Chapter 2
A Systematic Review of Serious Games for Health Education:
Technology, Challenges, and Future Directions

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ABSTRACT

Serious games offer an innovative blend of entertainment and learning in medical education. This chapter examines the technological underpinnings, challenges, and potential future developments in this domain. Drawing from publications between 2018 and 2023, this systematic review highlights the role of technologies such as web and mobile applications, game engines, augmented reality, virtual reality, mixed reality, and artificial intelligence in personalizing and enhancing the learning experience. However, the use of serious games in medical education also faces several challenges, including the need for adequate technological infrastructure, complex effectiveness assessments, and integration into existing curricula. Moreover, this chapter outlines projections for further research. The authors reveal how serious games have the potential to transform medical education to be more engaging, interactive, and effective, and inspire future research in the development of innovative technologies and learning methods.

INTRODUCTION

The role of serious games in the health sector has attracted much attention in research in recent years (Wattanasoontorn et al., 2013). In the last decade, technological developments have driven significant changes in medical education, especially in the application of serious games (Tori et al., 2022). A game genre that combines entertainment and educational elements can provide unique opportunities for a challenging and interactive learning process (Arif et al., 2021). Serious games are an innovative approach that combines elements of games with the goals of education, training, or behavior change (Avila-Pesantez et al., 2019; (Hamari et al., 2016). In contrast to traditional games, which focus on entertainment, serious games are designed to provide an interactive and exciting learning experience (Arif et al., 2020). This approach has the potential to improve understanding and knowledge retention in a fun and dynamic way. With the right design, serious games can adapt a variety of subject matter and present it in a context that is interesting to users. This condition makes serious games a very flexible tool in education and training. Its use has spread to various sectors, from schools to professional training (Nurhayati & Arif, 2023).

The benefits of serious games are very diverse and significant, including increased learning motivation, increased knowledge retention, and a more active and interactive learning experience. Its implementation can be found in various fields, such as education (Arif & Nurhayati, 2022), health (Damaševičius et al., 2023), military (Mun et al., 2017), tourism (Arif, Nurhayati, et al., 2023), and business (Beranič & Heričko, 2022). In the military, for example, serious games can simulate realistic combat situations for training. In business, serious games can help in training management and leadership skills. Meanwhile, these games can be used in the health sector for patient education or medical training. The technology used in serious games is diverse and continues to develop, ranging from personal computer platforms and game consoles to mobile technology (Devraj et al., 2021). Virtual and augmented reality technology is also starting to become commonplace in creating serious games, providing a more immersive learning experience (Lu et al., 2022; Strada et al., 2023). This ability allows players to truly experience and interact with the learning material in a way impossible with traditional methods. This technology also allows developers to create highly realistic and detailed scenarios. This condition can help depict complex or abstract concepts in a form that is easier to understand. Overall, the technology used in serious games provides excellent potential for innovation in how we teach and learn.

Artificial intelligence (AI) is essential in developing serious games (Eun et al., 2023). AI can be used to make in-game characters and scenarios more realistic and provide challenges that suit the user's abilities and needs (Arif, Nurhayati, et al., 2023). For example, AI can adjust a game's difficulty level based on a player's progress, providing just the proper challenge to ensure an optimal learning experience. AI also enables the development of dynamic and responsive content to player actions so that each gaming experience is unique and personal (Arif, Putra, et al., 2023). In an educational context, serious games offer an exciting alternative to traditional learning methods (Arias-Calderón et al., 2022). Students can not only gain new knowledge but can also interact directly with learning material. This ability can help them understand intricate and complex concepts better. In today's digital era, the younger generation is often more connected to technology and digital media. These conditions cause serious games in education to offer a more relevant and exciting approach (Arif, Novriantama, et al., 2023). Additionally, using games in teaching also helps reduce the stress and anxiety often associated with formal learning, making the learning process more enjoyable. Thus, serious games can be a very effective tool in increasing student engagement and learning outcomes.

In health education, serious games can provide knowledge about various aspects of health, from nutrition to medical procedures (Andrew et al., 2023). Additionally, serious games can also be used to train clinical skills and change health behavior (D'Aprile et al., 2019). For example, through serious games, a nursing student can learn how to perform clinical procedures safely and effectively (Wong et al., 2022), while patients can learn about the importance of a healthy lifestyle and adherence to treatment. This theoretical implementation has become a reality in many educational and health institutions worldwide. Technology and game-based approaches allow health education to become more engaging, interactive, and effective, with real potential to influence behavior and health outcomes (Sipiyaruk et al., 2018). The use of serious games in health education is not only limited to professional training but can also be an effective tool in patient education (Gomes Lisboa de Souza et al., 2022). Games designed to teach about a particular disease or how to manage a health condition can be an invaluable tool for helping patients understand and manage their condition (Ingadottir et al., 2020). For example, games that teach about diabetes can help players as patients understand how diet and exercise affect their blood sugar levels. However, many challenges must be faced, such as system requirements, player acceptance, and learning effectiveness in specific educational environments. This systematic literature review aims to understand the technology, challenges, and prospects for further research in using serious games for medical education.

MAIN FOCUS OF THE CHAPTER

In this chapter, we meticulously define our objectives and aims, setting out to interrogate the efficacy of serious games as pedagogical tools in medical education. We address fundamental questions regarding their role in enhancing learning outcomes, their integration into curricula, and the balance between educational utility and user engagement. The inquiry contributes a novel perspective by synthesizing cutting-edge AI technology (Kazi, 2024; Patibandla et al., 2024) with learning theory to elucidate the transformative potential of serious games. This chapter is designed for a varied audience, including educators, researchers, and developers, and aims to clarify complex concepts while maintaining scholarly thoroughness. We present a comprehensive methodological approach, employing a systematic literature review complemented by case studies to illustrate the real-world application of theory. Our discourse is circumscribed to the pedagogical implications of serious games, intentionally omitting a deep dive into the programming specifics or market analysis. The chapter is attuned to contemporary shifts towards digital pedagogies, situating our discussion within the vibrant mosaic of current educational innovations and contributing to the broadening discourse on the future of educational technologies.

By delineating the contours of the current educational landscape, the chapter recognizes the burgeoning trend of gamification in education (Mustafa et al., 2022; Valderama et al., 2022). It situates the analysis of serious games within the context of evolving pedagogical strategies. It aims to contribute to the dialogue on digital education, offering a critical examination of serious games' capacity to engage and educate the next generation of healthcare professionals. Through this exploration, the chapter aspires to provide actionable insights that will aid in the design of educational interventions that are both scientifically sound and pedagogically effective, resonating with the emerging needs of a digitally native student body.

