including the game interface, achievement interface, map interface, etc., and the related logic scripts are written to realize the switching and interaction between the interfaces. In the game logic programming stage, C# is used to write the logic code of the game, including the realization of player movement control, conversation with NPCs, triggering events, collecting items, completing quests, and other functions.

4 Evaluation and results

4.1 Participants

Usability evaluation is assessing the ease of use of a system or product to identify and improve the user experience and increase the usability and user satisfaction of a product [16]. To evaluate the design experience of the game, this study used a usability evaluation method. In this study, a total of 30 users were recruited to test the usability of the game. The participants were students and teachers from Harbin Institute of Technology in China. Ages were 15-40 years old (mean = 23, SD = 7.96), with 15 of each gender.

4.2 Usability Assessment

All 30 participants went through a complete usability evaluation process with the following steps: firstly, the users were introduced to the purpose of the test, the features of the serious game, and the gameplay; then, the users were allowed to experience the game on the computer for 15 minutes; after the experience, the users were allowed to fill in the questionnaires and the users were interviewed. The researcher will explain and guide the users during the testing process when necessary. The user experience site is shown in **Figure 11**.

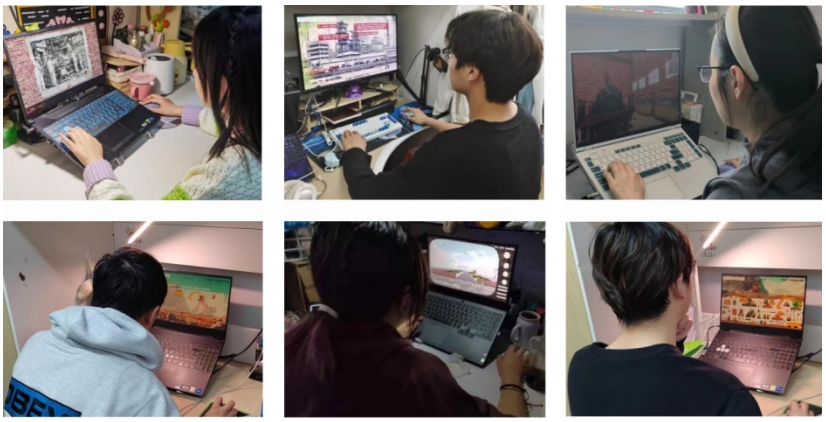

Fig. 11. Participants are experiencing the game.

To assess the level of acceptance of this serious game in this study, the SUS (System Usability Scale)questionnaire was used to verify the game's usability [17]. The SUS consists of the following ten questions:

(1) I'd like to play this game more often.

(2) I think this game is unnecessarily complicated.

(3) I think this game is easy to play.

(4) I need a technician's support to play this game.

(5) I found the various features in this game to be well integrated.

(6) I think there are too many inconsistencies in this game.

(7) most people will learn to play this game quickly.

(8) I think this game is a pain in the ass.

(9) I feel confident playing the game.

(10) I need to learn a lot before learning this game.

The statistical results of the questionnaire are shown in Table 1.

Table 1. Scoring statistics for each question with different scores

Q.	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Q1	1	3	0	0	11	37	11	37	7	23
Q2	14	47	7	23	6	20	2	7	1	3
Q3	1	3	7	23	8	27	6	20	8	27
Q4	8	27	13	43	7	23	1	3	1	3
Q5	0	0	2	7	5	17	9	30	14	47
Q6	7	23	14	47	7	23	2	7	0	0
Q7	0	0	3	10	4	13	8	27	15	50
Q8	13	43	13	43	3	10	1	3	0	0
Q9	1	3	2	7	4	13	13	43	10	33
Q10	12	40	7	23	7	23	2	7	2	7

Here are some of the results from our interviews with users:

(1) "Compared to purely entertaining games, I can learn a lot while playing this game, which awakens my memory of the Harbin industry."

(2) "It is very educational and can inspire people to learn about the history of the Harbin industry, especially young people interested in history."

