Design of a Digital Educational Game for Self-management of Adolescents Living with HIV: Theory and Framework

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Abstract

Background: The self-management of adolescents living with HIV (ALHIV) plays a pivotal role in enhancing their health quality of life. However, the current self-management practices within this population are suboptimal. Therefore, it is imperative to reinforce HIV self-management education interventions. The advent of digital educational games presents an unparalleled opportunity for innovative educational methods.

Objective: This study designed a digital educational game for self-management of ALHIV, offering an effective educational approach to enhance their self-management skills and facilitate comprehension of HIV self-management practices.

Methods: The integrative framework for HIV self-management, empowerment theories, and the learning-game mechanics (LM-GM) model were used as theoretical framework to guide the design of the game system. Experts in diverse fields such as medicine, nursing, psychology, software engineering were consulted for guidance and comments to improve the design of the game.

Results: The digital educational game was named Cute Pet Butler. The framework of game system consists of five modules, including home page, shop and backpack, story, database, and background management modules. The core module is the story module where players are given tasks to help their pet to solve various HIV self-management problems.

Conclusions: The development and sharing of the multidisciplinary theoretical framework adopted by Cute Pet Butler can help us clarify the design ideas and assumptions of digital educational games, understand the ability of educational games to change HIV self-management knowledge, emotion and behaviors, and promote the development of effective educational tools of digital games.

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KEYWORDS

digital game, educational game, game design, HIV self-management, adolescents living with HIV, theoretical framework, game system framework

Introduction

Background

HIV is one of the incurable diseases known to affect humanity, and is still a major public health problem [1]. Fortunately, the advent of antiretroviral therapy (ART) and its availability has turned HIV from a life-threatening disease into a manageable chronic disease [2]. This has resulted an emergence of new challenges about long-term medication use, multi-morbidities, and psychosocial stress [3]. In the context of limited medical resources, it necessitates a shift from provider-centered healthcare to patient-centered self-management practices, especially focus on how patients could effectively manage their disease. For HIV self-management, active engagement and empowerment of adolescents living with HIV (ALHIV) is required, encompassing adopting measures to reducing the transmission of HIV, adhering to treatment regimen, maintaining a positive mindset, and developing collaborative relationships with health care professionals [4].

The practice of self-management plays a pivotal role in enhancing patients' health status and elevating their quality of life. However, the self-management behavior among ALHIV is suboptimal. Studies in the United States [5], South Korea [6], Ethiopia [7], and China [8] revealed that compared with developing countries, the self-management among people living with HIV was better in

developed countries, while the self-management behavior remained poor, especially among ALHIV. ALHIV who lack self-management behaviors may face a range of serious consequences, including deteriorated health conditions, increased HIV transmission risks, increased psychological issues, and compromised quality of life [9]. To improve the self-management behavior among ALHIV, it is necessary to enhance health education on HIV self-management and encourage active engagement in managing their disease.

With the development of technology, digital educational games have emerged as a widely used tool in improving self-management with many diseases[10]. It has the potential to enhance patient engagement by transforming self-management skills into interactive gaming activities, thereby creating a relaxed gaming environment for patients to acquire and master essential self-management skills [11]. This approach effectively promotes active self-management behaviors in patients [12]. Sarasmita et al. (2021) designed a digital educational game incorporating elements of asthma self-management and enhanced the self-management abilities of children with asthma in Indonesia [13]. Radhakrishnan et al. (2021) conducted a randomized controlled trial among elderly patients with heart failure, and demonstrated that digital educational games can effectively promote adherence to self-management behaviors such as weight monitoring and physical activity [14]. Nørlev et al. (2022) used a smartphone-based educational game for diabetic children to train self-management skills, and received positive feedback from both participants and their parents [15]. Most existing digital educational games for HIV are focused on prevention education [16], accepting medical services [17], and improving patient medication adherence [18]. While there remains a lack of digital educational game design targeting the self-management education needs of ALHIV.