LITERATURE REVIEW

Serious Games

Serious games refer to games that are specifically designed for educational or training purposes, not just for entertainment (Stofella & Fadel, 2022). Serious game designers target understanding specific concepts, developing new skills, or changing behavior through engaging goal-oriented interactions. This concept paves the way for innovative learning approaches, where players can learn while playing in an engaging and interactive environment (Arif et al., 2021). Various elements such as graphics, narrative, and engaging game mechanics are essential in keeping players motivated and engaged. In the context of health education, serious games have the potential to support the delivery of health information and clinical training (de Oliveira et al., 2021). As time goes by, the scenarios offered by serious games become more diverse and sophisticated, allowing for deeper learning and richer experiences. The concept of serious games combines entertainment with education, making conveying complex and sometimes dull information more interestingly easier. Applying the latest technology in serious games also allows for realistic simulation of real-world situations, which is a perfect transition to discussions about scenarios in serious games (Arif, Novriantama, et al., 2023).

Scenarios in serious games offer replicas of real-world situations that allow players to explore and learn in a safe and controlled environment (Arif, Nurhayati, et al., 2023). These scenarios, especially in a medical context, can simulate clinical conditions, medical procedures, or medical emergencies, thereby assisting in improving understanding and retention of information. These scenarios can also be adapted to meet the specific needs of various target groups, thereby increasing the relevance and effectiveness of serious games. Through these scenarios, serious games are changing how medical education and training are delivered. Technological advances play an essential role in developing these scenarios, which brings us to the next topic regarding the application of serious games in the health sector (Schulz et al., 2020). Effective scenario development requires a deep understanding of learning objectives and how best to integrate these objectives into an engaging game experience. Additionally, player feedback and performance evaluation are essential to improve scenario design and ensure the achievement of educational goals.

Serious games have various uses in healthcare. They help teach patients, train medical staff, and simulate medical scenarios, making it easier for users to grasp health-related concepts interactively (Georgieva-Tsaneva, 2019b; Wong et al., 2022). This capability allows for deeper learning and more realistic training experiences, leading to better patient care. These applications are feasible due to on-going technological progress, which enhances the design and development of serious games. These advancements enable more effective medical training and the simulation of intricate clinical situations (de Oliveira et al., 2021). Furthermore, using serious games for patient education aids in understanding health conditions and improving patient compliance and treatment outcomes. These technological strides pave the way for a discussion on how technology boosts the creation of advanced serious games.

The latest technology supports the development of more sophisticated serious games. More realistic graphics, motion tracking technology, and virtual reality (VR) enable the creation of more immersive and realistic simulations, which can add valuable learning experiences (Nurhayati & Arif, 2023). These advances improve the quality and realism of simulations and open opportunities for new and more complex types of interactions in virtual environments. This potential leads us to discuss how this technology can be applied to take medical learning to the next level. Technologies like VR and augmented reality

(AR) open opportunities for impressive immersive learning, allowing players to explore and interact in 3D environments (Altan et al., 2022; Garcia, 2020a; Miller et al., 2024; Strada et al., 2023). Additionally, analytics and AI technology can customize learning experiences based on individual progress and needs, increasing learning effectiveness (Garcia, Arif, et al., 2024). This technology also enables real-time evaluation and feedback, which is essential for continuous improvement (Arif, Novriantama, et al., 2023). Through this potential, serious games have the way for further medical education and training innovation, which is a perfect transition to the next topic, Health Education Media. The potential integration between serious games and the latest technology opens opportunities to create a more comprehensive and effective health education platform.

Health Educational Media

Health education media refers to the tools or platforms used to convey health information and promotion to the public or individuals (Hayes et al., 2023; Stellefson et al., 2020). This media aims to increase public awareness and knowledge about health issues and support positive health behavior. The role of health education media is significant in building health literacy (Miranda, 2024; Ramos, 2024; Tomé et al., 2024) and helping people make better health decisions (De Jesus, 2013; Lowry et al., 2022). The transition from serious games to health education media is a logical step because both have the same goal: increasing health education and awareness (Sharifzadeh et al., 2020). This media can complement serious games in creating a comprehensive health education ecosystem. Health education media can also serve as a platform to convey the latest information about health and disease to the public. Examples of health education media applications cover a variety of formats and platforms. Printed materials such as brochures and posters (Mackert et al., 2014), educational videos (Garcia & Yousef, 2022; Weidmann et al., 2023), mobile applications (Çalış et al., 2023), and online platforms such as websites (Penedo et al., 2021), social media (Thapliyal et al., 2024), or health portals are some examples of media used to convey health information. Each of these media has advantages and disadvantages in reaching audiences and effectively conveying health information. The availability of these platforms allows for broader and easier access to health information, which is an essential foundation for promoting health awareness (Ofosu-Ampong et al., 2024; Panja, 2024). Integrating these platforms and serious games can also create a more comprehensive and interactive health education experience.

The latest technology allows the development of more innovative health education media. AR and VR offer new ways to present health information in an interactive and immersive way (Gandedkar et al., 2021). This technology opens up opportunities for more engaging and immersive learning experiences, which can help understand complex health concepts. This progress also creates opportunities for further integration with serious games, creating a more holistic health education ecosystem (Damaševičius et al., 2023). Additionally, advances in AI and analytics can help personalize educational content, making the learning experience more relevant and engaging for everyone. This technology enables real-time evaluation and feedback, which is essential for continuous adaptation and improvement in health education strategies. Online platforms and mobile applications make access to health information easier (Mohammadzadeh et al., 2023) and can be customized to suit user needs and preferences (Ramaswamy et al., 2023). Features such as easy search, access to extensive health databases, and the ability to track and manage personal health data make this medium a powerful tool for health education. This ease of access and customization is a significant step in shaping health education to be more inclusive and personal-

ized. Additionally, using big data and analytics can help present more accurate and timely information to users, thereby improving the quality and effectiveness of health education (Garcia, Garcia, et al., 2024).

