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Designing a Health Education Card Game for Adolescents Based on Constructivist Learning Theory: A Case Study of "Night of Hospital"

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Abstract: This study explores the design of functional health science games from the perspective of constructivist learning theory, with a particular focus on card-based gameplay. Using antibiotic-resistant bacteria and phage therapy as thematic content, the research proposes three core design principles: interactive exploratory environments, progressively challenging yet controllable level structures, and trial-and-error-based learning. These principles are applied in the prototype game Night of Hospital. The study details the design process across three key dimensions—visual environment, level mechanics, and deck-building systems—and demonstrates how knowledge construction can be embedded within the game system. The findings provide a viable framework for enhancing both the educational impact and entertainment value of science communication games.

Keywords: Constructivist learning theory; Health science communication; Card game design

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1. Introduction

Currently, digital games are increasingly being applied in the field of education to meet more diverse teaching needs. Science communication games (also known as science-based serious games) are a genre of games centered on science communication or education. Positioned between "serious games" and "entertainment games," they aim to achieve educational outcomes while also emphasizing player engagement and immersion, thereby gaining widespread recognition [1–3].

Compared with traditional methods of health science communication, functional health science games offer three key advantages: stronger communicability, higher user engagement, and the ability to educate through entertainment. In an era where public concern for health is increasing, such games have gained growing attention and promotion across medical institutions, universities, relevant professional sectors, and enterprises.

In theoretical research, Jean Piaget is regarded as a leading figure of cognitive constructivism. He

emphasized that individuals actively construct knowledge within their cognitive structures through direct interaction with the environment [4–6]. Shalom Fisch, in his analysis of educational television programs such as Sesame Street and Arthur, proposed a cognitive capacity model that explains how viewers process the relationship between educational and entertainment content when engaging with edutainment media [7].

In terms of design practice, a number of well-regarded health science games have already been developed. Examples include Foldit (2008) [8], where players solve protein-folding puzzles to contribute to scientific research; ImmuneQuest (2013) [9], in which players embody immune cells to fight viruses and learn about the immune system.

However, there are some common problems in health science games today, such as the inability to balance functionality and entertainment, lack of immersion and experience, and insufficient motivation and driving force for players [10]. In order to improve these problems, some effective and appropriate design ideas and methods are urgently needed.

As a type of science game, health science games need to avoid being boring and "cramming" education, and enable players to actively and voluntarily participate in the research and exploration of knowledge during the game. Players' "initiative" is the key to making the dissemination of health science games more effective.

This study combines constructivist learning theory and positions players as active participants in knowledge construction rather than passive information receivers. Based on Piaget's cognitive development model, interactive exploration and visual feedback are used to support learners' self-exploration and construction. By integrating health knowledge into an interesting and structured card game model, players can explore, try, adapt, and learn in the context, which embodies the core principles of exploratory learning.

2. Design principles for integrating constructivist theory into health science card games

Jean Piaget's experiential learning model is a classic cognitive learning model, which believes that learners actively construct knowledge through interaction with the environment, and learning is a gradual and autonomous process based on exploration, operation, and reflection [4]. Based on this, this paper proposes three principles for the design of health science games, which are as follows.

2.1. Space is interactive and exploratory

There are interfaces that can be manipulated and explored in the game, giving players more opportunities to discover information through their own will, making the way to obtain this information more active, rather than letting players passively be instilled with relevant knowledge, which is boring, tedious, and difficult to gain cognitive and thinking interest.

Specifically, there should be an interface where players can voluntarily choose whether to read cards, achievements, stories, monster information, skill buffs, and equipment, so that players can check all their information at any time during the game. At the same time, different cards have different functions, and different functions correspond to different visual effects, so that players can explore what effects can be triggered by using different cards and better recognize, classify, and memorize the knowledge information carried by the cards.

2.2. The level design principle is to make it both challenging and controllable

Level design is the key to whether the game can be played, and the difficulty of the level needs to be varied and selectable.

For example, the level can be divided into three modes: easy, normal, and difficult. After completing the easy mode, the next level can be unlocked. For example, if the ability is restricted (such as the monster developing drug resistance and the damage reduced), the gain and currency reduction can stimulate the player's interest in continuing to challenge and try.

