
Research on the Application of Two-Dimensional Card Games Based on Situated Cognition Theory in Food Science Popularization Games for Teenagers

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Abstract: To address the issues of fragmented popular science content, lack of situational immersion, and the separation of educational and entertainment elements in current food science popularization games for teenagers, this study introduces situated cognition theory as the core guiding framework based on an investigation and pain point analysis of existing food science popularization games. Combining the interactive advantages of two-dimensional card games, an innovative design scheme is proposed, featuring situational construction, task-driven gameplay, and card-based interaction. The scheme encompasses core elements such as modular knowledge systems, scenario-based interaction mechanisms, and situational visual presentation. By creating authentic agricultural production scenarios, it aims to help teenagers systematically acquire food knowledge and develop an understanding of food security through interactive card gameplay. The study seeks to provide a novel pathway for the engaging dissemination of food science popularization while offering references for the design and practice of similar educational games.

Keywords: Food Science popularization; Situated cognition; Card-based interaction; Situational construction; Edutainment

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1. Introduction

Grain, as the foundation of people's livelihood and a crucial cornerstone of national security, embodies the wisdom of millennia-old agricultural civilization and meets the survival needs of contemporary society. The General Secretary has emphasized that scientific and technological innovation and science popularization are the two wings of achieving innovative development, and that science popularization should be placed on an equal footing with scientific and technological innovation^[1]. The Outline of the National Action Plan for Scientific Literacy (2021–2035) further highlights the enhancement of scientific literacy among young people and the implementation of science and technology support actions for rural revitalization as key tasks for improvement^[2]. Grain is intricately linked to every family's dining table, societal stability, and national security. In today's context, food science popularization is an essential course for every citizen to safeguard food safety at the dining table, foster national consensus, and practice ecological principles. However, contemporary youth, particularly those in urban areas, often lack practical agricultural experience, leading to widespread issues such as an inability to distinguish between different grains and a weak awareness of food security. Traditional methods of science popularization,

such as lectures and textbook-based learning, struggle to stimulate their interest in learning.

In the digital age, games have emerged as a significant medium through which young people receive information, giving rise to food science popularization games. However, existing food science popularization products often fall into the trap of prioritizing entertainment over education, simplifying agricultural labor into mere clicking operations, and offering monotonous, unrealistic approaches to farming, thereby undermining their educational value. Alternatively, some products adhere rigidly to knowledge-imparting models, delivering content through mechanical question-and-answer sessions that lack engaging elements. Based on these observations, this study introduces situated cognition theory and leverages the characteristics of two-dimensional card games to explore a pathway for the deep integration of food science popularization and game design, proposing a game design scheme that is both scientifically rigorous and entertaining.

2. Current status review and core pain points of food science popularization games

In the era where digital technology permeates both education and entertainment, food science popularization games have transcended the limitations of traditional science popularization methods, such as textual instruction and exhibition board displays, by offering interactive, immersive experiences and engaging expressions. Even field-based agricultural science popularization activities, which provide a more authentic agricultural experience, are often constrained by multiple factors: financially, the high costs of venues, farming tools, and instructors hinder the regularization of such activities; geographically, the physical barriers and resource disparities between urban and rural areas significantly reduce the reach and accessibility of science popularization. In contrast, food science popularization games offer distinct advantages: although they require initial development investment, they can be disseminated at a low cost once launched, eliminating the need for material consumption and venue maintenance associated with field activities. Leveraging digital platforms, they break free from spatial constraints, enabling urban and rural youth to participate anytime via electronic devices. Moreover, their high reusability allows for repeated experiences of the science popularization content, and the ability to enrich modules through updates amplifies the educational benefits, aligning with the game-based learning habits of young people.

However, despite the increasing number of food science popularization games, their full potential for science popularization has not been realized. Analyzing products such as FoodForce, Harvest Farm's Reaper, and QQ Farm reveals three major categories of pain points: knowledge transmission focuses on a simplified process from sowing to harvesting, with situational construction detached from real agricultural scenarios, lacking emotional and value transmission; the integration of science education and entertainment is insufficient, with entertainment logic dominating, making it difficult to guide users in forming a systematic understanding of agriculture and food security awareness, severely limiting the effectiveness of science popularization; and the neglect of conveying real-world significance fails to establish the goal of cultivating and enhancing users' food security awareness.