METHODS AND DATA COLLECTION

The methodology chosen in this study is the systematic literature review method. This approach was chosen because it allows structured and in-depth research into relevant literature (Linnenluecke et al., 2019). This method aims to systematically collect, evaluate, and analyze current research, providing comprehensive insight into the research (Ahn & Kang, 2018). In the context of this research, the main focus is how serious games are used in health education, specifically on the use of technology, implementation challenges, and further research directions. To ensure the highest standard of transparency and reporting completeness, we adhered strictly to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines throughout our research process. This adherence is demonstrated through the application of the PRISMA checklist and the inclusion of a flow diagram that delineates the study selection process. The PRISMA checklist was meticulously followed, outlining each step of the literature review and selection process. We documented the flow of information through different phases of the systematic review. We provided a PRISMA flow diagram to map out the number of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage. This rigorous approach not only enhances the credibility of our systematic review but also provides a clear and replicable methodology for future research endeavors in this domain.

The criteria for selecting studies to be included in this review are articulated with precision and follow a predefined protocol to ensure relevance and rigor. We included randomized controlled trials, observational studies, and qualitative research that directly examine the application and impact of serious games in health education. The subjects were restricted to those involving specific health conditions or educational settings that utilize serious games as a primary intervention tool. Specific inclusion criteria were applied, such as the publication type, which encompassed peer-reviewed journal articles, conference proceedings, lecture notes, and book sections published between 2018 and 2023. Conversely, we excluded non-English publications, grey literature, and studies that did not focus on the defined scopes of technology application in serious games, their challenges, or future directions in health education. In the literature search process, we used the Scopus database and obtained 809 records related to research on serious games for health education. This research only uses a search period from 2018 to 2023. The aim is to ensure that this research covers the latest developments and trends in serious games and health education. The results of the subsequent selection process showed 481 research publication data with titles and abstracts related to discussing serious games for health education. This number includes a wide range of research from around the world and various scientific disciplines, showing how diverse this topic is. However, most references obtained still need to clearly show the actual relevance of proposals or research results regarding serious games for health education.

In synthesizing the data from the selected studies, we adopted a methodical approach that began with a thematic analysis to identify core concepts and patterns within the serious games literature. Each publication was meticulously coded for themes related to technology application, educational challenges, and future research directions in the context of medical education. This qualitative thematic synthesis enabled us to construct a narrative that encapsulates the multifaceted dimensions of serious game usage in health education. To complement the thematic analysis, we also employed a bibliometric

analysis using the VOSviewer application, which allowed us to visualize and interpret the interrelationships among key terms extracted from the literature. This non-statistical method provided a macro-level overview of the field, highlighting the central topics and thematic clusters without the use of statistical meta-analysis techniques. The synthesized findings from both the thematic and bibliometric analyses offer a comprehensive perspective on the current state and emerging trends within the domain of serious games in health education.

Figure 1. Record selection process
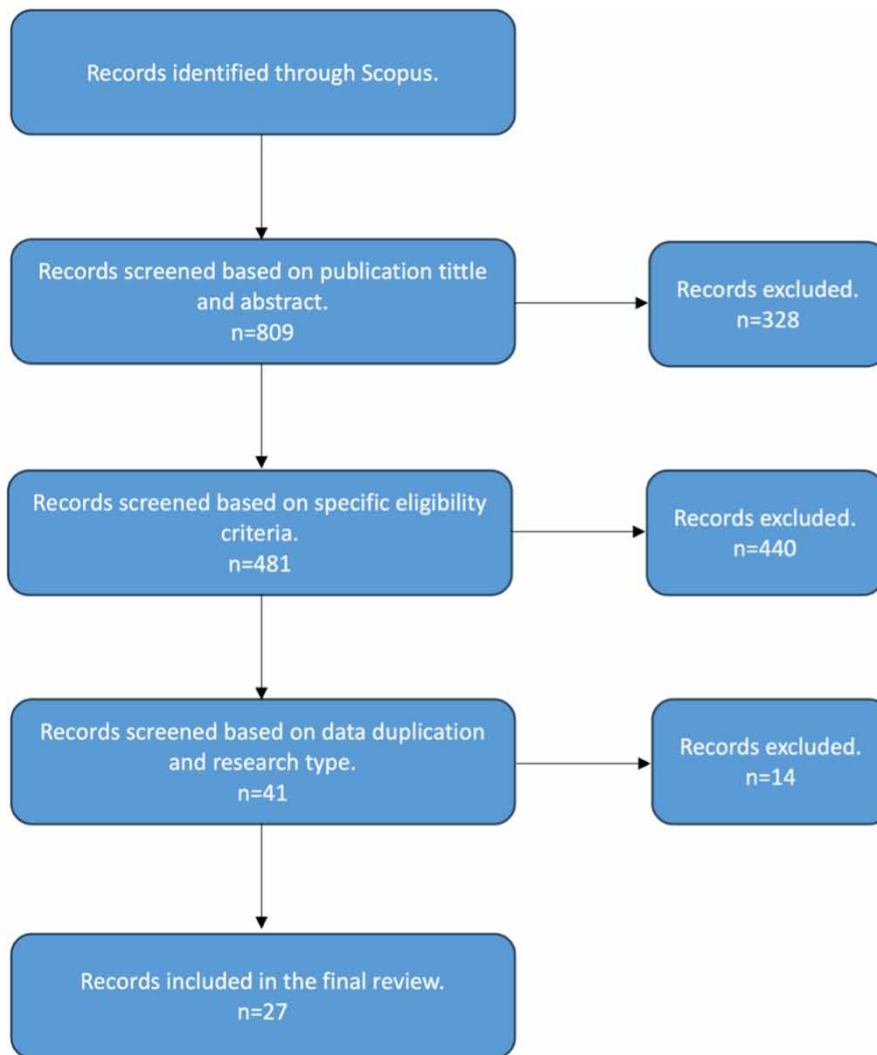
Therefore, the selection process was repeated to ensure the publication's relevance and quality. The main selection criterion was that publications should show research material related to serious games used in medical education. One indicator is the presence of the keywords "serious game" and "health" or "medical" and "education" or "training" or "practice" in the title of the publication reference. After

a rigorous selection process, we obtained 41 appropriate publication data that met these criteria. The next step is the publication selection process based on data duplication and research type. The selection process for the literature, depicted in Figure 1, details the progression from the initial stages to the final selection, resulting in 27 publications being chosen. All selected publications include 20 journals, 4 conferences, 3 lecture notes, and 1 book section, as shown in Figure 2.