At the same time, the level also needs to follow the monster design idea from easy to difficult, so that players can choose their own card type according to the difficulty of the monster, and the game events that are more suitable for improving their own card modules, so that players can pass the level through their own understanding during the game, and have a deeper thinking about the knowledge.

2.3. Design principles guided by trial and error

As one of the most classic battle games, card games have a very rich deck combination and experimental space. Different decks mean different coping strategies. How to get the most powerful deck in the game is a very good experience.

Players constantly look for ways to stably pass monsters by looking for the best solution in different cards. In which a poor combination may lead to the failure of the battle.

However, in a whole game level, after failure, there will be a limited number of times to guide players to re-select a card or trigger a game event, so that players can get an adjustment opportunity to challenge again, and can get cognitive adjustments in the process of trial and error.

3. Design practice: Night of Hospital

This study uses drug-resistant bacteria and bacteriophages as cases and explores how to improve the benefits and effectiveness of health science games based on the design principles proposed in the second part.

3.1. Design background

Antibiotics are drugs used to prevent and treat bacterial infections. In the post-antibiotic era, new resistance mechanisms are emerging and spreading around the world, threatening humanity's ability to treat common infectious diseases.

3.1.1. Phage therapy

Phage therapy is an alternative to traditional antibiotics that uses bacteriophages (a virus that can infect and destroy specific bacteria) for targeted treatment to fight bacterial infections. First explored in the early 20th century, phage therapy has been revived with the rise of antibiotic-resistant "superbugs." Because it can act on a single bacterium, it has fewer side effects on other bacterial flora in the human body [11,12].

3.1.2. Proportions of antibiotic-resistant strains

In China, the most prevalent antibiotic-resistant bacteria include *Staphylococcus aureus*, *Klebsiella pneumoniae*, *Escherichia coli*, *Pseudomonas aeruginosa*, and *Acinetobacter baumannii*. Among these, Gram-negative bacteria account for approximately 71.1% of resistant strains, while Gram-positive bacteria represent about 28.9%.

3.2. Prototype design of Night of Hospital

3.2.1. Design concept and strategy

This study presents a prototype that integrates an aesthetically cohesive and information-rich exploratory

environment. The game world is designed to stimulate players' curiosity through interactive elements and investigative storytelling, encouraging voluntary information gathering and engagement. The gameplay mechanics are structured to allow repeated trial-and-error experiences, fostering reflection and adaptive learning.

By enhancing players' sense of agency and accomplishment during the knowledge acquisition process, the game aims to simultaneously fulfill its functional role in disseminating health science knowledge and provide an engaging entertainment experience.

The core design strategies are as follows:

(1) Environment and visual design

The overall visual style adopts a bold, vibrant, and minimalist flat design. Color is used not only to convey emotional information but also to clearly differentiate functional zones, allowing players to intuitively and actively choose which areas they wish to explore. Most environments are designed with clickable elements that lead to detailed views, encouraging user-driven investigation.

When players acquire story fragments, cards, or achievements, they can choose whether to view detailed text descriptions. Similarly, when players obtain buffs or event items during exploration, corresponding icons are displayed on the interface, allowing players to click and view them at any time, reinforcing agency and self-directed interaction.

In terms of character role, the player takes on the role of a scientific investigator exploring a long-abandoned hospital to uncover its hidden secrets. The narrative blends elements of reality with surreal fantasy to enhance the sense of mystery and player engagement.

Five types of bacteria—each associated with a typical color representation—are reimagined as monster-like entities, designed with distinct visual characteristics and embedded within different scenes of the game. This visual metaphor not only adds to the atmosphere but also stimulates players' curiosity to learn more about each pathogen.

(2) Level design

The level design integrates narrative progression, tiered unlocks, and multiple endings to create a structure that is both challenging and player-driven (see **Figure 1**). Difficulty levels are not imposed but selectable, allowing players to engage at their own pace.

Narrative serves as the core driver of progression: the player, acting as an investigator, begins their journey by entering the abandoned hospital. As the investigation deepens, they uncover fragments of the hidden truth, culminating in a complete storyline that ends with their escape.

Progressive unlocking encourages continued exploration: upon completing the game in easy mode, players unlock the normal mode for the second playthrough, and subsequently gain access to hard mode under the same logic.