2.1. Disconnection between scenario design and knowledge transmission, hindered cognitive implementation

Currently, most food science popularization games suffer from a disconnection between the science popularization content and the transmission scenarios. The game pages lack regional scenario designs that align with the growth habits of crops, failing to replicate the differences in planting environments across regions. All crops are typically planted in generalized scenarios, ignoring their real growth habits. For example, in the game Harvest Farm's Reaper, a circular area is divided into concentric rings for planting different crops, with a central rotating sprinkler causing the crops to mature with each rotation. This is entirely inconsistent with the natural laws that require different environmental conditions and water supply tailored to the needs of each crop. Users cannot intuitively perceive the relationship between crops and their growth environments, nor can they appreciate the real differences in food planting across regions. Under such designs, users can only mechanically memorize crop names and engage in patterned planting, unable to establish associative cognition between the environment, crops, and knowledge, failing to grasp the logic of real agricultural production or understand the practical value of food knowledge, ultimately rendering the goal of popularizing food knowledge a mere formality.

2.2. Imbalance between science education and entertainment, compromised communication effectiveness

The extreme phenomenon is particularly prominent in most games, characterized by an excessive pursuit of entertainment, simplifying scientific processes such as fertilization and pest control into click-to-score actions, and even disseminating incorrect knowledge, while the output of knowledge remains superficial and fails to deeply integrate with entertainment gameplay. For instance, in QQ Farm, the excessive pursuit of entertainment simplification undermines the scientific and practical nature of agricultural knowledge. The complex agricultural production process is reduced to a mechanical sequence of clicking actions: sowing, watering, fertilizing, harvesting, and stealing crops. The core fun lies in time management to prevent theft and social interaction, rather than exploring agricultural knowledge. For example, crop planting does not consider real-world conditions such as soil acidity and alkalinity or regional climate adaptability, allowing rice and wheat to be freely switched in the same plot; the growth cycle is compressed into fixed durations ranging from minutes to hours, completely detached from the natural laws of spring sowing and autumn harvest. Even if some NPCs mention basic planting techniques, these are mostly fragmented pieces of information for entertainment purposes, failing to form a systematic knowledge transmission chain, making it difficult for players to understand the scientific logic of agricultural production through their actions. Although the game features over a hundred crop images and claims to convey agricultural concepts, it only achieves basic recognition through icons and names, without covering core science popularization content such as crop growth habits, pest control, and ecological planting. This entertainment-dominated, science-education-as-an-afterthought model leaves adolescents with only operational pleasure after long-term gameplay, unable to form an understanding of the complexity and scientific nature of agricultural production, and may even lead to misunderstandings about real agriculture due to simplified virtual scenarios, completely deviating from the science popularization goal of combining education with entertainment.

2.3. Lack of transmission of food security values, disconnected from real-world issues

Currently, most science popularization games focus solely on the technical knowledge of food planting, failing to connect this knowledge with real-world value issues such as food security, food conservation, and agricultural sustainable development. Knowledge needs to be linked with real-world practical issues to stimulate deeper meaning and reflection. However, most adolescents, after using relevant science popularization software, often only acquire technical knowledge and fail to understand the social significance and responsibilities behind food production. For example, in the game mechanism of Harvest Farm's Reaper, the victory standard is solely based on the quantity of harvested food, without considering the consequences of over-irrigation leading to soil fertility decline; although FoodForce involves food rescue themes, it fails to connect with real-world issues such as China's red line for arable land protection and seed industry security, making it difficult for adolescents to link the food issues in the game with the current state of national food security or form a sense of responsibility^[3-4].

In summary, the disconnection between knowledge and scenarios, the imbalance between science education and entertainment, and the detachment between values and real-world significance collectively constitute the core bottlenecks in the current development of food science popularization games. These issues not only reduce the games to mere entertainment without science popularization or dull indoctrination without fun, but may also mislead adolescents' perceptions of agricultural production, deviating from the essential goal of combining education with entertainment in science popularization games. Only by being guided by situated cognition theory and breaking free from existing design constraints can food science popularization games truly serve as a bridge connecting adolescents with agricultural knowledge, achieving a win-win situation between science popularization value and entertainment experience.

