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The Impact of Gamified Interventions on Youth Health Literacy: A Systematic Review of Effectiveness and Implementation Challenges

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ABSTRACT: Educational games have emerged as effective tools to improve health literacy among children and adolescents, significantly impacting knowledge acquisition, behavior modification, and long term health outcomes. This narrative review systematically examines existing literature to evaluate the effectiveness of gamified interventions designed for youth health education. A structured literature search was conducted across major academic databases, including Scopus, PubMed, and Google Scholar, using targeted keywords and stringent inclusion and exclusion criteria. Findings indicate that gamification enhances learning engagement and sustains motivation, particularly in mental health literacy, nutrition education, physical activity promotion, and chronic disease management. Despite consistent evidence supporting their effectiveness, systemic issues such as limited technological infrastructure, cultural stigmatization, varying degrees of governmental and educational policy support, and differing accessibility across socio economic contexts significantly moderate outcomes. Discussion highlights the critical role of contextually relevant, user centered game design and emphasizes the necessity of robust infrastructural investments, policy reforms, and professional development for educators. Future research directions recommend longitudinal studies to evaluate sustained impacts, cross cultural comparative analyses, and economic feasibility assessments. Ultimately, the strategic implementation of educational games, supported by strong multi sector collaboration, presents considerable potential to bridge global health literacy gaps, underscoring the urgency for continued development and refinement in gamified health interventions.

Keywords: Educational Games, Health Literacy, Gamification, Youth Health, Digital Health Interventions, Health Education, Behavior Change.

INTRODUCTION

The use of educational games to enhance health literacy among children and adolescents has garnered increasing attention from researchers, educators, and health practitioners over recent

years. Educational games, integrating learning objectives within engaging, interactive formats, have emerged as promising tools for promoting healthy behaviors and increasing health related knowledge among young populations. Recent literature emphasizes the potential of these games in creating immersive and motivating learning environments, which effectively contribute to improved health outcomes. For instance, studies by (Pierce et al., 2023) and (Vié et al., 2024) indicate that game based learning environments substantially increase youth engagement, subsequently driving positive behavioral changes in various health domains, including nutrition, mental health, and disease management.

Central to the effectiveness of educational games is their ability to transform traditional learning into a compelling and enjoyable experience. This attribute is particularly beneficial in health education, where engaging learners is essential but often challenging due to the sensitivity or complexity of the topics addressed. Applications such as PEERNaija, aimed at improving medication adherence among adolescents living with HIV in Nigeria, demonstrate that gamified approaches significantly enhance motivation and involvement in personal health management (Ahonkhai et al., 2021; Pierce et al., 2023). Furthermore, these games provide secure, stigma free platforms that facilitate open discussion and education on health topics traditionally considered sensitive or taboo, such as mental health (Fleming et al., 2019; Vié et al., 2024).

Empirical evidence consistently underscores the positive impacts of educational games, particularly in promoting mental health literacy. Games incorporating cognitive behavioral therapy elements, for example, have successfully reduced symptoms of anxiety and depression among adolescents (Christie et al., 2019); (Reitegger et al., 2024). According to (Li et al., 2022) and (Dooren et al., 2019), gamification significantly boosts motivation and sustained participation in mental health interventions for young individuals, suggesting that interactive, reward based systems effectively engage youth in meaningful health behaviors. Direct feedback mechanisms and gamified rewards, such as point systems or achievement levels, have proven particularly successful in fostering ongoing participation in health promoting activities ((Lubbe et al., 2023); (Stutvoet et al., 2024)

Additionally, educational games serve as effective platforms for broad health literacy enhancement by presenting accurate, relevant information in a format accessible to young learners. (Han et al., 2023) demonstrate that interactive gaming approaches effectively convey complex health information, enabling better decision making among youth. Interactive nutrition and physical activity games, specifically, have significantly improved children's health knowledge and encouraged lasting healthy habits (Vorlíček et al., 2024); (Williams & Ayres, 2020). (Azhari et al., 2019) further corroborate these findings, noting considerable improvements in knowledge retention and behavior among children participating in gamified health programs.