Objectives

To address the need of HIV self-management health education, we developed a digital educational game called *Cute Pet Butler*, which aims to enhance self-management education for ALHIV. In this paper, we present the theoretical and game system framework of the game. This game endeavors to empower ALHIV by enhancing their understanding of HIV self-management strategies and offering a wide range of relevant resources and support. We aim to deliver accurate and reliable information that enables patients to make well-informed decisions and take appropriate actions towards maintaining optimal health.

Methods

Theoretical Framework

The game system of *Cute Pet Butler* was constructed by using the integrative framework for HIV self-management [19], empowerment theories [20], and the learning-game mechanics (LM-GM) model [21] as theoretical framework. The integrative framework for HIV self-management was served as a fundamental basis for educational content (i.e. the game themes and stories) in the game. The storyline design of this game was grounded in the theoretical framework of empowerment theories. The LM-GM model was served as a benchmark for the functional gameplay design. In the design process of *Cute Pet Butler*, we integrated the 3 theories into a theoretical framework of the system (Figure 1).

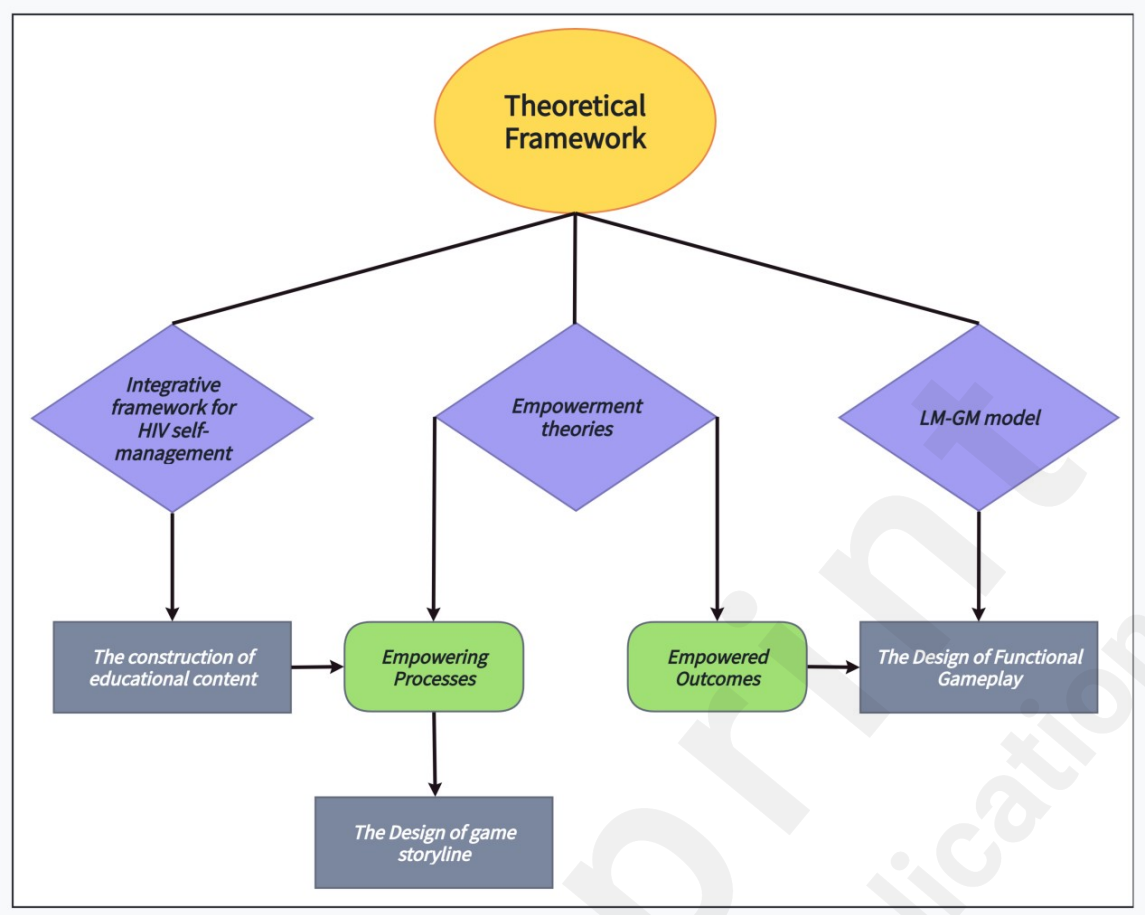
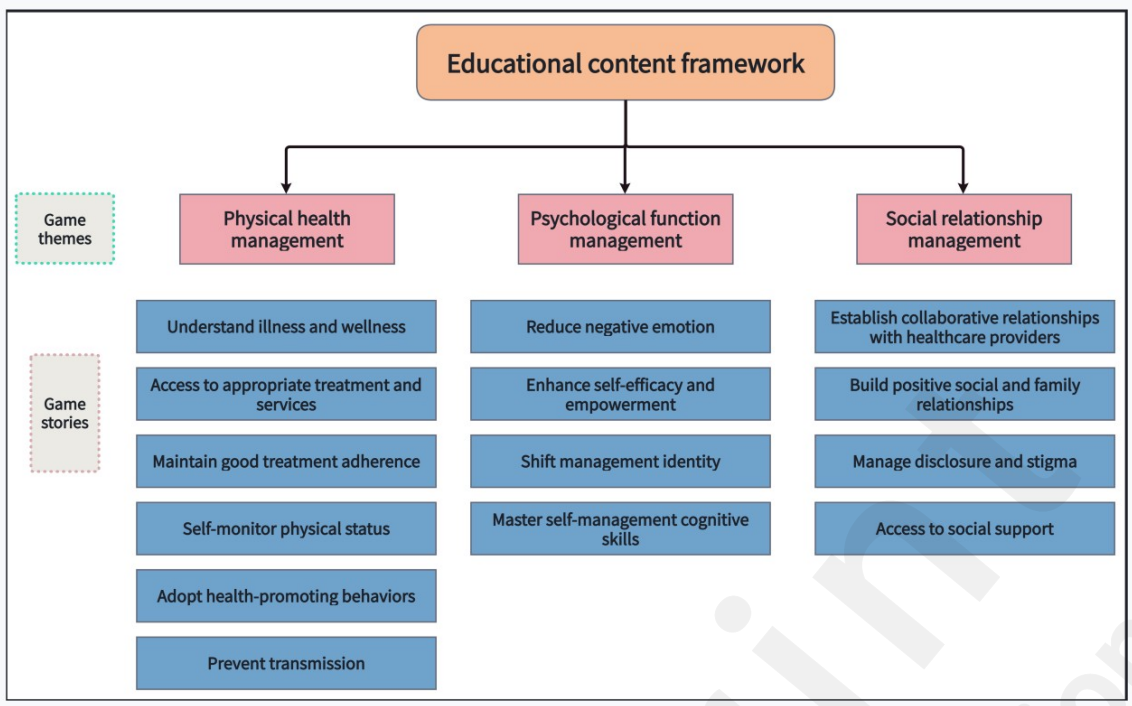


Figure 1. The theoretical framework.

Integrative Framework for HIV Self-management: The Construction of Educational Content.

Swendeman et al. (2009) proposed an integrated framework for HIV self-management that outlines 14 elements in three broad categories: physical health (6 elements); psychological functioning (4 elements); and social relationship (4 elements). According to the integrative framework for HIV self-management, we identified the educational content framework (i.e. game themes and stories) for self-management of ALHIV. The game themes are determined by three broad categories, and 14 game stories are created based on 14 elements. Figure 2 shows the overall educational content framework of the game.