On the other hand, Figure 3 shows the distribution of the number of publications from 2018 to 2023. After the publications were selected, we carried out a critical analysis of every article. This analysis process includes determining how the technology is applied, what challenges are faced in its application, and the prospects for future research. This analysis will provide an in-depth understanding of each study's context, methodology, findings, and implications.

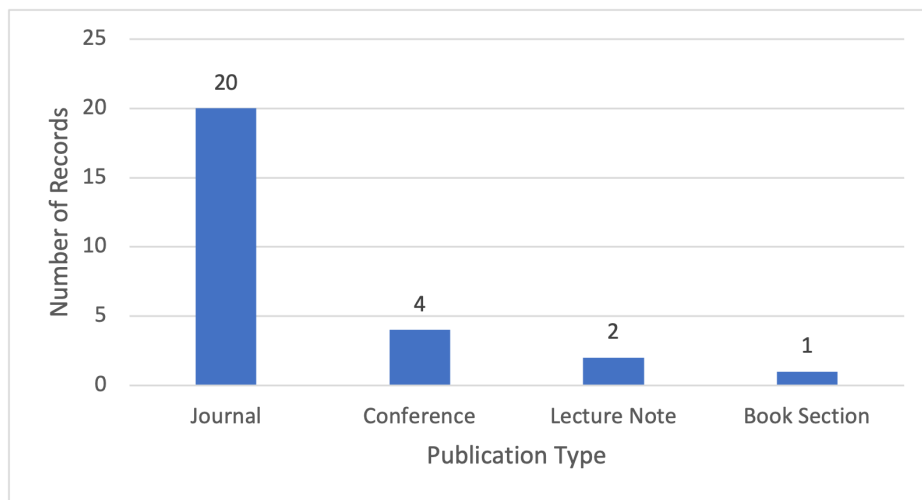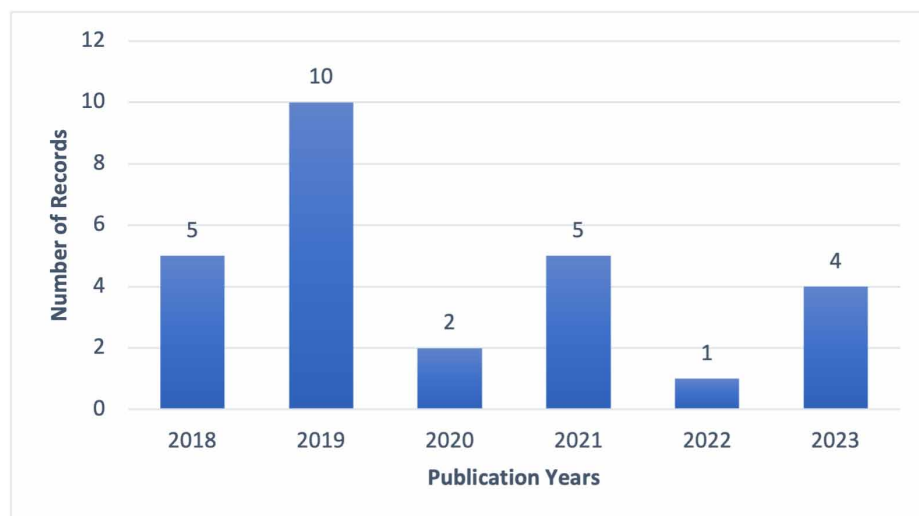*Figure 2. Publication type classification*

Figure 3. Distribution of publication years

In this research, we also tried to visualize the relationship between keywords and selected publication references using the VOSviewer application, as shown in Figure 4. Network visualization using VOSviewer revealed several key findings, where the central topics that dominated were "serious games", "medical education", and "video game learning". This signals a significant literature focus on linking serious games to medical education and video game-based learning technologies. The relationship between these words shows a significant link between the use of serious games in medical education and the learning approach through video games. In addition, the visualization also highlights thematic clusters, which indicate groups of keywords that frequently appear together. For example, "virtual simulation," "health care education," and "decision-making computing" were grouped in the same cluster, indicating a thematic connection between virtual simulation and health education. Demographic factors also are of concern in the literature, with words such as "human," "male," "female," "child," and "adolescent" emerging as relevant topics. These characteristics show consideration of individual characteristics in applying serious games in the health sector. Overall, this visualization provides a comprehensive picture of serious games' foundation and future direction in health education.

Figure 4. Visualization of relationships between keywords in VOSviewer
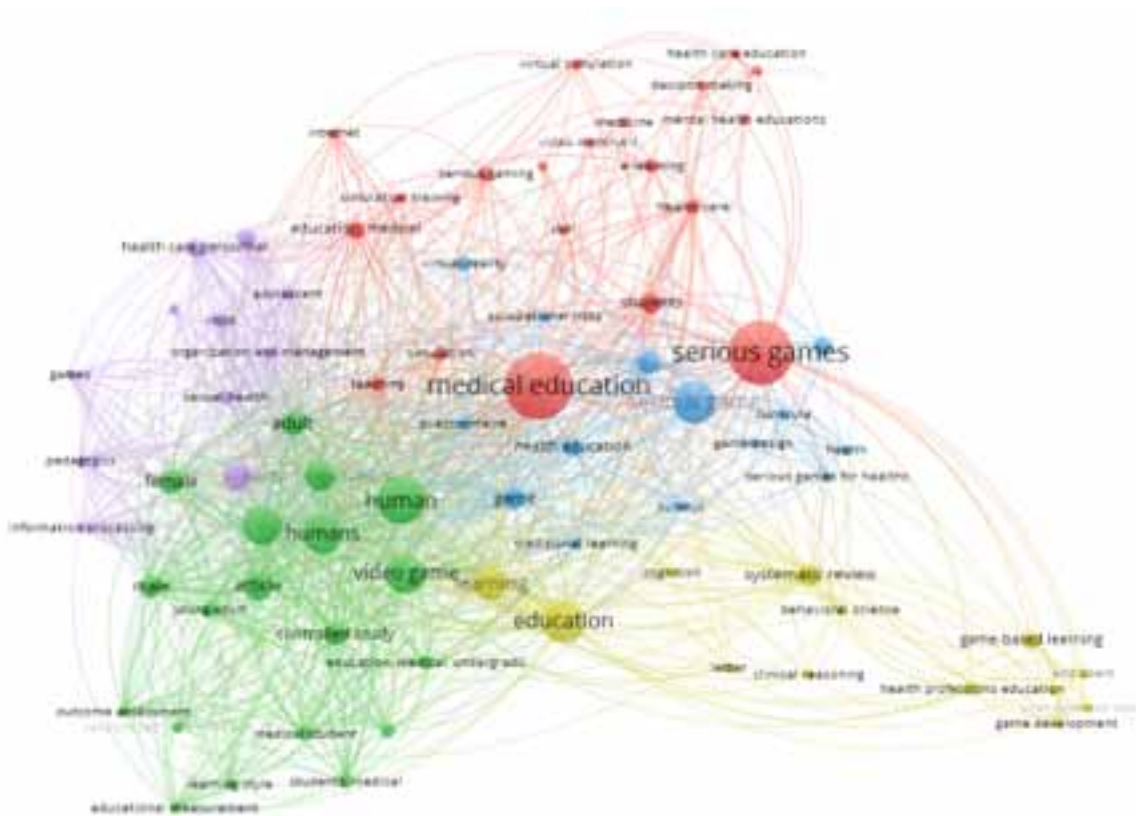
RESULTS AND DISCUSSION