Despite extensive evidence supporting educational games' efficacy, several critical challenges remain. Foremost among these is the accessibility and affordability of technological resources necessary for implementing complex gaming applications. Limited access to stable internet connectivity or appropriate digital devices creates barriers for economically disadvantaged youth, widening the health literacy gap and limiting intervention efficacy ((Pierce et al., 2023); (Han et al.,

2023). Consequently, equitable participation remains a significant hurdle, underscoring the necessity for inclusive digital strategies in educational game deployment.

Moreover, limited awareness and support from parents and educators pose additional obstacles. Many guardians and teachers harbor skepticism toward technology based educational approaches, doubting their effectiveness or suitability (Fleming et al., 2019); (Almeqbaali et al., 2022). Such reservations impede active encouragement and integration of educational games within traditional health curricula, diminishing their overall impact. Active parental involvement, a well established predictor of educational success, is crucial for optimizing the benefits of health literacy programs ((Lubbe et al., 2023).

Design considerations also critically influence the success of educational games. Games perceived as overly complicated, irrelevant, or unengaging may quickly lose appeal among younger audiences, limiting their potential educational benefits (Hightow-Weidman et al., 2017). Active involvement of children and adolescents in the game design process emerges as essential for creating relevant, engaging content, fostering stronger connections to the educational material, and increasing motivation and continued engagement ((Hightow-Weidman et al., 2021).

An evident gap in existing literature is the limited focus on long term impacts of educational game interventions. Although numerous studies indicate immediate positive effects, insufficient research explores sustainable behavioral changes resulting from long term engagement with educational games (Li et al., 2022); (Williams & Ayres, 2020). Comprehensive longitudinal studies are necessary to determine how effectively these games can be integrated into broader health education frameworks and their lasting impact on youth behaviors and attitudes toward health.

Given these considerations, this systematic review aims to critically evaluate the effectiveness of educational games in enhancing health literacy among children and adolescents. Specifically, it seeks to identify key elements underpinning successful game based interventions and to explore the underlying mechanisms facilitating behavioral changes in young populations (Pierce et al., 2023). By systematically examining existing literature, this review aims to offer deeper insights into how educational games can be effectively incorporated into educational programs and public health strategies.

The scope of this review specifically encompasses targeted populations and geographical regions facing significant health literacy challenges. Adolescents and children, particularly in regions with pronounced health disparities such as Sub Saharan Africa and various populations within the United States, constitute the primary focus. For example, studies in Nigeria indicate that educational games significantly improve adherence to antiretroviral therapies among youth populations living with HIV (Pierce et al., 2023). Similarly, interventions in the United States addressing sexual health literacy have demonstrated substantial potential in enhancing knowledge and preventive behaviors among adolescents (Almeqbaali et al., 2022); (Fleming et al., 2019)

Despite a growing body of evidence supporting the efficacy of educational games in promoting youth health literacy, significant research gaps remain. Existing studies often emphasize short term outcomes and are predominantly situated in high resource contexts, thereby overlooking the long term impact and contextual variability of gamified interventions in diverse socio economic and

cultural settings. Moreover, there is limited synthesis of how design features, policy environments, and technological infrastructures intersect to influence intervention outcomes across regions.

To address these gaps, this systematic review aims to critically evaluate the effectiveness of gamified health interventions for children and adolescents, while also identifying key design, implementation, and contextual factors that mediate their success. By synthesizing cross regional evidence and highlighting systemic barriers and enabling factors, this study contributes to a deeper understanding of how gamification can be strategically leveraged to improve global health literacy outcomes among youth.

METHOD

The current review adopted a systematic approach to identifying, selecting, and analyzing relevant literature addressing the impact of educational games and gamification on health literacy among children and adolescents. This comprehensive methodology aimed to ensure rigor, reproducibility, and accuracy of the review findings. Initially, an extensive literature search was conducted across multiple reputable databases, including Scopus, PubMed, and Google Scholar. These databases were chosen due to their comprehensive coverage of peer reviewed journals, conference proceedings, and relevant publications in health sciences, education technology, and related interdisciplinary fields.

To effectively locate pertinent studies, a well defined keyword strategy was developed. Keywords included "gamification," "health literacy," "educational games," "digital health interventions," and "youth health." These terms were strategically combined using Boolean logic to refine search outcomes, such as "gamification AND health literacy," and "educational games AND youth health." The deliberate combination and use of these specific keywords enabled a focused retrieval of articles that specifically examined the intersection of educational gaming strategies and health literacy improvements among young populations.