Figure 2. The educational content framework



Empowerment Theory: The Design of Game Storyline

The connotation of empowerment theories encompasses two dimensions: empowerment processes and empowered outcomes. Empowering processes are those where people create or are given opportunities to control their own destiny and influence the decisions that affect their lives [22]. Empowering processes comprise a five-step approach: (1) explore the problem or issue; (2) clarify feelings and meaning; (3) develop a plan; (4) commit to action; and (5) experience and evaluate the plan [23][24]. Empowered outcomes are one consequence of empowering processes, including four components: (1) an emotional component referring to self-perceptions of one's competence in exerting influence in the sociopolitical domain; (2) a cognitive component referring to the skills and critical understandings necessary for exerting sociopolitical influence; (3) a behavioral component referring directly to the actions taken to exert influence; and (4) a relational component referring to the interpersonal interactions that form the foundation for successful empowerment [25].

The fundamental principles of empowerment theories are consistent with the objectives of HIV self-management education in this study, namely facilitating patients in clarifying their responsibilities for HIV self-management, fostering intrinsic motivation, and unleashing the potential for behavioral transformation. We developed the storyline of the game based on the five-step of the empowerment processes (Table 1). Additionally, we sought guidance and input from experts in diverse fields such as medicine, psychology, software engineering, to enhance and refine our game narratives.

Table 1. The combination of theory and game storyline design

Empowerment processes	Storyline
step Ⅰ: explore the problem or issue	In the narrative presented by the game system, the game character will encounter challenges related to HIV self-management.
step Ⅱ: clarify	The game character articulates the feelings about the

feelings and meaning	challenges of self-management based on the authentic experiences of ALHIV.
step Ⅲ: develop a plan	The game system releases specific game tasks for the player to complete within the narrative, which involves assisting the game character in resolving HIV self-management problems.
step Ⅳ: commit to action	The game system provides prompts to guide players in assisting the game character in problem-solving, while the player accomplishes story-based tasks through manipulation of game controls.
step Ⅴ: experience and evaluate the plan	If the player successfully accomplishes the game task, the system provides positive feedback; But if the player fails to complete it, negative feedback is given by the system.

LM-GM Framework: The Design of Functionality and Gameplay

The LM-GM model, proposed by Lim et al. (2013), serves as a valuable tool for guiding the design of educational games [26]. By integrating learning mechanisms with game mechanics, this model effectively addresses the issue of mismatch between game elements and educational objectives during the game design process, making game mechanics applicable to a wide range of educational scenarios [27]. The proper combination of these mechanisms can be used in developing functional educational games across various themes such as classical laboratory classes, teaching science, humanities and arts.

According to the four components of empowerment outcomes described above, we developed educational objectives for HIV self-management, converted these objectives to learning mechanics, and linked the learning mechanics with game mechanics through the LM-GM model. Furthermore, we integrated the game mechanics into functional gameplay design (Table 2). The functionality and gameplay design were revised and improved with the guidance of experts, leading to the formation of the final design scheme.

Table 2. The combination of theory and functional gameplay design

Empowerment outcomes	Educational objectives	learning mechanics (LM)	Game mechanics (GM)	Functional gameplay
Emotional component	Enhance self-efficacy and perceived control, and bolster motivation for HIV self-management.	Participation Feedback Motivation Responsibility Incentive	Behavioural Momentum Feedback Vitality Status Rewards/Penalties	The game character will exhibit diverse reactions based on the completion of the game task, the player will also receive corresponding rewards or penalties.
Cognitive component	Increase knowledge and comprehension of HIV self-management	Experimentation Question & Answer Instructional Incentive	Appointment Question & Answer Resource management Rewards	The game provides HIV self-management education materials, and players can earn rewards by engaging with educational content.
Behavioral component	Practice HIV self-management behaviors	Experimentation Repetition Action/Task	Role Play Cut Scenes/Story Appointment	The player's self-management behavior is continuously reinforced through the implementation of game tasks.
Relational component	Cultivate strong interpersonal connections and enhance social adaptability.	Guidance Action/Task Experimentation Incentive	Tutorial Cut Scenes/Story Cooperation Interaction	The game incorporates dedicated stories and tasks designed for social relationships, and there are plans to introduce player interactive gameplay in the future to enhance the game's social functionalities.