The implementation of serious games in various areas of health education, creating unique and immersive learning platforms for various sub-fields, has been highlighted in recent research. With the proliferation of diverse serious gaming applications, from primary medical education to industrial safety training, researchers and developers face challenges and opportunities in aligning technology, methodology, and educational needs. The various initiatives and approaches taken in developing and implementing serious games in various health fields show the dynamics and potential of this method in enriching the teaching and learning process. Table 1 shows the heterogeneity of information on the 27 serious game themes for health education discussed in this research.

Table 1. List of serious game references for health education

References	Implementation Field	Serious Game Name	Research Sites
Georgieva-Tsaneva (2019a)	General medical education.	-	Bulgaria
Wong et al. (2022)	Interprofessional education for medical and nursing students.	Virtual ER	-
Monteiro et al. (2018)	Sexual and reproductive education for teenagers.	DECIDIX	-
Hale et al. (2021)	General medical education.	GridlockED	Canada
Gürer et al. (2023)	Occupational health and safety education.	MINING-VIRTUAL	-
Khan and Kapralos (2017)	General medical education.	Fydlyty	Canada and the United States
Jaunay et al. (2019)	Medical education for general practitioners.	HyGIE	-
Da Silva et al. (2021)	Education for mental health disorders.	-	-
Sara and Guay (2014)	Sexual health education.	-	-
Brar et al. (2021)	Simulation of shifts in the emergency department.	GridlockED	-
Lamnai and mhouti (2023)	General medical education.	-	-
de Oliveira et al. (2021)	General medical education.	Mobile teaching	Brazil
Kostenius et al. (2018)	General medical education.	-	-
Antoniou et al. (2020)	General medical education.	-	-
de Sena et al. (2019)	Cardiopulmonary resuscitation training.	-	-
D'Aprile et al. (2019)	Patient education.	Tako Dojo	-
Anders et al. (2023)	Forensic medical education.	Adventure Legal Medicine	-
Bellemare et al. (2018)	Simulation of medical students for practical sessions.	-	-
Pietrafesa et al. (2021)	Occupational safety and health training.	-	-
Georgieva-Tsaneva (2019b)	General medical education.	-	Bulgaria
Al Kahf et al. (2023)	General medical education.	Chatprogress	-
Delmas et al. (2018)	Health education for children with asthma.	KidBreath	-
Busari et al. (2018)	Teaching methods in negotiation modules for postgraduate medical education.	-	-
Chon et al. (2019)	Emergency department simulation.	EMERGE	-
Arayata et al. (2022)	Mental health education.	Chyilax	Philippines
Torres et al. (2021)	Mental health education.	Scenario Editor	-
Parel et al. (2022)	Mental health education.	Escape from Oblivion	Philippines
Vallefuoco et al. (2019)	Decision making in medical education.	-	-
Cortez et al. (2022)	Teaching COVID-19 safety protocols	Corona Larona	Philippines

Several researchers proposed a serious game system for medical education by creating a variety of new terms. One is "Virtual ER" introduced by Wong et al. (2022). This serious game system creates a learning bridge between medicine and nursing, showcasing the potential for serious games to support and stimulate interprofessional collaboration and improve communication skills among students from different fields of expertise. On the other hand, a study introduced "DECIDIX", a serious game that presents an innovative approach to sexual and reproductive education for teenagers. This research also discusses a pedagogical methodology rooted in Paulo Freire's principles, which provides access to accurate and relevant information in an exciting and interactive format (Monteiro et al., 2018). Meanwhile, the experience provided by research on "GridlockED" in medical education workshops shows that serious games can be an effective medium for conveying complex learning material.

The material is delivered in an accessible and engaging format while providing participants with an authentic learning experience (Hale et al., 2021). In another study, Gürer et al. (2023) propose "MINING-VIRTUAL" which expands the scope of implementation of serious games into the industrial sector by providing innovative and immersive OHS training in the mining context. The serious game, introduced in 2023, shows the successful integration of VR technology and the Unity3D game engine, opening up opportunities for similar applications in other high-risk industries (Gürer et al., 2023). Next, Khan and Kapralos (2017) discussed a serious game that was introduced as "Fydlyty". They developed a serious game for developing cultural competency in medical education, introducing concepts and practices that support diversity and inclusivity in medicine and care.

In developing health education through serious games, Jaunay et al. (2019) through "Hygie" offer an insight into how continuing medical education can be realized in an engaging and interactive format. Serious games target general practitioners by exploiting the appeal of video games to convey learning material (Strada et al., 2023). Meanwhile, another serious game proposed by Brar et al. (2021) takes the concept of simulation to the next level by creating a virtual replica of a shift in an emergency department. They integrate crucial aspects such as prioritization in a multi-patient context and resource management. They offer a platform for risk-free practice and exploration of decisions in a busy and stressful environment.

Going further, de Oliveira et al. (2021) proposed "Mobile doc training" and explored the potential of mobile technology to support medical education. They provide a platform for medical students in Brazil to hone their skills in managing clinical cases through accessible and portable devices. Furthermore, research on serious games called "Tako Dojo" presents a unique approach to combining behavioral science with serious games. The concept bridges gaming experiences, patient empowerment, and health behaviors. Serious games introduced by D'Aprile et al. create a paradigm in which patients are passive recipients of health information and active participants in their health journey through play experiences designed to support the development of positive health-related knowledge and behavior (D'Aprile et al., 2019).