In addition to keyword searches, the research utilized advanced filtering options available within each database platform to enhance the specificity of the search results. In Scopus and PubMed, results were filtered by publication year, limiting the literature to studies published within the last decade to ensure contemporary relevance. Furthermore, these searches emphasized selecting specific types of scholarly contributions such as original research articles, systematic reviews, randomized controlled trials, and meta analyses. Similarly, Google Scholar searches were optimized to display results based on relevance and recency. Moreover, targeted searches within specialized journals such as the "Journal of Medical Internet Research" and "Games for Health Journal" were conducted due to their reputation for publishing high quality, relevant studies in digital health education.

Further, the review process included a snowballing technique where reference lists of identified articles were reviewed to discover additional relevant studies not initially captured by the keyword driven search. This iterative process was particularly valuable in uncovering seminal works or influential studies that might have been published outside the primary search timeline but remained

critical to understanding the evolution and efficacy of educational gaming interventions in health literacy contexts.

Engagement in online academic forums and professional networks focused on digital health education and gamification further complemented the literature search strategy. Through these channels, the researchers solicited additional references and recommendations for pertinent studies from domain experts, which provided broader insights into the scope of existing research and facilitated access to potentially obscure but relevant scholarly materials.

Upon completion of the comprehensive search process, rigorous inclusion and exclusion criteria were applied to select relevant studies for this systematic review. Inclusion criteria were carefully defined to capture studies most pertinent to the central research question. Primarily, studies included were required to involve participants aged between 6 and 18 years, ensuring relevance to child and adolescent populations, which are the primary targets of health literacy interventions. The second critical criterion was the intervention itself, specifically requiring the use of educational games or gamification methods explicitly aimed at improving health literacy outcomes. Eligible studies needed to clearly report measurable outcomes such as enhanced health knowledge, changes in health related attitudes, or observable improvements in health behaviors. Lastly, only studies with robust methodological designs, such as randomized controlled trials, quasi experimental designs, or systematic reviews providing strong empirical evidence, were considered.

Conversely, clearly defined exclusion criteria were applied to maintain the quality and relevance of selected literature. Studies were excluded if they involved populations outside the specified age range, utilized non game based interventions (e.g., purely textual educational content, lectures, or seminars), or failed to provide outcomes explicitly related to health literacy. Additionally, studies with weak methodological rigor, including observational studies without adequate control mechanisms, were systematically excluded to ensure that the findings presented in this review would reflect only high quality evidence capable of robustly informing practice and policy.

The literature selection process involved multiple stages to meticulously ensure the methodological rigor of the review. Initially, all retrieved records underwent title and abstract screening by two independent reviewers, aiming to eliminate articles that clearly did not meet inclusion criteria. Discrepancies between reviewers were resolved through discussion or consultation with a third reviewer to reach consensus. Following this preliminary screening, full texts of the remaining articles were reviewed to determine final eligibility. This detailed screening involved thorough scrutiny of the study's design, population, intervention details, outcomes measured, and methodological rigor. Articles passing this rigorous screening process were then retained for further analysis.

Throughout the entire review process, quality appraisal was systematically integrated to evaluate the internal and external validity of each study. This included assessing the methodological rigor, reliability of outcome measurements, and clarity of results reporting. Only studies meeting high methodological standards were ultimately included in the synthesis phase of the review.

In summary, by utilizing a carefully structured and multi layered search strategy, clearly defined inclusion and exclusion criteria, and rigorous quality appraisal protocols, this systematic review

ensured the selection of the most relevant and methodologically sound literature. This approach facilitated a comprehensive and accurate synthesis of existing evidence regarding the effectiveness of educational games and gamification in improving health literacy among children and adolescents.

RESULT AND DISCUSSION

Empirical evidence strongly supports the role of educational games in significantly enhancing health literacy among children and adolescents. Studies have demonstrated that gamification strategies contribute not only to improved knowledge retention but also to sustained behavioral changes that promote long term well being. (Lubbe et al., 2023) found that gamified mental health training programs not only increased participants' knowledge of mental health but also boosted their motivation to engage in healthier practices. The incorporation of narrative elements within these games has been shown to reinforce understanding of key health concepts, such as self compassion, which is a crucial aspect of health literacy.