(3) "Harbin was once a glorious industrial center, and learning about this history in the form of a game is eye-opening. It draws people's attention, especially young people while popularizing knowledge."

(4) "This game is still relatively easy to get started at the same time with the general game is not the same as in the past, this game still many gains after playing, through playing this game, get not only happy but also gained much knowledge about industrial history and culture."

(5) "The game is not very difficult; you can get the information by visiting the exhibition hall carefully and listening to the dialogues of the NPCs attentively. By incorporating industrial knowledge into the game, learning this knowledge is not boring."

(6) "Presenting history in the form of a game is an excellent form of cultural dissemination and resonance, and the combination of a puzzle-type mini-game and the collection of map fragments to open the map can increase the player's motivation to explore and immerse the player in experiencing the atmosphere of history and culture."

(7) "Simple plots can be added to connect different levels."

(8) "The game page is made to fit the industry theme and is also wonderful and easy to use. It would be nice to design more mini-games elsewhere to give me more knowledge."

(9) "The cultural value of the game is worth recognizing, and while there isn't necessarily much content presented, it is focused on a specific point."

(10) "An exciting game, and playing the game by browsing through the whole pavilion is not only fun, but it also teaches much knowledge. I hope more good games like this will be available to us, the public, in the future."

4.3 Results

The average score of the SUS test results for this experiment was 73.4. When the SUS score is between 52-72, it indicates that the product is satisfactory; when the SUS score is 73-84, it suggests that the product is good; and when the SUS score is higher than 85, it indicates that the product is excellent[18]. Overall, participants generally had a more satisfactory attitude towards the serious game.

5 Discussion

This study adopts situational cognition theory as the theoretical framework and uses unity as the development engine to design an interactive situational game. It aims to popularize Harbin's industrial history and culture and promote the protection and inheritance of industrial heritage. This study provides valuable inspiration and reference for the field of serious games.

First, contextual cognition theory emphasizes the importance of the environment to individual cognition and experience, so in serious game design, players' interest and participation can be stimulated by setting up appropriate contexts and scenes. In this study, the Harbin Welding Research Institute was selected as the base of the venue design, and its rich industrial history and cultural resources were utilized to create the Ice City Industrial Culture Exhibition Hall. Such a design makes a situation with a solid industrial atmosphere and provides players with a more realistic game experience and learning effect.

Second, game design needs to focus on user experience and interactivity to play the motivational factors of serious games. To increase the player's sense of participation and desire to explore, this study sets up several levels and hidden mini-games to guide the player to explore and learn step by step. At the same time, the game interface design should be simple and easy for players to operate and understand. Through these designs, the fun and attractiveness of the game can be effectively enhanced, and the players' learning effect and feeling of experience can be improved.

Finally, serious game design should focus on educational and cultural values to play the educational factors of serious games. Serious games provide an entertaining experience and should focus on the functions of education and cultural inheritance. In this study, through the setting and content of the game, the knowledge of Harbin's industrial history and culture was conveyed to the players, which stimulated their awareness of the protection and inheritance of industrial heritage. This kind of game design, which integrates educational and cultural values, helps enhance players' sense of social responsibility and historical and cultural awareness and proposes innovative ideas for developing the serious gaming field.

6 Conclusions and future work

The interactive situational game designed in this study provides new ideas and methods for the field of serious games. By utilizing situational cognition theory and virtual reality technology, we have designed serious games that are educational and entertaining, enriching the players' gaming experience and bringing them a comprehensive and in-depth education on the history of industrial heritage. This helps enhance the public's interest in industrial history and culture and injects new impetus into preserving and inheriting industrial heritage.

According to the feedback from users, in the future, we will gradually increase the difficulty and challenge of the game based on playing the educational significance of the game to meet the needs of different user groups, especially young people, for the game's playability. We will reflect on the current situation of Harbin's industrial culture in the game in real time so that the game can be expanded in the dimension of time and space.

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