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Research on Serious Game Design for Children's Food and Agriculture Education

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Abstract: This study takes children as the research subjects to explore the rationality of integrating food and agriculture education with serious games, thereby consolidating children's agricultural knowledge, fostering agricultural skills, and developing healthy eating habits. Based on the game mechanics of serious games, combined with children's cognitive and behavioral characteristics, this study identifies the core indicators of food and agriculture education, refines them into specific design elements, constructs a serious game design model for children's food and agriculture education, and conducts usability evaluation through the design of corresponding game interfaces. The contextual and incentive properties of serious game mechanics are crucial factors in enhancing children's acquisition of food and agriculture knowledge, skills, and healthy eating habits. The game design integrating food and agriculture education with serious games can significantly improve the level of children's food and agriculture education, and has important guiding value for promoting the design and development of children's educational games.

Keywords: Food and agriculture education; Serious games for children; Interface design; Usability study

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1. Introduction

In modern society, with the development of urbanization and technology, many children lack a basic understanding of food sources, agricultural production processes, and food culture, making food and agriculture education particularly important. Currently, food and agriculture education mainly relies on study-practice activities. However, as a long-term cultivation process, food and agriculture education requires a combination of online and offline educational forms to achieve a more comprehensive educational effect.

Serious games, as an emerging educational tool, enhance learners' interest and memory through interactive and gamified methods. Integrating serious games into food and agriculture education can provide children with a more comprehensive and vivid online learning experience. The usability of serious game design directly affects the educational effect; therefore, it is crucial to design serious games that align with children's cognitive and behavioral characteristics and the core elements of food and agriculture education.

This study aims to explore the design approach of integrating food and agriculture education into serious games

for children, verify the usability through game interface design, provide references for the future design of children's serious games, and promote the wide application of food and agriculture education in children's education.

2. Children's food and agriculture education and serious games

2.1. Food and agriculture education

Food and agriculture education is a process that emphasizes hands-on experience and learning through practice. It covers two aspects of experience: diet (food culture) and agriculture (farming culture). In agricultural experience education, participants engage in labor activities such as sowing, farming, harvesting, and cooking. In dietary experience education, participants learn about food sources, local ingredients, cooking methods, and healthy dietary lifestyles.

During this process, by enhancing the interaction between people and food and experiencing various food-related roles (such as food producers, collectors, processors, and consumers), multiple senses are activated to perceive food. This helps to improve participants' ability to identify and select food, arouse respect and gratitude for food and laborers, and cultivate food culture while inheriting farming culture [1].

Food and agriculture education is promoted and implemented in different ways abroad. For example, Japan promotes a national food education program through the Basic Law on Food Education, while the United States and Europe advance food and agriculture education through school garden projects and community farms [2].

In China, "study tours + food and agriculture education" is an innovative educational practice. It combines the on-site learning of study tours with the practical experience of food and agriculture education, providing students with an opportunity for a comprehensive and in-depth experience. At present, food and agriculture education mainly relies on offline study tours, but it is limited by geographical location and time, making it impossible for children to absorb all the knowledge about crops and experience the entire daily planting process in a short period.

However, for children, food and agriculture education is a long-term development process that cannot undergo qualitative changes solely through short-term study tour experiences. Therefore, online food and agriculture education, as an extension of offline study tour services, enables children to participate in the process from crop growth to maturity (when crops become food) and develop correct dietary attitudes. This expands the achievements of offline study tours and provides children with a platform for continuous learning and growth. See **Table 1** for the characteristics of online and offline food and agriculture education.