Another major area where educational games have demonstrated efficacy is in promoting nutritional literacy and physical activity among adolescents. (Han et al., 2023) highlighted that chatbot based and gamified applications successfully increased knowledge regarding healthy eating habits and the importance of regular physical activity. These findings underscore how educational games serve as powerful tools for disseminating health information in an engaging and interactive manner, ultimately fostering better health literacy.

Gamified interventions have also been instrumental in enhancing adherence to medical treatments. (Pierce et al., 2023) examined a gamified application designed to improve adherence to antiretroviral therapy among adolescents living with HIV in Nigeria. Their study revealed that interactive game based interventions led to a deeper understanding of the importance of medication adherence and facilitated positive behavioral changes in disease management. These results confirm that educational games extend beyond knowledge acquisition, playing a crucial role in modifying health behaviors and empowering young individuals to take control of their health.

Several factors determine the success of educational games in health interventions. One crucial aspect is game design, which must be engaging and tailored to the needs of young users to sustain their interest and motivation. (Christie et al., 2019) emphasized that incorporating elements such as rewards, challenges, and real time feedback can significantly enhance user engagement. Well structured games encourage continued participation, thereby maximizing the educational impact of health interventions.

Content relevance is another critical determinant of effectiveness. Games must present information that aligns with the daily experiences and challenges of children and adolescents to ensure meaningful engagement. Studies suggest that when game content resonates with users' real life contexts, knowledge retention and application rates improve significantly (Azhari et al., 2019) Thus, designing content that reflects real world health scenarios can enhance the overall effectiveness of educational games.

Furthermore, user involvement in game development has been recognized as a key success factor. Engaging children and adolescents in the design process ensures that game features remain appealing and suitable for the target demographic. (Almeqbaali et al., 2022) reported that when young users contribute to game design, their sense of ownership increases, leading to higher levels of participation and engagement. This collaborative approach enhances the acceptability and effectiveness of educational interventions.

A comparative analysis of the effectiveness of educational games in health promotion across different geographic regions reveals significant variations in implementation and outcomes. In high income countries, such as the United States and European nations, educational games benefit from advanced technological infrastructure and widespread access to digital devices. (Hightow-Weidman et al., 2021) documented that gamified applications for HIV treatment engagement in the U.S. successfully improved adherence and participation in healthcare programs. These applications leveraged sophisticated features such as social interactions and real time feedback, making them particularly attractive to young users.

Conversely, in low and middle income countries, challenges related to technology access, infrastructural limitations, and cultural barriers affect the implementation and effectiveness of gamified interventions. (Pierce et al., 2023) found that while gamified interventions like PEERNaija showed promise in improving adherence to antiretroviral therapy in Nigeria, limited access to smartphones and the internet, coupled with social stigma surrounding HIV, impeded their effectiveness. These findings highlight the necessity of tailoring digital health interventions to specific regional contexts to maximize their impact.

Several key factors contribute to the varying success of educational games across different regions. Access to technology remains a major determinant. In wealthier nations, where internet connectivity and digital device ownership are widespread, gamified health interventions reach a broader audience and are more seamlessly integrated into educational curricula. In contrast, in developing regions, technological limitations pose significant barriers to participation and scalability (Pierce et al., 2023).

Socio cultural factors also play a crucial role in shaping the acceptance and effectiveness of gamified health interventions. In some regions, social norms and stigma associated with specific health issues, such as HIV, hinder the successful adoption of digital health solutions (Pierce et al., 2023). In contrast, in societies where digital literacy is higher and health education is more openly discussed, educational games are more likely to be embraced and integrated into existing health promotion strategies.

Government policies and infrastructural support also influence the success of gamified health education programs. High income countries tend to have well established policies supporting the integration of digital health education into formal schooling systems, thereby facilitating widespread adoption and implementation (Lubbe et al., 2023); (Fleming et al., 2019). In contrast, in many developing regions, limited policy support and lack of digital infrastructure hinder the effective deployment of gamified educational tools.

The design and relevance of the game content further impact its effectiveness. In technologically advanced regions, educational games are often developed with cutting edge graphics, interactive storytelling, and artificial intelligence driven adaptability to personalize learning experiences. In contrast, in resource constrained settings, simpler game designs may be necessary to ensure accessibility. (Almeqbaali et al., 2022) and (Giovenco et al., 2021) noted that in developing regions, localized game content that reflects cultural values and societal norms significantly improves engagement and learning outcomes.