3. Situated cognition theory as an innovative engine for food science popularization games

3.1. The core of situated cognition theory

Situated cognition theory emerged in the 1990s as a significant innovative direction following learning theories such as behaviorism and information processing. Its core viewpoint breaks away from the traditional perception of knowledge as

isolated symbols, providing a brand-new framework for understanding the essence of learning. It has been widely applied in fields such as education and teaching, career development and organizational management, as well as human-computer interaction and product design. Situated cognition theory posits that knowledge is not an abstract concept detached from practice; rather, it is born and exists within specific application scenarios, closely tied to real-world problem-solving processes. Simultaneously, learning is a process of actively constructing a knowledge system and acquiring knowledge through interactive practices with the environment, tasks, and others in authentic or simulated situations. Effective education should center on the learner, achieving unity between knowledge and abilities by creating typical situations and designing task-driven activities. Situated cognition theory opposes designs that separate knowledge from practice, advocating for the use of concrete scenarios and objectives to guide learners in mastering knowledge content and enhancing application abilities while solving practical problems, ultimately achieving the integration of knowledge and action.

3.2. Situated cognition theory infuses vitality into science popularization games

In science popularization games, situations serve as the core hub connecting knowledge transmission, experience creation, and educational value. Science popularization content often includes abstract concepts, complex principles, or professional terminology. Even when simplified to accommodate the weaker comprehension abilities of adolescents, direct can still lead to difficulties in user understanding. The application of situated cognition theory can largely avoid this situation. Situated cognition theory emphasizes the situated nature of knowledge, embedding knowledge construction within the situational environment, where cognitive subjects complete knowledge construction through interactions with the situational environment and objects ^[5]. Specifically, situations can transform abstract content into interactive specific rules by constructing perceivable scene logic for knowledge, leveraging scene restoration and role assignment to reinforce this advantage, and promoting users' transition from passive recipients to active explorers. In most science popularization games, the common contradiction arises where entertainment dilutes science popularization, or didacticism weakens fun. Situations, through the co-design of tasks, knowledge, and experiences, become the key to resolving this contradiction. They transform science popularization goals into situational core tasks, making learning a necessary path for play. The purpose of science popularization games is not merely to transmit knowledge but also to cultivate users' interest in science and recognition of the value of the field. Situations play a crucial role in this value transmission process. Therefore, based on the core pain points of most food science popularization games on the market, designing situations guided by situated cognition theory can precisely address issues such as the disconnection between knowledge and scenarios, situational inauthenticity, and the imbalance between science education and entertainment, injecting targeted vitality into food science popularization games.

4. Innovative design approach for a two-dimensional card-based grain science game under the framework of situated cognition theory

Card games, centered around cards as the primary interactive medium, achieve strategic confrontation, narrative progression, or knowledge transmission through predefined rules. Their core logic lies in enabling players to accomplish game objectives through the combination, utilization, and interaction of cards. Card games attract a broad spectrum of players across age groups due to their high rule flexibility, adaptability to various settings, ease of learning, and high inclusivity. Naturally serving as content carriers, cards can effectively integrate grain knowledge into their design, allowing players to naturally encounter and understand grain knowledge through card assembly and combat, thereby stimulating their interest in learning. Guided by the core principles of situated cognition theory, this design innovatively merges the interactive characteristics of two-dimensional card games with the real-world logic of grain production, constructing a "Situational Construction-Task-Driven-Card Interaction" science popularization model. Addressing the prevalent issues in most existing grain science games for teenagers, this design proposes the following innovative approaches.

4.1. Healing visual style and organic integration of cards and knowledge

- (1) The game's style is crucial, shaping user experience, enhancing its dissemination, and ensuring long-term value across multiple dimensions. The visual appeal of the game significantly determines its quality. Given teenagers' propensity for engaging content, this design adopts a hand-painted watercolor illustration style as the overall visual and narrative foundation, creating a warm, soft, and immersive atmosphere reminiscent of a fairy tale, thereby enhancing the appeal and immersion of grain knowledge transmission.
- (2) In terms of science popularization methods, this design deeply integrates grain knowledge with card interactions. Knowledge is naturally embedded within the card interaction logic, making the connections between the environment, crops, and knowledge a prerequisite for basic game operations rather than supplementary content. Through the interconnection of chapter and scenario cards and the correlation between card growth and scenario knowledge, players naturally encounter and understand why specific crops are suitable for particular scenarios while selecting cards and manipulating terrain, effectively addressing the disconnect between knowledge and scenarios.