Results

Game System Framework

The game revolves around a pet infected with an incurable virus that causes its energy to be continuously drained (Figure 3). The indelible virus is a metaphor for HIV, and the pet is a metaphor for ALHIV. Players are tasked with assisting the pet in managing daily challenges related to HIV self-management, completing objectives to acquire energy and replenish the pet's energy levels. The pet will exhibit varying reactions and granting corresponding rewards or penalties Depending on the player's task completion.

Figure 3. The game of *Cute Pet Butler*

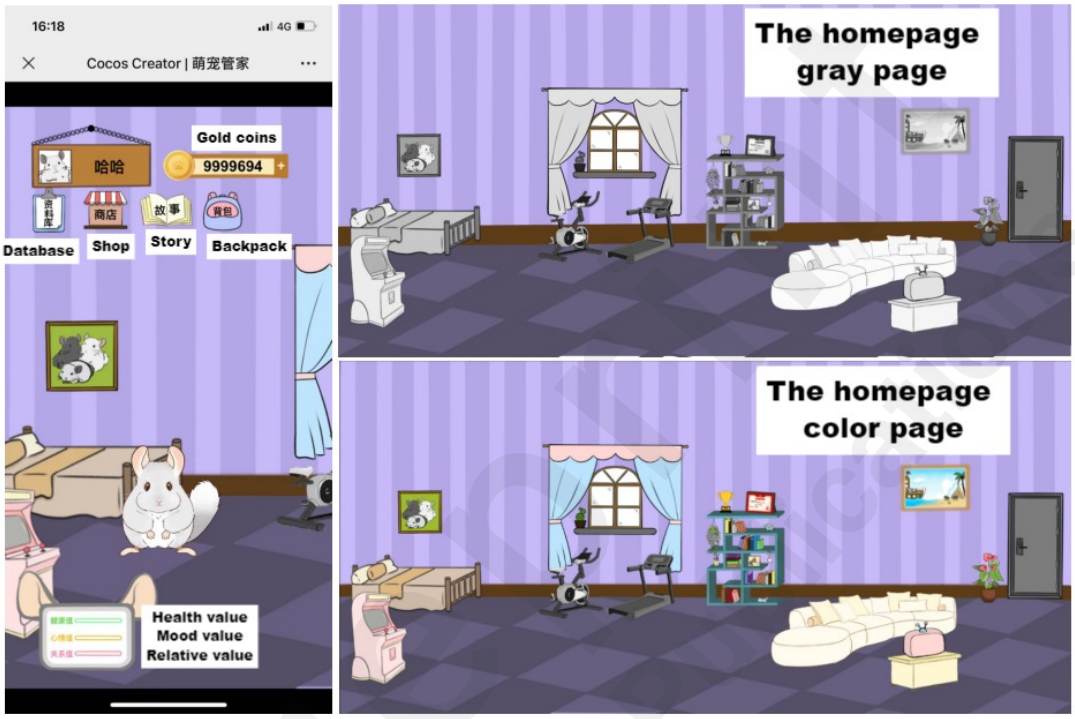
The game system framework of *Cute Pet Butler* consists of five modules: home page module; shop and backpack module story module; database module; and background management module. The game can be accessed by players through their mobile phones, tablets, or computers by clicking on the network link or scanning the QR code. No registration is required, and it is free to play.