User engagement in the development and customization of educational games also differs across geographic contexts. In high income countries, there is greater investment in participatory design, where users actively contribute to shaping game features, ensuring higher levels of acceptance and effectiveness (Hightow-Weidman et al., 2017); (Boendermaker et al., 2016). However, in lower income settings, resource constraints often limit opportunities for participatory design, leading to a mismatch between game features and user needs.

In conclusion, substantial evidence underscores the effectiveness of educational games in enhancing health literacy among children and adolescents. These interventions not only improve knowledge retention but also drive meaningful behavioral changes that contribute to long term health benefits. However, the success of gamified health education varies significantly across regions due to factors such as technological access, socio cultural considerations, policy support, game design, and user engagement in development processes. Understanding these differences is crucial for designing and implementing more effective and contextually appropriate digital health interventions. Future research should explore strategies for bridging the digital divide and optimizing gamified learning experiences to ensure their benefits are equitably distributed across diverse populations.

Recent findings regarding the use of educational games to enhance health literacy among children and adolescents show substantial consistency with earlier research, while also identifying critical contextual variations that influence intervention outcomes. Studies by (Han et al., 2023) align with prior research (Azhari et al., 2019), emphasizing that gamified applications, including chatbots designed for nutrition and physical activity education, are both highly accepted and effective at improving health knowledge and behaviors. This reinforces the recognized value of interactive, engaging approaches within health literacy initiatives targeting youth populations.

However, notable differences emerge in application contexts and associated challenges. (Azhari et al., 2019), despite confirming gamification's efficacy in enhancing leptospirosis knowledge among students, underscored practical implementation barriers such as accessibility and user engagement. This aligns with the assertion by (Conley et al., 2022) that the success of game based interventions significantly depends on the socio cultural contexts in which they are deployed. Such contextual differences suggest that while educational games hold universal appeal, their effectiveness can be heavily moderated by local environmental and infrastructural realities.

Further supporting this view, (Pierce et al., 2023) reported promising outcomes of gamified applications aimed at increasing adherence to antiretroviral therapy among HIV positive adolescents in Nigeria. Yet, their study also highlighted significant obstacles, particularly related to stigma and limited technology access. These findings are consistent with literature indicating that

educational games can reduce health related stigma by providing secure, interactive learning platforms (Fleming et al., 2019). Nevertheless, the persistence of technology and accessibility barriers indicates that broader systemic issues must be addressed to realize the full potential of such interventions in resource constrained environments.

Key factors accounting for the varying success rates of gamified interventions across geographical contexts have been extensively documented. (Christie et al., 2019) emphasized the necessity of attractive and relevant game designs aligned with youths' lived experiences. In high income countries, advanced technological infrastructure enables the development of sophisticated educational games incorporating features such as real time feedback, interactive narratives, and social connectivity, thereby significantly enhancing user engagement (Hightow-Weidman et al., 2017). Conversely, in low resource settings, technological limitations restrict the complexity and sophistication achievable in educational games, thus potentially diminishing user engagement and intervention effectiveness.

Moreover, user participation in the development of educational games significantly impacts their effectiveness. (Lubbe et al., 2023) demonstrated that active youth involvement in game design enhances both content relevance and user engagement, supporting earlier findings by (Williams & Ayres, 2020) on the importance of user centered design in health education interventions. Engaging youth as active stakeholders in development processes not only improves the relevance of game content but also fosters stronger identification with the interventions, potentially enhancing their overall efficacy.

Systemic factors such as governmental support, technological infrastructure, and educational policies critically influence the deployment and sustainability of educational gaming interventions for health literacy. Government support, particularly through targeted funding and policy initiatives, creates favorable environments for implementing game based health literacy programs. As highlighted by (Han et al., 2023), policy driven support for technological integration into health education can significantly enhance the reach and effectiveness of gamified interventions by ensuring appropriate resource allocation and prioritization.

The availability and quality of technological infrastructure further dictate the success of digital health initiatives. (Fleming et al., 2019) noted that effective implementation of educational games requires consistent internet connectivity and appropriate digital devices, resources often scarce in developing regions. (Pierce et al., 2023) specifically identified limited internet access and insufficient digital device availability as substantial barriers, underscoring the need for infrastructural investments as prerequisites for effective gamification interventions in health education.