Table 1. Analysis of the characteristics of online and offline food and agriculture education

Characteristics	Online food and agriculture education	Offline food and agriculture education
Convenience	High, accessible anytime and anywhere	Low, limited by geographical location and time
Interactivity	High, game design encourages user participation	Medium to high, actual interaction but may be limited by resources and environment
Experience method	Virtual experience	Actual experience, direct interaction with the natural environment and plants
Personalized learning	High, difficulty and content can be adjusted according to user progress	Medium, personalization is limited by curriculum design and resource allocation
Cost	Low, digitalization reduces the need for physical resources	High, requiring payment for venues, equipment, materials, etc.
Social function	High, easy-to-integrate chat and community functions	Medium, social interaction mainly occurs on-site and may require additional organization to promote communication

Table 1 (Continued)

Characteristics	Online food and agriculture education	Offline food and agriculture education
Educational depth	Medium, may lack in-depth experience and practical operation	High, providing opportunities for practical operation and in-depth understanding of agriculture
Technical requirements	High, requiring a stable network and technical support	Low to medium, depending on the use of auxiliary technical tools
Scalability	High, can quickly expand content and user groups	Medium, on-site expansion may require more resources and planning
Educational goals	Combining entertainment and education, emphasizing fun and participation	Combining education and practice, emphasizing in-depth knowledge and practical skills

2.2. Design of food and agriculture education games for children

Food and agriculture education plays a vital role in children's growth. It not only helps children acquire agricultural knowledge and develop healthy eating habits but also contributes to preventing diet-related diseases such as obesity and diabetes. As a new type of educational tool, gamified food and agriculture education games have attracted increasing attention from families, schools, and society. This study evaluates and analyzes existing food and agriculture education games through case analysis.

(1) BabyBus Wonderful Farm (**Figure 1**)

This game allows children to experience various agricultural activities such as planting, breeding, and processing. Each link is accompanied by detailed operation guidelines, enabling children to learn agricultural knowledge while having fun. However, the game may overemphasize entertainment and lack sufficient educational content or in-depth explanations, resulting in limited learning effects.

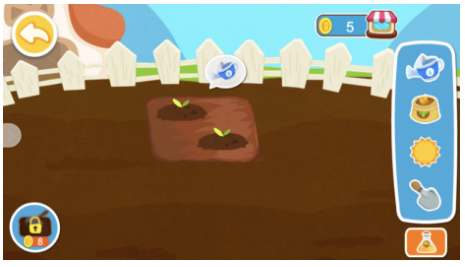

Figure 1. Screenshots of BabyBus Wonderful Farm

(2) Rice Planting Factory (**Figure 2**)

The game takes the process of rice from planting to harvesting and finally to the dining table as the clue to drive the game, presenting players with a series of knowledge about rice planting and processing. The overall story clue is clear and has a strong narrative, which easily encourages players to continue experiencing. However, there is no corresponding knowledge explanation, and players can only learn through game graphics and their own operations.

Figure 2. Screenshots of Rice Planting Factory

(3) Farm to Table

The story of this game takes the process of wheat planting to processing as the clue, allowing players to learn about wheat planting and processing during the game. In terms of mechanics, the core gameplay is puzzles: wheat images are turned into disordered puzzles, and players click on the images to complete the puzzles, unlock corresponding knowledge, and enter the next level. The game has a strong narrative, and the puzzle format is interesting. However, the corresponding explanations are only displayed after completing the puzzles, and these explanations have no audio and can be skipped, which weakens the knowledge transfer effect. **Figure 3** shows the corresponding game screenshots.

Figure 3. Screenshots of Farm to Table

Through the study of the above cases, it is found that the current food and agriculture education games have the following problems: (1) They overemphasize entertainment and fail to provide sufficient educational content or in-depth explanations, leading children to only enjoy the fun of the game without a deep understanding of the knowledge learned. (2) Interaction may mainly focus on game operations rather than knowledge learning, limiting the educational effect. (3) Knowledge promotion and skill learning are not fully integrated, preventing children from truly learning agricultural skills and absorbing agricultural knowledge through practical processes. See **Table 2** for the analysis.

Table 2. Analysis and evaluation of food and agriculture education games

Game name	Educational goals	Knowledge promotion	Skill learning
BabyBus Wonderful Farm	Knowledge-oriented (food and agriculture knowledge)	Medium	Low
Rice Planting Factory	Skill-oriented (habit cultivation)	Low	High
Farm to Table	Knowledge-oriented	Medium	Low

2.3. Serious games

Serious games (**Figure 4**), as a form of games aimed at education, training, and other non-entertainment purposes, have been widely applied and studied in the field of education in recent years. By simulating real scenarios or using gamified learning methods, these games effectively impart knowledge, cultivate skills, and enhance learners' problem-solving abilities and creativity. Moreover, through interactive forms, they adjust the active-passive perspective of knowledge acquisition.