Home Page Module

The initial interface of this module is gray, and all of the game items are initially inaccessible. Players can acquire gold by completing tasks, then unlock various game items in the shop to decorate their room, and use these items to interact with their pet. This module also displays the player's current gold balance as well as the pet's current health, mood, and relationship values. Health value: Players unlock and complete themed stories about physical health management, making the pet run and riding a shared bike to improve this value; Mood value: Players unlock and

complete themed stories about psychological function management, shopping in the store module and using game items in the backpack module to improve this value; Relationship value: Players unlock and complete themed stories about social relationship management and interact with pet to improve this value. Additionally, players can access other modules through this interface (Figure 4).

Figure 4. Interface diagram of home page module



Shop and Backpack Module

Players can use gold coins to purchase and unlock items in the shop module. The acquired items will be stored in the backpack module, while the unlocked ones will appear in vibrant colors on the home page. Players can interact with their pet using both the backpack and home page items. The shop offers a range of categories including food, beverages, and home goods. Food and drink fall under disposable consumables that are kept in the backpack, whereas home goods are permanently accessible on the main page after purchase. Figure 5 showcases both the shop and backpack interfaces.

Figure 5. Interface diagram of store and backpack module

Story Module

This module comprises of three themes and 14 stories. Players can earn gold rewards by completing game tasks within the stories, and a deduction will be given if the task is unsuccessful. At the conclusion of each story, players have the option to navigate to the corresponding educational content in the database module through an interface. Unlocking the subsequent story is contingent upon successful completion of the previous game task, while unlocking a new theme requires completion of all story tasks within the given theme. Figure 6 illustrates the interface for the story module.

Figure 6. Interface diagram of story module

Database Module

The learning materials in this module were determined by the HIV self-management education content, encompassing with text, images, videos, and other digital resources. A total of 42 educational resources are available for editing, adding, or deleting through the background management module. Upon successfully completing a game task within the story module, players will unlock subsequent story along with the corresponding learning materials in this module. By viewing the learning materials in this module, players can earn gold coins. The details of the database module are illustrated in Figure 7.

Figure 7. Interface diagram of database module

Background Management Module

This module is for the administrator and can be accessed through a web page link to login the account. The module encompasses user management, story management, and database management. The function of user management is to collect player data such as online time, module duration, and game task completion. The story management is for modification of the current stories and continuous updating of new game narratives. The database management is to enable modification of the existing content of database module.

Discussion

Principal Findings

ALHIV are the target population of *Cute Pet Butler*, and we hope to improve their self-management behavior through game education. Empowerment is an effective method to facilitate and support patients in actively engaging in self-management of their diseases, which can stimulate patients' awareness of disease management, enhance capacity to control their health, and facilitate adaptation to their disease[28]. The theories of empowerment have been extensively used in self-management interventions for various chronic diseases, and the health education based on empowerment strategies have gained widespread recognition[29][30][31][32]. In the game of *Cute Pet Butler*, empowerment theories guided the game storyline design and provided the educational objectives. The immersive and mapping gaming experience could stimulate players' self-management consciousness and sense of responsibility, facilitate their comprehension and mastery of self-management knowledge and skills, as well as repeatedly train them in daily self-management behaviors to enhance their overall self-management proficiency.

The crucial of developing educational game is to effectively transfer theoretical principles into game design elements. In the game design of *Cute Pet Butler*, the educational content and story themes are determined by the integrative framework for HIV self-management, while the plot of each story is crafted in accordance with the five-step approach of empowerment processes. This ensures that players are provided with an immersive and practical learning scene of HIV self-management [33]. The story module of *Cute Pet Butler* clearly showcases the current self-management problems faced by the game pet, portraying the pet's responses to those problems to evoke empathy from players. This module provides players with tasks aimed at assisting the pet solve HIV self-management problems, guides them complete these tasks, and gives timely feedback. It is hoped that such game tasks could help cultivate the self-management behavior of ALHIV. The amalgamation of authentic identity and virtual identity can give rise to a "projected identity" [34]. When engaging in gameplay, players construct a projected identity by assuming a virtual role. In essence, they are no longer mechanically executing predetermined game scripts but rather exploring the virtual world with an alternative persona, possessing individual goals and thoughts. This allows for introspection through their virtual identity and provides ample opportunities to acquire knowledge from diverse perspectives.