4.2. Knowledge-driven game mechanics design

In designing science games for teenagers, the deep integration of learning and playing is the core logic for achieving educational entertainment, effectively addressing the pain points of traditional didactic approaches. It transforms knowledge from an ancillary element into a core variable in the game's progression, enabling knowledge internalization through practical interaction and preventing science popularization from becoming a mere formality. To achieve this goal, a unique game mechanics design is crucial. For teenage science games, game mechanics serve not only as a vehicle for entertainment but also as a critical bridge for value guidance, skill development, and knowledge transmission, directly influencing teenagers' cognitive gains, behavioral habits, and emotional experiences in the game. Therefore, this design incorporates knowledge-driven combat and card growth mechanics, visually presenting the value of knowledge through win-loss feedback while offering both motivation and visibility. For instance, players' mastery of knowledge determines the effectiveness of card usage in combat; achieving knowledge standards leads to card ability growth, rewards, and unlocking of more card types or resources.

4.3. Game narrative carries value and conveys practical significance

Teenagers' values are continuously shaped through observation, interaction, and experience. Transforming abstract value concepts into perceivable behavioral feedback is the core path for science games to achieve value transmission. However, teenagers, being at a critical stage of value formation, naturally resist rigid moral teachings. For science games targeting teenagers based on situated cognition theory, immersive narrative methods like story missions effectively compensate for the rigidity and obscurity of traditional value transmission methods by transforming abstract real-world values such as food security and sustainable agriculture into perceivable and interactive story content. In the main storyline, chapters are set based on grain crop types, with each chapter's narrative unfolding around the corresponding crop's production process. Real-world issues are embedded within the storyline, while real-world weather and natural disasters are decomposed into character mission branches and narrative feedback within the story, allowing teenagers to naturally understand the social value behind grain while exploring the entire grain production process alongside the narrative.

5. Design and implementation of a two-dimensional card-based grain science popularization game under the framework of situated cognition theory

Building upon the aforementioned design concepts, the authors have developed a two-dimensional card-based grain science popularization game titled "Grain Gathering Chronicles" under the guidance of situated cognition theory. **Figures 1 and 2**, respectively, depict the game cover and main homepage. Centered around grain science knowledge, this product employs situated cognition theory as its design guideline and utilizes two-dimensional cards as the primary interactive

medium. By integrating a healing visual style reminiscent of hand-painted watercolor illustrations, it creates an innovative science popularization model featuring situational construction, task-driven gameplay, and card interaction. Through elements such as advancing main storylines, card battle interactions, and resource management and development, the game combines the real-world logic of grain production with the strategic nature of card games, enabling teenagers to naturally encounter, understand, and master grain knowledge through an immersive gaming experience while simultaneously conveying the practical values of food security and sustainable agriculture. The product's content is divided into four core modules: the main storyline science popularization module, the card battle interaction module, the card growth and development module, and the economic and illustrated guide system module. These modules are interconnected, collectively constructing a comprehensive science popularization gaming experience.

Considering that the primary target audience for this game is teenagers, a group with a high receptivity to fun and visually appealing content and currently at a critical stage of value formation, who tend to resist rigid didacticism, the game's design and development process centered around situated cognition theory. Guided by the aforementioned innovative design concepts, implementation was carried out across three dimensions: game content module and interaction design, visual effect design, and the linkage between game scenarios and reality.



Figure 1. Game cover



Figure 2. Game homepage

5.1. Design of game content modules and interaction methods

The game content modules are structured around the entire grain production process as the logical mainline, dividing the core game content into four major modules: main storyline science popularization, card battle interaction, resource economy, and illustrated guides. These modules systematically convey grain science knowledge, complemented by diverse interaction methods that enable players to understand the knowledge through operation and optimize interaction efficiency, ensuring players can quickly get started.

5.1.1. Design of core content modules

- (1) Main Storyline Science Popularization Module: In this game, grain crops are categorized by type and production method into chapters, with each type of grain, such as wheat, rice, and corn, corresponding to an independent chapter. Each chapter contains 3 to 5 sections. Every chapter covers the authentic full production process line of the corresponding crop. For instance, in the rice chapter, players go through processes such as rice breeding and selection, paddy field cultivation, irrigation management, pest and disease control, and ultimately harvesting and storage. The chapter progression employs a mechanism of linear guidance combined with open choices: the first two chapters are mandatory and linearly advanced, guiding players through simple story missions to familiarize them with basic operations and knowledge; from the third chapter onward, chapter selection becomes open, allowing players to prioritize unlocking grain varieties of interest based on their preferences, meeting personalized learning needs. Story rewards are tied to knowledge: upon completing each section of the story, in addition to unlocking cards corresponding to the grain variety, upgrade resources are distributed based on story completion: basic resources such as fertilizers and water sources, and rare resources such as high-quality seeds; collecting three-star evaluations for all sections of a single chapter unlocks an additional science popularization illustrated guide for that grain variety: such as a growth cycle diagram of rice or the historical development of rice. **Figure 3** shows the map for the rice chapter.