Multiple endings encourage diverse decision-making: in the higher difficulty levels, players encounter a wider range of branching events and moral dilemmas. The different choices they make—such as acquiring certain items or responding to specific situations—will directly affect which ending they achieve.

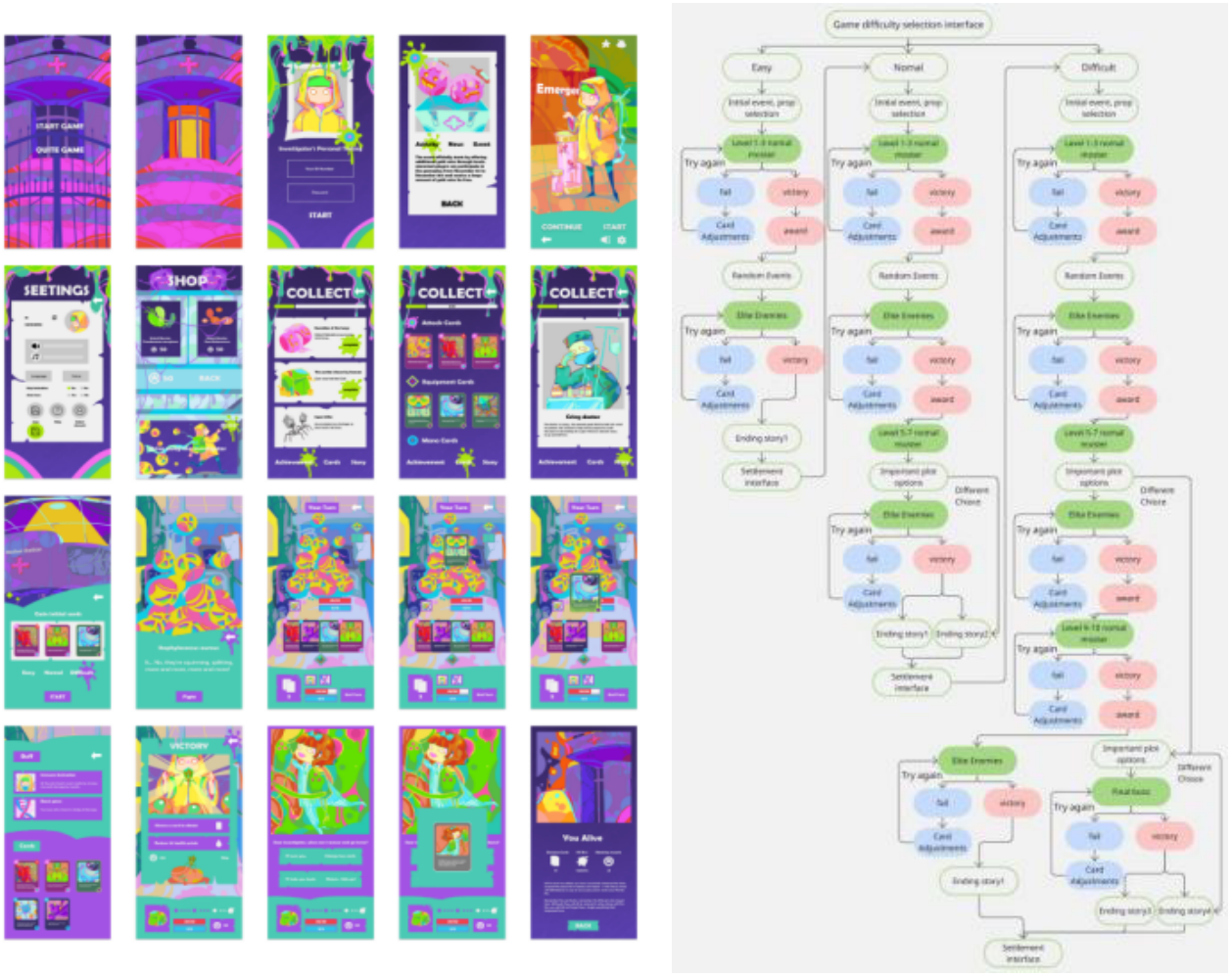

Figure 1. Game level and art design

(3) Deck-building design

As a card-based game, deck-building constitutes the core area where players engage in repeated experimentation. The design is informed by current mainstream approaches to combating antibiotic-resistant bacteria—namely, antibiotic therapy, phage therapy, and the human immune response. These three methods are translated into the game's primary deck types available to players.