In the design of educational games, it is essential to strike a balance between the educational and gameplay [35]. In this study, the LM-GM model solves the problem of mismatch between game elements and educational goals in the game design process by linking learning mechanics to game mechanics. To stimulate players' interest in learning about HIV self-management, the game designed interaction, rewards/penalties, feedback and other mechanisms, and through the shop purchase, gold collection, decorate the home page, pet reaction and other forms to achieve. In addition, the game provides visual and auditory feedback, not only as a reminder of the player's operating system, but also as an evaluation of the correct and incorrect results of the player's choices in the game, which helps to enhance the player's

attention. The repetition of information is an effective method for enhancing memory [36]. Therefore, in the game of *Cute Pet Butler*, repeatable stories and tasks help players to deepen the impression and enhance the awareness of HIV self-management.

The game type in this study is designed as a pet-raising simulation, with the aim of providing players with a sense of healing, stress relief, and overall happiness. Compared to the exhilaration brought by action games and the sense of accomplishment offered by role-playing games, pet-raising games provide players with a greater sense of relaxation and enjoyment. Additionally, fostering a bond between pets and players could contributes to enhancing user engagement. In the game of *Cute Pet Butler*, the player helps the pet to solve the problem of HIV self-management with a third perspective and switching from "parties" to "bystanders", which could help players to correctly and objectively treat HIV self-management problems, reduce resistance.

In terms of visual effects and user interface, the game design of this study places particular emphasis on the artistic quality and presentation of game images. By employing warm, friendly, and inviting visual effects along with an emotionally engaging atmosphere, players can experience tranquility and comfort. This effectively alleviates inner pressure, anxiety or sorrow while promoting healing and relaxation. The selection of UI interface types also adheres to a unified overall tone and color balance to align with players' psychology and guide their interactions.

A database module to the game was developed, which could provide a variety of materials to players, to provide systematic and comprehensive guide to HIV self-management. We hope that this could help to standardize their self-management behaviors. With the help of information technology, it is beneficial to obtain the specific usage of players, and timely modify and supplement the content of ALHIV self-management education in the game.

Limitations

There are some limitations in this study. The immersion and playability of the digital game designed in this study may make some young or low-self-control players addicted to it. However, this problem may be solved by limiting the length of usage time [37]. In addition, the game is unsuitable for people living with HIV who are unable to utilize electronic devices, particularly older individuals. Future empirical studies are necessary to validate the effectiveness of the game, understand user reviews, and identify more suitable populations for use.

Conclusions

The use of the digital game in health education for HIV self-management may address the issue of inadequate self-management among ALHIV. Based on the solid educational content, rich teaching resources, virtual game scenarios, complete story

plots, and interactive functions, the game realizes the visualization of HIV self-management health education, which can stimulate the self-management motivation of players, enhance their self-management behaviors, and improve the educational effect. In future practice, to enhance the self-management level of ALHIV, it is necessary to further perfect and promote its use for HIV self-management education of *Cute Pet Butler*.

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Authors' Contributions

The concept was developed by MT; the methodology by JT, YHC, WW, and LSX; and the design by MT, WW, LSX, JT, and YHC. The original draft preparation (writing) was performed by YL, ML, JLR, and JT; review and editing (writing) by MT, WW, LSX, JT, and YHC; project administration by MT and YHC; and funding acquisition by JT. YHC and JT have contributed equally to this work and share first authorship.

Conflicts of Interest

None declared.

Abbreviations

HIV: Human Immunodeficiency Virus

ART: antiretroviral therapy

ALHIV: adolescents living with HIV

LM-GM: learning-game mechanics

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