Figure 3. Map of the rice chapter

- (2) Card Battle Interaction Module: Centered around simulating the grain planting process, this module adopts a Player vs Environment (PVE) mode, where each battle round corresponds to a specific grain planting task. Players must apply their knowledge to achieve three major objectives: reaching the target yield, ensuring quality standards, and controlling disaster-related losses. The battle process is divided into three stages: In the preparation stage, an animated and textual introduction provides an overview of the characteristics of the grain variety to be planted in this round and the initial resources available, enabling players to clearly understand the planting

requirements and resource constraints. During the planting stage, the map accurately represents the real-world terrain for the corresponding grain, and players need to drag cards to the appropriate areas. Simultaneously, they must manage the timing and ratios of water, fertilizer, and pesticide application based on the knowledge guidance provided by the existing cards. In the settlement stage, the system evaluates the results based on three indicators: final crop yield, quality, and disaster-related losses. Achieving the targets results in passing the level, while failing to do so highlights areas of knowledge weakness. **Figures 4, 5, and 6**, respectively, correspond to the battle start, success, and failure screens.



Figure 4. Battle commences



Figure 5. Battle success



Figure 6. Battle failure

- (3) Card Growth and Development Module: Modeled after the grain growth cycle, this module constructs a visual growth path, allowing players to intuitively perceive the laws of grain growth through the card upgrading process while simultaneously reinforcing their memory of grain knowledge. The core design comprises two parts: growth stages and a dual-dimensional enhancement mechanism.

The growth stages divide card levels into three phases, corresponding to the three periods of crop growth. Taking rice as an example, during the seed morphology period, the card frame is green, and the card face features a dormant seed. At this stage, the card only possesses basic planting functions. The rice seed card can only perform sowing and has no disaster resistance capabilities. During the growth period, the card frame upgrades to purple, and the card face depicts a seedling breaking through the soil, unlocking basic disaster resistance capabilities. The rice seed card can now withstand mild drought, corresponding to the knowledge that rice in the growth period requires frequent but small amounts of irrigation. During the maturity period, the card frame upgrades to gold, and the card face shows full rice ears, unlocking strong disaster resistance capabilities and attribute bonuses. At this stage, the rice seed card can resist severe flooding while increasing yield by 15%, corresponding to the knowledge that although mature rice requires water, excessive water accumulation can lead to lodging.

In the dual-dimensional enhancement mechanism, card upgrades require the simultaneous consumption of resource points and knowledge points. Resources are used to increase combat power values, while knowledge points are obtained through knowledge quizzes in story missions. Only when knowledge points reach the required level can the next growth stage be unlocked. This design effectively prevents situations where players only accumulate resources without learning knowledge. **Figure 7** displays the card screen when unlocking the growth stage of rice.



Figure 7. Unlocking screen for rice card

- (4) Resource Economy and Illustrated Guide Module: Focusing on resource circulation adaptation and knowledge review and reinforcement, this module not only supports gameplay mechanics through the resource system but also enhances the science popularization effect through the illustrated guide. The specific design is as follows:

Game resources are categorized into basic resources and rare resources. Basic resources such as water and fertilizer can be obtained by advancing the main storyline and completing regular battles. Rare resources like high-quality seeds and special-effect pesticides require achieving three-star battle ratings or unlocking chapter achievements, creating differentiated acquisition paths. The game features a resource store that offers two core operations for players: first, card synthesis, which involves exchanging lower-level cards for higher-level ones, with simultaneous improvements in card attributes and knowledge coverage; second, resource allocation, where players can convert surplus basic resources like fertilizer into rare resources like high-quality seeds, enabling flexible resource utilization. The illustrated guide system serves the function of knowledge consolidation. Cards unlocked by players and

completed story chapters are automatically recorded in the grain science illustrated guide, which contains two core components: first, knowledge associated with the cards, and second, a comprehensive diagram of the grain production process. Players can consult these at any time to review and deepen their understanding of grain knowledge. **Figures 8 and 9**, respectively, display the pages for the resource store and the science illustrated guide.