In China, there are only 12 academic papers focusing on children as the target group. Among them, three papers summarize and analyze domestic and foreign cases or directly discuss the interface design principles of serious games based on children's psychological characteristics, but the research depth is relatively shallow [3–5].

Overall, compared with the relatively abundant theoretical research abroad, the number of empirical studies on the effectiveness of interface design for children's serious games and theoretical exploration papers on the design models and principles of children's serious games in China is relatively insufficient,

and further discussion and deepening are needed. In addition, the application of food and agriculture education in serious games has not been fully explored. Therefore, using serious games as a carrier for food and agriculture education, through the interactive mechanism of games, can gradually cultivate children's agricultural knowledge, agricultural skills, and healthy eating habits, continue the experience of offline learning achievements, and thus achieve the effect of enhancing the depth of learning.

Figure 4. Serious games

3. Construction process of the experimental model for the design of serious games for children's food and agriculture education

3.1. Extraction of children's cognitive and behavioral characteristics

At present, there is no unified standard for defining the age of minors in China, and there are great disputes. The Convention on the Rights of the Child, adopted in 1989, states that all persons under the age of 18 are children. In the theory of children's cognitive development, children are divided into four periods: 0–2 years old, 2–6 years old, 7–11 years old, and 12–18 years old.

Children at different age stages show different developmental characteristics in terms of physical development, behavioral concepts, and color preferences. Therefore, children of different age groups have different needs for product experience [6]. To more accurately position the design practice, this paper selects children aged 6–12 as research subjects (**Table 3**).

Table 3. Cognitive and behavioral profiling of children

Children's age	Cognitive and behavioral characteristics of children
6–8 years old	- Can concentrate attention and will not shift goals until they fully master a task. - Prefer intuitive information and do not like to explore or guess. - Like things with "continuity" and enjoy having entities related to the virtual space in the real world. - Like to collect things.
8–10 years old	- Self-awareness is enhanced, and they like challenging things. - Do not like to read instructions for new products, but start trying directly.
10–12 years old	- Will consider the possible consequences of their actions before acting. - Will find fields they are very interested in and good at, and devote themselves to them with great concentration. - Adolescent children will become very sensitive and feel that it is difficult for them to integrate into the surrounding environment.

3.2. Extraction of design elements for children's food and agriculture education

The educational goals of learning content are the guidelines for various teaching activities. Food and agriculture education has two core indicators: eating habits and agricultural knowledge. The specific learning content revolves around these two indicators, as shown in **Table 4**. Eating habits: Dietary education needs to convey a concept of healthy eating. Developing the good habit of not being picky about food from childhood can help the

human body achieve nutritional balance and promote healthy growth. Agricultural knowledge: By participating in farming activities, children can experience the fun of agriculture, acquire relevant agricultural knowledge, and experience agricultural life.

Table 4. Extraction of design elements for food and agriculture education

Dimension	Core indicator	Learning content	Educational goal
Dietary education	Eating habits	Correct diet	Not picky about food
Agricultural education	Agricultural knowledge	Concrete knowledge	Recognize food
		Abstract knowledge	Skill learning

3.3. Application of serious games in children's food and agriculture education

Education is an important application field of serious games. The application of serious games in the teaching field is divided into two aspects: knowledge learning and technical training [7].

In terms of knowledge learning, serious games are a practical teaching model. Students acquire knowledge and experience through practice rather than through reading or being told. In terms of technical training, the characteristic of serious games is to virtualize some tasks that are difficult to complete or consume a lot of energy in reality, helping trainees complete their training.