Each deck represents a different knowledge framework and combat strategy. Combinations of different decks produce varied battle effects, which, when effectively integrated, support players in clearing levels successfully. Accordingly, the design links specific treatment approaches and bacterial mechanisms to distinct, coherent card sets.

Players are encouraged to experiment by combining cards across different decks to address various bacterial threats. This trial-and-error process enables players to reflect on and adjust their understanding of antimicrobial strategies and resistance mechanisms while playing, thus reinforcing educational outcomes through gameplay.

3.2.2. Game design

The game emphasizes an exploratory and informational design model. To support this, each interface includes clickable buttons that allow players to access detailed information at any time. For example, during battles,

players can freely check card details, active buffs, and equipped items. After completing a level, the game records the deck used for that playthrough, which players can revisit and analyze at any time.

Additionally, the game allows players to pause mid-play and temporarily return to the main menu. From there, they can enter auxiliary information interfaces to further explore story elements, card explanations, or character data. After acquiring additional knowledge or context, players can seamlessly resume gameplay from where they left off (see **Figure 2**).

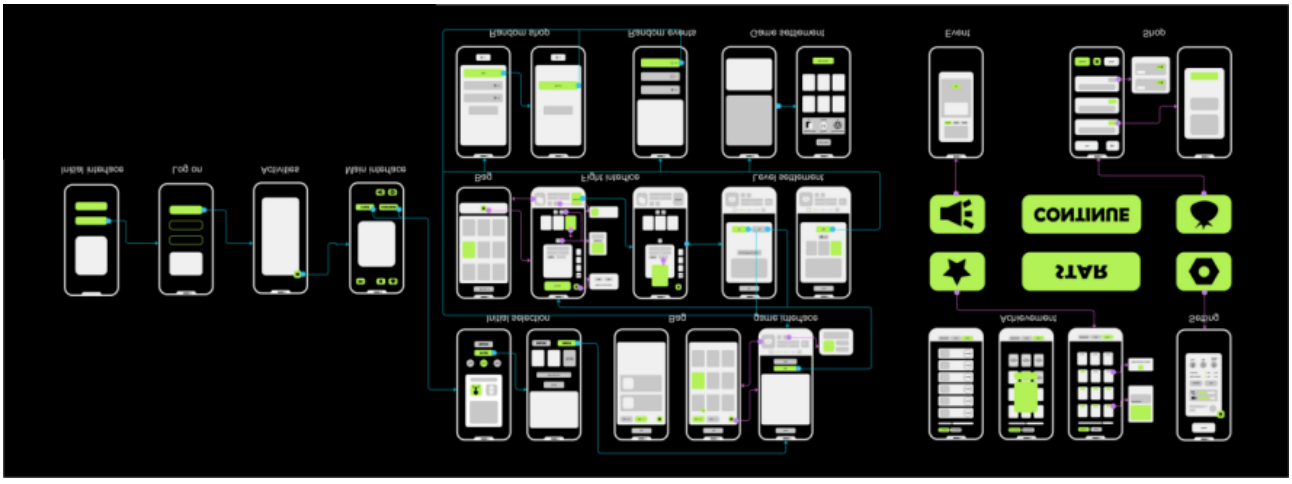

Figure 2. Game operation logic design

4. Conclusion and future directions

This study, grounded in constructivist learning theory, conducted an in-depth design investigation into the card game genre within health science games. Based on literature analysis and using antibiotic-resistant bacteria as a thematic case study, the research developed clear and actionable design strategies and pathways. Through specific design components—including visual environment design, level design, and deck-building design—the prototype game A Fantastic Night at the Hospital was created. This project demonstrates the feasibility and effectiveness of applying constructivist theory to the design of science communication games.

Future research will further explore the integration of constructivist principles with a broader range of game formats, with the aim of expanding the reach and impact of health science games across diverse audiences.

Disclosure statement

The author declares no conflict of interest.

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