Figure 8. Resource store



Figure 9. Grain science illustrated guide

5.1.2. Design of interaction methods

Combining the gameplay characteristics, the authors have designed dual-dimensional interactions involving both visual and auditory elements to enhance the game's immersion and operational convenience.

Visual Interaction: Focusing on scenarios such as story dialogues, knowledge quizzes, and card battle operations, the system provides corresponding knowledge explanations or operational guidance prompts to help players better understand relevant agricultural knowledge and science popularization gameplay. Additionally, system feedback pages for loading, network errors, etc., are designed to align with the psychological state of teenage players, offering positive guidance to enhance the game's user experience and achieve completeness in game design. **Figure 10** shows the game loading feedback interaction page.

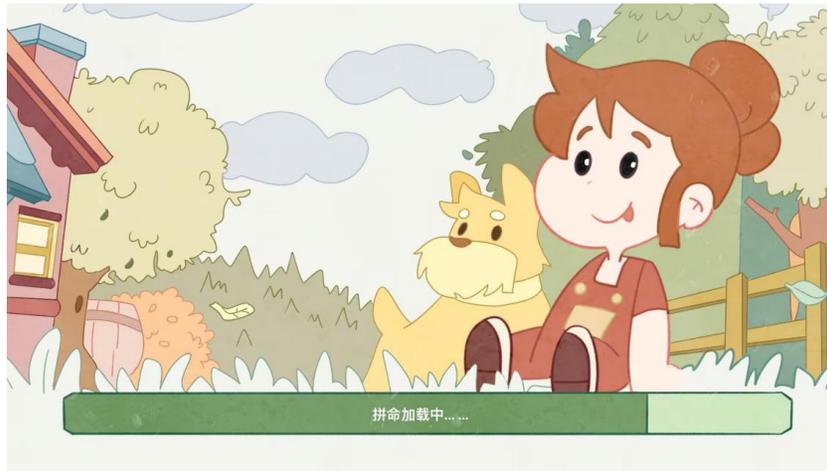


Figure 10. Prompts on the game loading screen

Auditory Interaction: Sound feedback is used to enhance operational effects and situational atmosphere. When players perform actions, different cards trigger corresponding sound effects. For example, using an irrigation card automatically plays the sound of flowing water, while using a pest control card plays the sound of spraying. Correct operations are accompanied by light and cheerful sound effects, whereas incorrect operations trigger warning sounds, helping players quickly determine the reasonableness of their actions through hearing. Additionally, each chapter map featuring different grain varieties is paired with exclusive background music to enhance players' sense of immersion in the scenario.

5.2. Visual effect design

The visual style centers on a hand-drawn watercolor illustration aesthetic, balancing a healing and soothing feel with clear knowledge presentation. This ensures that visual elements support the dissemination of educational content while reducing visual fatigue for players. A soft, natural color palette is employed, with each grain variety assigned its own dominant hue. This not only distinguishes the grain types through color but also creates a planting environment that closely resembles nature. In terms of graphic design, both card faces and map elements feature a hand-drawn texture, avoiding rigid vector graphics, as shown in **Figure 11**. For card illustrations, seed cards focus on cartoonish seed forms, while function cards highlight their operational scenarios. Players can quickly identify card types and functions through intuitive hand-drawn imagery, as exemplified by the rice card content in **Figure 12**.