(1) Design elements of children's serious game mechanics

According to the game analysis framework proposed by Jesse Schell in the book The Art of Game Design, the elements that constitute a game include aesthetics, story, mechanics, technology, etc. [8], among which mechanics are considered the most important design element affecting the operation of the game. Based on this, Sha and Xia concluded in *A Study on the Design of Serious Games for School-Age Children* that contextuality, incentive, challenge, and autonomy are the main game mechanics for the design of children's serious games. **Figures 5** and **6** show the mapping relationship between game mechanics and game effects, as well as the educational effects of serious games.

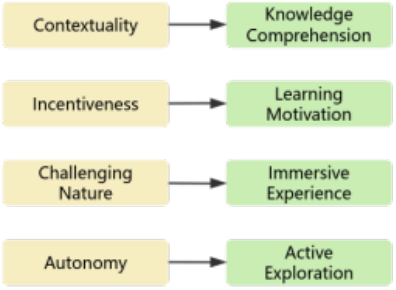

Figure 5. Mapping relationship between game mechanics and game effects

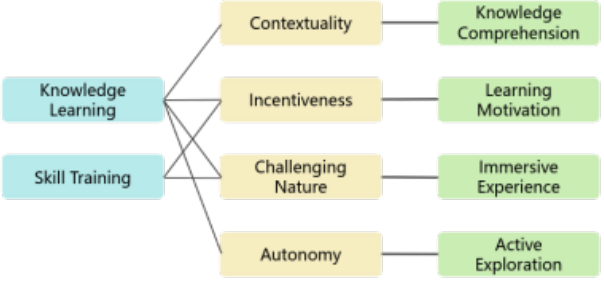

Figure 6. Mapping relationship between game mechanics and the educational effects of serious games

(2) Design elements of children's serious game interfaces

Wang proposed design strategies for the interface design of children's serious games from the perspectives of children's cognition, physical structure, emotions, and social development in *A Study on the Interface Design of Mobile Children's Serious Games*. Based on the proposed design elements, this paper reclassifies and summarizes them from the perspective of children's cognition and behavior into four aspects of children's serious game interface design: interaction design, function layout, operation layout, and visual design (**Table 5**).

Table 5. Interface design elements of children's serious games

Classification of design elements	Specific elements	Design content
Interaction design	Graphical metaphor, touch feedback, animation guidance	Reduce the use of text, use graphical metaphors and touch technology to provide intuitive operation feedback; animated characters are used for emotional attraction and learning guidance.
Function layout	Interface structure, icon spacing, task system	The interface structure should be concise and orderly, the icon spacing should be appropriate, and the task system should be designed reasonably to avoid frustration. Provide a clear "escape hatch" mode and support the progressive construction of the game world view.
Operation layout	Avoid excessive interactive buttons, widen icon spacing on the interface	Simplify the interface, reduce unnecessary interactive buttons, and increase the icon spacing to adapt to children's operating habits, reduce misoperations, and improve the user experience.
Visual design	Graphical metaphor with less text, triggering learning content through icons, color use	Use graphical metaphors and a small amount of text to improve cognitive efficiency; display relevant learning content (such as image groups and color block groups) when icons are triggered to enhance visual attraction; use bright colors and color blocks to attract children's attention, consider the impact of colors on emotions, and consider the indicative role of colors in the interface.

3.4. Construction of the experimental model for the interface design of serious games for children's food and agriculture education

Children at different stages have different cognitive and behavioral characteristics. Educational serious games include two aspects: knowledge learning and skill training. Game mechanics and interface design are important factors in the design of serious games. Based on the analysis of the above factors, a model of serious games for children's food and agriculture education is constructed (**Figure 7**).