To enrich health education through serious games, Anders et al. (2023), through "Adventure Legal Medicine" have opened new horizons in forensic medical education. They present an independent learning platform that is not limited by space and time, providing easy access and flexibility to students. On the other hand, Al Kahf et al. (2023) proposed "Chatprogress" namely the serious integration of games and chatbots in medical education. The 2023 research provides incentives for further exploration of how technology can be effectively applied in learning strategies and raises questions about the potential for similar applications in other medical education contexts. Apart from that, "KidBreath" as an e-learning platform puts forward an innovative concept for health education for children with asthma. Serious games introduced by Delmas et al. (2018) integrate health education programs with digital learning technology and offer exciting solutions to common problems in children's health education.

In another study, Chon et al. (2019), via "EMERGE" displays a detailed emergency department simulation. This serious game creates a virtual platform that allows medical students to hone their declarative and procedural knowledge in a context close to reality, offering a breakthrough in practical learning approaches. The following serious game "Scenario Editor" provides an innovative and intuitive solution for mental health education through virtual simulations and serious games. The research discussed by Torres et al. (2021) allows educators to create and customize virtual learning experiences tailored to their specific needs, even with a limited computer or programming background. The variety and innovation in developing serious games for health education, as demonstrated by previous research examples, indicate great potential in various applications and contexts. From forensic medicine to pediatric patient education and emergency room simulations to mental health scenario development, serious gaming applications in health education have covered various fields and topics. These conditions create a varied and flexible framework where technology and pedagogical methods can complement and enrich each other, providing significant added value in learning and developing competencies in health and medical practice.

Innovation in medical education continues to develop along with technological advances (Erisen & Uludag, 2024; Tariq, 2024a; Toit & Goosen, 2024), which is visible in the various implementations of serious games in various countries and educational contexts. In Bulgaria, medical education innovations involve using video materials and serious games as two main approaches to enhance the learning process. Algorithmic videos present detailed and didactic action sequences for medical manipulation, while serious games provide a simulated environment to strengthen mastery of the concepts (Georgieva-Tsaneva, 2019a, 2019b). In Canada, a serious game has been used in workshops to provide a rich and engaging learning experience for participants, showing how serious games can be integrated into more formal educational settings and structures (Hale et al., 2021). On the other hand, a serious game developed in Canada and the United States brings innovation to medical education by providing a web-based platform that includes scenario and dialogue editors. This serious game allows the creation of realistic conversations and interactions with virtual patients to increase cultural competency in medical practice (Khan & Kapralos, 2017). With advances in mobile technology, a serious game developed in Brazil integrates this technology to support medical education. Serious games visualize virtual learning environments that can accommodate clinical case training for medical students. This research also shows how the application of technology can be adapted to local needs and context (de Oliveira et al., 2021).

The diversity of countries in applying serious games in health education reflects the flexibility and adaptability of this method in various educational contexts and cultures. From Bulgaria to Brazil, these diverse implementations create a roadmap that shows how serious gaming technologies and methodologies can be adapted and applied in various educational settings and needs. This diversity also provides a foundation for sharing experiences and best practices between countries, enabling the further development of innovative educational strategies and applications worldwide.

Supporting Technology

The involvement of technology in the world of health education has brought fresh air and innovation through the development of serious games that aim to improve the understanding and skills of medical students and practitioners. Highlighting several case studies, this discussion will explore the use of various technologies, platforms, engines, and applications that have been integrated into developing serious games for health education. A list of references that discuss the use of technology to support serious health education games is shown in Table 2.

Table 2. Technology supports serious games for health education

References	Technology/Platform/Engine
de Oliveira et al. (2021)	Mobile
Kostenius et al. (2018)	Mobile
Wong et al. (2022)	Web-based application
Khan and Kapralos (2017)	Web-based application
Gürer et al. (2023)	Unity3D
Antoniou et al. (2020)	VR and MR
Georgieva-Tsaneva (2019b)	Innovative technology
Delmas et al. (2018)	Intelligent Tutoring System
Al Kahf et al. (2023)	Chatbots

On the first point, mobile technology stands out as an effective tool in supporting the development and use of serious games in health education (de Oliveira et al., 2021; Kostenius et al., 2018). The main advantage of mobile technology lies in its accessibility and flexibility, allowing users to access learning materials anywhere and at any time, which can facilitate the achievement of educational goals in a wider context and the diversification of clinical scenarios that can be simulated in games. Furthermore, web-based applications also get a sufficient portion of serious game development. Studies conducted by Wong et al. (2022) and Khan and Kapralos (2017) present a web-based approach that utilizes scenario and dialogue editors to create conversations and interactions with virtual patients, emphasizing educational enrichment through combining serious gaming elements with collaborative learning. The application of VR and game engines such as Unity3D, as illustrated by Gürer et al. (2023), opens up the potential for exploration of virtual environments that can facilitate users in identifying potential hazards and accessing critical information in the context of K3 education and training. On the other hand, Antoniou et al. (2020) reveal the role of biosensor technology and VR or mixed reality (MR) platforms, which can enrich the learning experience by presenting material interactively and integrating user emotional analysis to increase engagement and educational focus.

Adopting innovative technologies in medical education curricula, as discussed by (Georgieva-Tsaneva, 2019b), can create a basis for developing and implementing serious games. Meanwhile, other approaches, such as the use of chatbots and Intelligent Tutoring System (ITS) applications (e.g., Garcia & Garcia, 2023; Garcia et al., 2022), show how integrating AI technology and chatbots (Garcia, 2023a, 2023b) can provide step-by-step answers and pedagogical comments and create learning experiences tailored to user needs (Al Kahf et al., 2023; Delmas et al., 2018). Technological advancements are significantly influencing the landscape of health education through the integration of AI, VR/AR, and mobile platforms into serious games. These technologies enhance the learning experience by offering immersive, interactive scenarios that cater to the evolving needs of medical students and professionals. Comparative analysis of various studies reveals a trend towards more user-centric educational tools, with some discrepancies in technology application and effectiveness, indicating areas for further research. Practical implications suggest that such insights could be applied to refine current educational practices, making them more engaging and accessible (Chauhan et al., 2024). Educators, developers, and health professionals could leverage the potential of serious games by incorporating these technologies into curricula, ensuring a

more dynamic learning environment. These findings align with existing literature that recognizes the importance of innovative educational strategies, confirming and expanding upon the known benefits of serious games in health education.