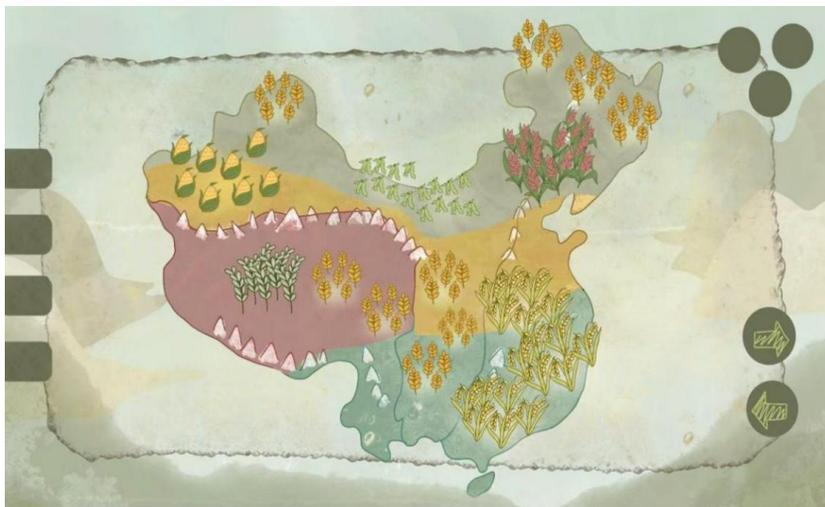


Figure 11. Map division corresponding to crop chapters



Figure 12. Rice card

5.3. Linked design between game scenarios and reality

The game scenario design draws inspiration from real-world grain production scenes, constructing a diverse scenario system that guides players to understand grain knowledge through simulated practice. Scenario feedback is utilized to reinforce knowledge retention. Additionally, a linkage system between game scenarios and reality is established from two dimensions: environmental adaptation and issue communication. This enables young players to intuitively perceive the profound connections between grain production, real-world environments, and agricultural issues during interactive gameplay.

Considering the core needs of combining educational value with entertainment in science games for young audiences, the scenarios are categorized into knowledge cognition scenarios and practical challenge scenarios. Knowledge cognition scenarios employ the main storyline as a vehicle, guiding players to make judgments and choices through narrative dialogues and scene interactions. Abstract grain knowledge is transformed into actionable game behaviors, helping players intuitively understand and remember key concepts. Practical challenge scenarios incorporate card battle elements, simulating real-world issues encountered in grain cultivation. Players are prompted to apply their acquired knowledge to overcome challenges. During battles, players may randomly encounter natural disasters such as floods, locusts, and droughts, requiring them to correctly utilize relevant knowledge and select appropriate cards to mitigate disaster damage to acceptable levels. Through task pressure and win-loss feedback, players are motivated to actively recall knowledge, achieving internalization and application of knowledge. Figure 13 illustrates the game interface during the onset of a natural disaster.



Figure 13. Disaster strikes

Linking Scenarios to Reality: By integrating game scenarios with dynamic weather data and real-world issues, the educational significance of the science popularization is enhanced. In terms of the dynamic weather system design, the weather in the battle maps is linked to real-world weather data. The system adjusts the probability of triggering in-game battle scenarios based on the actual weather conditions in the player's location. For instance, if a particular region experiences heavy rainfall in reality, the likelihood of triggering a flood scenario in the corresponding storyline for players in that area significantly increases. This design enables players to intuitively understand the real-world pattern of how climate affects grain production while facing challenges in game scenarios, thereby enhancing the game's sense of realism and making the scientific knowledge more relatable to daily life. Regarding the storyline branching design, the main storyline is deeply intertwined with real-world issues, featuring relevant branching choices centered around sustainable development. Taking the section on post-harvest handling in the corn chapter as an example, players are faced with a choice between traditional straw burning and returning straw to the fields. If players opt for traditional straw burning, they can immediately gain short-term resources, but subsequent chapters will trigger negative effects such as decreased soil fertility, affecting grain yield. Conversely, if players choose to return straw to the fields, although additional resources are required, subsequent chapters will unlock soil improvement cards, leading to a long-term increase in grain yield. Through the narrative feedback resulting from different choices, players can clearly recognize the close relationship between environmental protection and grain production, subtly conveying the concept of sustainable agriculture and helping players establish a correct understanding of agricultural development.

6. Conclusion

This paper addresses the current pain points in grain science popularization games for young people, such as the lack of meaningful value and the separation of science education from entertainment. Guided by situated cognition theory and combined with the characteristics of two-dimensional card games, it constructs an innovative science popularization model of "situational construction—task-driven—card interaction." Through the design of conveying knowledge via the main storyline, reinforcing application through card battles, and connecting scenarios to reality, it deeply integrates the logic of grain production with game mechanics. Simultaneously, it attracts young people's participation with a healing visual style and engaging interactions, and binds knowledge-driven mechanisms with real-world issues, enabling young people to systematically acquire grain knowledge and establish an understanding of food security and sustainable agriculture through gameplay.

This design not only provides a new and engaging pathway for the dissemination of grain science knowledge but also breaks down the barriers between virtual gaming and real-world agriculture, helping young people understand the complexity and importance of grain production. Looking ahead, the authors anticipate further refining the details of scenarios and deepening the knowledge content to offer more practically valuable references for the design of science popularization games for young people. The authors hope to drive science popularization games to truly achieve the goal of combining education with entertainment and contribute to cultivating a new generation with a strong awareness of food security.

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