Educational policies supporting technology integration into curricula also significantly influence intervention outcomes. Integration of educational games into standard teaching practices has been shown to enhance students' engagement and facilitate deeper learning experiences, suggesting that systemic curriculum integration could significantly improve health literacy outcomes (Williams & Ayres, 2020). For this to succeed, educator readiness is crucial, indicating the importance of comprehensive training and professional development for teachers to confidently incorporate

gamification into their instructional practices ((Hightow-Weidman et al., 2017); (Anikamadu et al., 2024).

Public private collaborations represent another strategic approach for addressing systemic barriers. Partnerships between technology companies, health institutions, and educational organizations can drive innovation in game development, ensuring that educational interventions are both technologically sophisticated and contextually relevant. (Conley et al., 2022) suggested that such collaborations could facilitate the production of higher quality, tailored educational content, thus optimizing intervention effectiveness and appeal.

Potential solutions to address the identified barriers include enhanced governmental support, strategic investment in technological infrastructure, curriculum aligned educational policies, targeted professional development for educators, meaningful user engagement in game design, and sustained research and evaluation efforts. Governmental involvement through dedicated funding, policy development, and public advocacy could significantly mitigate accessibility barriers, especially in lower resource contexts. Simultaneously, infrastructure investments by both government and non government organizations could ensure equitable access to essential digital resources, thus broadening the reach and effectiveness of gamified health interventions (Almeqbaali et al., 2022).

Educational policy reform is equally critical. Integrating gamification systematically within health education curricula requires policies supporting technology enhanced learning environments. Schools adopting gamification approaches have shown increased student engagement and improved educational outcomes, suggesting that strategic curriculum integration could significantly amplify health literacy impacts (Fleming et al., 2019). Moreover, training and professional development opportunities for educators on effective gamification use are imperative for maximizing intervention impacts (Lubbe et al., 2023).

Meaningful user involvement in game design remains a fundamental solution. As (Christie et al., 2019) argued, incorporating youth perspectives in design phases enhances both engagement and intervention effectiveness. Ongoing user feedback and participatory design practices ensure educational games remain relevant, engaging, and reflective of young users' real world experiences, thereby improving overall effectiveness.

Finally, continuous research and evaluation are crucial to optimizing gamified interventions. Regularly assessing intervention effectiveness, identifying persistent barriers, and documenting best practices can inform iterative improvements and enhance future interventions. (Hightow-Weidman et al., 2021) emphasized the need for continuous evaluation to maintain intervention relevance, efficacy, and adaptability to evolving user needs.

Despite extensive evidence supporting the effectiveness of gamified interventions, notable research gaps remain, including limited longitudinal studies assessing long term impacts, insufficient comparative studies between diverse geographic and cultural contexts, and sparse evidence on cost effectiveness analyses. Future research should prioritize these areas to better understand sustained behavioral impacts, cross context effectiveness, and economic feasibility,

thus enhancing the global applicability and scalability of educational gaming interventions for health literacy.

CONCLUSION

Educational games and gamification significantly enhance health literacy among children and adolescents by increasing knowledge, motivation, and promoting healthier behaviors. The findings from this review underscore the efficacy of interactive, narrative driven games in delivering health education effectively across various domains, including mental health, nutrition, physical activity, and chronic disease management. However, systemic barriers such as technological accessibility, infrastructure limitations, cultural stigma, and varying policy support significantly influence the outcomes and sustainability of gamified interventions, especially in resource limited regions. Given these challenges, interventions must prioritize user centered game design, ensuring cultural relevance, technological accessibility, and active engagement of young users in the developmental stages. Policies supporting comprehensive integration of gamification within educational curricula, bolstered by targeted investments in technology infrastructure and professional training for educators, are crucial. Further research is necessary, particularly longitudinal studies to assess long term impacts, comparative analyses across different socio cultural contexts, and comprehensive cost effectiveness evaluations. Addressing these research gaps will inform more effective strategies for global implementation. Emphasizing collaborative approaches involving government bodies, educational institutions, and private sector stakeholders will facilitate innovation and broader adoption of gamified health education. Ultimately, strategically leveraging educational games presents a viable pathway to addressing global disparities in health literacy, reinforcing the urgent need for continued investment and exploration in this dynamic field.

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