Research Challenges

Serious games in health education have shown promising prospects in enhancing learning experiences and facilitating understanding of complex concepts. However, behind its potential are a series of challenges that educational developers and practitioners need to face and address. This discussion will involve an in-depth exploration of these challenges based on various related studies and studies. Collaboration between medical professionals and developers is becoming a necessity in the development of effective and medically accurate serious games. However, the challenge lies in creating an intersection between accurate medical information and engaging gameplay elements (Georgieva-Tsaneva, 2019a). Furthermore, this condition creates a paradox where informative and educational content must be balanced with an entertaining and exciting user experience, especially in the context of sexual health education for young audiences (Sara & Guay, 2014). Further discussion on how to create this balance in various contexts and themes, such as cultural competency and education about occupational safety and health, would help define balanced and effective content development guidelines (Khan & Kapralos, 2017; Pietrafesa et al., 2021).

In the realm of technological accessibility and digital competence, there is a need for continuous initiatives to improve the digital capabilities of both teachers and students (Georgieva-Tsaneva, 2019a; Kostenius et al., 2018). Implementing serious games in existing medical education curricula demands extensive adaptation from both a technological and a pedagogical perspective. Therefore, further exploration of how conventional teaching approaches and new technologies can complement each other in professional practice contexts, such as residency, would provide valuable insights (Busari et al., 2018). When integrating serious games in practical educational contexts, linking the concepts and strategies learned in games with actual clinical experience emerges as a significant challenge (Brar et al., 2021). Therefore, an in-depth understanding of how game experiences can be related to real situations in clinical practice will be essential (de Sena et al., 2019). Further research would be beneficial to identify and develop mechanisms to facilitate this integration.

As for challenges related to cultural and gender sensitivities, inclusive and participatory solutions in serious game development will ensure that the user experience is equitable and relevant for all users (D'Aprile et al., 2019; Khan & Kapralos, 2017). In other words, involving users from diverse backgrounds in the design and evaluation process can yield important insights for creating more inclusive and compelling learning experiences. The challenges of user information security and the development of realistic and relevant clinical scenarios demand a user-centered approach in serious game design (Bellemare et al., 2018; Sara & Guay, 2014; Tariq, 2024b). Further research into how the user experience can be optimized to ensure that information security is guaranteed and how the developed scenarios can be as accurate and detailed as possible will help optimize the implementation of serious games in medical education (Chon et al., 2019; Revano et al., 2018; Yousef et al., 2023).

The review illuminates pivotal challenges such as the imperative for collaborative synergy between healthcare experts and game designers and the critical incorporation of cultural and gender sensitivities in game development. To surmount these challenges, fostering multidisciplinary teams and embracing inclusive design methodologies are key (Dollente et al., 2023; Garcia, 2020b; Isles et al., 2023; Luluquisin

et al., 2021). These teams should prioritize the integration of diverse perspectives from the early stages of development to ensure that serious games are both educationally sound and culturally competent. Additionally, implementing iterative design processes with continuous user feedback can enhance the relevance and efficacy of serious games. By addressing these challenges with strategic solutions, the field can advance toward creating serious games that are not only effective educational tools but also inclusive and reflective of a diverse user base.

Research Directions

Amid the digital transformation, serious games have emerged as a promising innovation in health education. With its ability to offer a more exciting and interactive learning approach, this technology seems ready to replace conventional learning methods. However, every innovation inevitably raises new challenges, and serious games are no exception. To maximize its potential, we need to identify and overcome these challenges. Based on the literature study, the following discussion outlines the challenges and directions for further research in the context of serious games for health education. Entering the era of AR/VR and AI technology, expectations for medical education are becoming increasingly higher (Antoniou et al., 2020; Darda & Matta, 2024). Integrating this technology into serious games offers deeper learning and personalization (Georgieva-Tsaneva, 2019a). However, the challenge is combining technological innovation (Pilueta et al., 2022) with strict medical education standards so that graduates still meet the expected standards of professionalism. This condition is where further research is essential to ensure that serious games with AR/VR and AI technology provide optimal educational value.

As the gaming and information technology industries grow, games such as "MINING-VIRTUAL" are emerging as innovative educational solutions (Gürer et al., 2023). However, despite its potential, there is an urgent need to ensure the content's relevance to the field's realities. Therefore, collaboration between medical experts and game developers is crucial, providing guarantees that the games being developed are in line with health education needs. When developing a serious game, many considerations must be considered. Apart from content, other factors, such as learning methods and user interaction, are also essential (Antoniou et al., 2020; de Sena et al., 2019). Given the potential for integrating different learning methods in serious games, future research may focus on how the various methods complement each other and synergize, ensuring optimal learning outcomes.

The current digital era demands fast and real-time interactions, such as those offered by chatbot-based games (Al Kahf et al., 2023). Although promising, the challenge is how to increase the effectiveness and relevance of chatbots in the context of medical education, as well as how further research can improve the quality and outcomes of learning through this medium. The adaptation and development of serious games across various medical specialties signal the need for more inclusive and adaptive game design (Anders et al., 2023; Chon et al., 2019; Georgieva-Tsaneva, 2019b). Addressing these challenges, further research could focus on how serious games can be developed and adapted to the specific needs of various medical specialties, ensuring relevance and effectiveness in various contexts. Technologies such as Scenario Editor have opened up new opportunities in designing and implementing virtual learning experiences (Torres et al., 2021). With this tool, educators can create learning scenarios that suit their needs. However, the biggest challenge is ensuring that the scenarios are created to support the learning objectives, and this is an area where further research is urgently needed. Serious games have opened new possibilities in health education, promising a more interactive and engaging approach. However, as with all innovation, there are obstacles to overcome. Through this discussion, we have reviewed vari-

ous crucial challenges and areas that require further attention. Then, we can exploit serious games' full potential in redefining how we educate future generations in health.