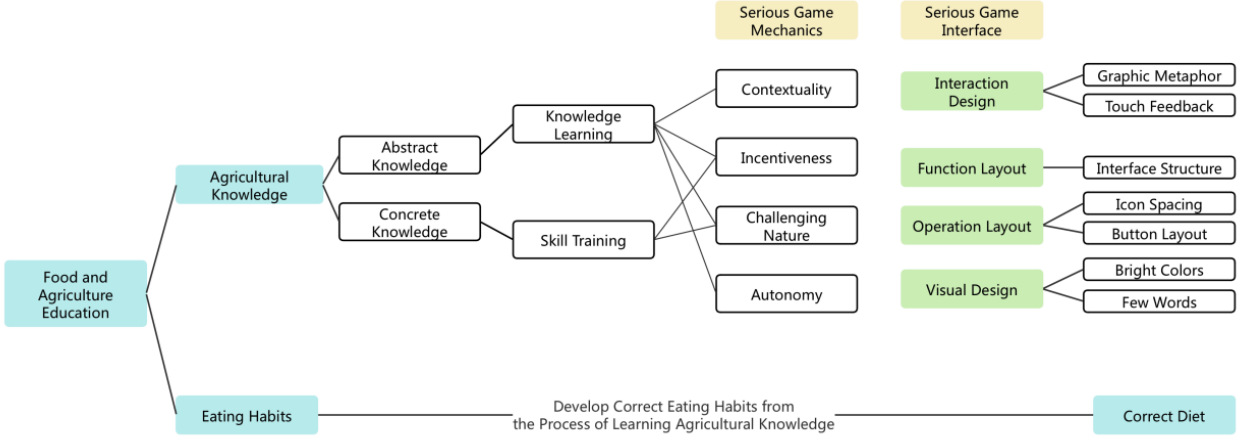

Figure 7. Experimental model for the design of serious games for children's food and agriculture education

4. Usability testing of serious games for children's food and agriculture education

4.1. Experimental process

4.1.1. Participants

A total of 105 children who participated in offline study-practice activities of food and agriculture education were randomly selected from a primary school in Chengdu. The average age of the participants was 8.50 ± 0.50 years, with a balanced gender ratio. All participants had normal language development, normal audio-visual functions, and no cognitive impairments.

4.1.2. Test materials

(1) Knowledge questionnaire: A knowledge questionnaire corresponding to the selected games was compiled, which was divided into two parts: basic knowledge and skills, with a score ratio of 5:5 (total score 100 points). It was used to assess the participants' performance before and after the experiment.

(2) Game experience scale: Based on the research of Guo *et al.*, a game experience scale was compiled for this experiment to score the knowledge learning effect and skill learning effect of the game. The game experience scale uniformly adopted a 5-point Likert scale.

4.1.3. Experimental procedures

All participants were randomly divided into three groups, and each group used the selected serious games for a one-week learning period. The experiment process was divided into four parts: Before the experiment, the participants completed the knowledge questionnaire related to the theme of the food and agriculture education serious game. The researchers explained the game operations to the participants and required them to learn through the serious games and complete the target tasks within one week. After the one-week learning period, the participants completed the same knowledge questionnaire again. Finally, the participants filled out the questionnaire scale, including scoring the learning effect and skill cultivation effect of the game.

4.2. Results of experimental data analysis

After the actual application by the children, relevant usage data and information feedback were obtained. By integrating duplicate and similar content and eliminating irrelevant information, the results were summarized into the following three points: After using serious games for food and agriculture education, the children's performance significantly improved, and their cognitive level of agricultural knowledge and technology was enhanced. Serious games had a more significant effect on improving the abstract knowledge of food and agriculture education. Contextuality had the most significant impact on the learning of concrete agricultural knowledge, while challenge had the most significant impact on the learning of abstract knowledge. therefore, the above design practice verifies the effectiveness of integrating serious games into children's food and agriculture education.

5. Conclusion

Serious games have shown a significant teaching effect in the field of children's food and agriculture education. The experiment verifies that serious games not only enhance children's understanding of agricultural knowledge and mastery of skills but also achieve a breakthrough in the learning of abstract concepts.

The contextual and challenging game mechanics in the design of serious games play a positive role in children's learning. Contextuality promotes the learning of concrete knowledge by simulating real scenarios,

while challenge stimulates in-depth understanding of abstract concepts by setting tasks.

In conclusion, this study provides empirical support for the innovative approaches of food and agriculture education, demonstrates the potential of serious games in improving the experience and effect of children's food and agriculture education, and provides practical guidance for the design of children's food and agriculture education games.

Disclosure statement

The authors declare no conflict of interest.

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