CONCLUSION

In advancing health education, serious games have emerged as a transformative learning medium, integrating educational principles with interactive gameplay to elevate learner engagement and comprehension. The application of cutting-edge technologies such as VR and AR in serious games offers highly immersive experiences that closely replicate real-world scenarios. Coupled with AI, these platforms are capable of tailoring learning experiences to individual needs. While the deployment of such advanced tools in health education is fraught with challenges, a collaborative synergy between medical experts and game designers is crucial to ensure the delivery of precise educational content in an engaging format. Future research avenues should explore new technologies, evaluate the enduring impacts of serious games on educational outcomes, and develop designs that are both inclusive and culturally sensitive. Investigating how the knowledge and skills acquired from serious games translate to clinical practice is another critical area of study. Ongoing assessment of the effectiveness of these educational tools will be essential. Despite the challenges, with sustained inquiry and cooperative efforts, serious games hold significant potential to reform the education and training of healthcare professionals, rendering them more adaptable, interactive, and attuned to the evolving demands of healthcare delivery.

REFERENCES

Ahn, E., & Kang, H. (2018). Introduction to Systematic Review and Meta-Analysis. *Korean Journal of Anesthesiology*, *71*(2), 103–112. doi:10.4097/kjae.2018.71.2.103 PMID:29619782

Al Kahf, S., Roux, B., Clerc, S., Bassehila, M., Lecomte, A., Moncomble, E., Alabadan, E., de Montmolin, N., Jablon, E., François, E., Friedlander, G., Badoual, C., Meyer, G., Roche, N., Martin, C., & Planquette, B. (2023). Chatbot-Based Serious Games: A Useful Tool for Training Medical Students? A Randomized Controlled Trial. *PLoS One*, *18*(3), 1–12. doi:10.1371/journal.pone.0278673 PMID:36913346

Altan, B., Gürer, S., Alsamarei, A., Demir, D. K., Düzgün, H. Ş., Erkayaoğlu, M., & Surer, E. (2022). Developing Serious Games for CBRN-e Training in Mixed Reality, Virtual Reality, and Computer-Based Environments. *International Journal of Disaster Risk Reduction*, *77*, 1–24. doi:10.1016/j.ijdrr.2022.103022

Anders, S., Steen, A., Müller, T., Krause, W., Sanwald, A., Raupach, T., Ondruschka, B., & Krebs, O. (2023). Adventure Legal Medicine: A Free Online Serious Game for Supplementary Use in Undergraduate Medical Education. *International Journal of Legal Medicine*, *137*(2), 545–549. doi:10.1007/s00414-023-02946-x PMID:36625885

Andrew, L., Barwood, D., Boston, J., Masek, M., Bloomfield, L., & Devine, A. (2023). Serious Games for Health Promotion in Adolescents – A Systematic Scoping Review. *Education and Information Technologies*, *28*(5), 5519–5550. doi:10.1007/s10639-022-11414-9 PMID:36373044

Antoniou, P. E., Arfaras, G., Pandria, N., Athanasiou, A., Ntakakis, G., Babatsikos, E., Nigdelis, V., & Bamidis, P. (2020). Biosensor Real-Time Affective Analytics in Virtual and Mixed Reality Medical Education Serious Games: Cohort Study. *JMIR Serious Games*, *8*(3), 1–16. doi:10.2196/17823 PMID:32876575

Arayata, P. A., Banzon, J., Franco, B. M., Lubrin, D., Perez, M. R., & Garcia, M. B. (2022). Chyilax: An Innovative 3D Game Approach for Mental Breakdown Awareness Campaign. *2022 IEEE 14th International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment and Management (HNICEM)*. IEEE. 10.1109/HNICEM57413.2022.10109535

Arias-Calderón, M., Castro, J., & Gayol, S. (2022). Serious Games as a Method for Enhancing Learning Engagement: Student Perception on Online Higher Education During COVID-19. *Frontiers in Psychology*, *13*, 1–11. doi:10.3389/fpsyg.2022.889975 PMID:35572251

Arif, Y. M., Harini, S., Nugroho, S. M. S., & Hariadi, M. (2021). An Automatic Scenario Control in Serious Game to Visualize Tourism Destinations Recommendation. *IEEE Access : Practical Innovations, Open Solutions*, *9*, 89941–89957. doi:10.1109/ACCESS.2021.3091425

Arif, Y. M., Novriantama, V., Nurhayati, H., Karami, A. F., Nugroho, F., & Kurniawan, F., Supriyono, & Damastuti, F. A. (2023). A Scenario Selection for Tourism Promotions Serious Game Based on Player Expectations. *2023 International Electronics Symposium (IES)*, (pp. 637-642). IEEE. 10.1109/IES59143.2023.10242551

Arif, Y. M., & Nurhayati, H. (2022). Learning Material Selection for Metaverse-Based Mathematics Pedagogy Media Using Multi-Criteria Recommender System. *International Journal of Intelligent Engineering and Systems*, *15*(6), 541–551. doi:10.22266/ijies2022.1231.48

Arif, Y. M., Nurhayati, H., Karami, A. F., Nugroho, F., Kurniawan, F., Rasyid, H. A., Aini, Q., Diah, N. M., & Garcia, M. B. (2023). An Artificial Neural Network-Based Finite State Machine for Adaptive Scenario Selection in Serious Game. *International Journal of Intelligent Engineering and Systems*, *16*(5), 488–500. doi:10.22266/ijies2023.1031.42

Arif, Y. M., Pradana, R. P., Nurhayati, H., Nugroho, S. M. S., & Hariadi, M. (2020). A Blockchain-Based Multiplayer Transaction For Tourism Serious Game. *2020 International Conference on Computer Engineering, Network, and Intelligent Multimedia (CENIM)*, (pp. 138-143). IEEE. 10.1109/CENIM51130.2020.9297837

Arif, Y. M., Putra, D. D., Wardani, D., Nugroho, S. M. S., & Hariadi, M. (2023). Decentralized Recommender System for Ambient Intelligence of Tourism Destinations Serious Game Using Known and Unknown Rating Approach. *Heliyon*, *9*(3), 1–21. doi:10.1016/j.heliyon.2023.e14267 PMID:37101510

Bellemare, P., Cinter, F., Van Gessel, E., Mèche, P., & Paignon, A. (2018). Report on a Pilot Study Using a Serious Game Combined With Simulated Practice for Interprofessional Health Training Curriculum. *Journal of Interprofessional Education & Practice*, *13*, 5–7. doi:10.1016/j.xjep.2018.07.004

Beranič, T., & Heričko, M. (2022). The Impact of Serious Games in Economic and Business Education: A Case of ERP Business Simulation. *Sustainability (Basel)*, *14*(2), 1–17. doi:10.3390/su14020683

Brar, G., Lambert, S., Huang, S., Dang, R., & Chan, T. M. (2021). Using Observation to Determine Teachable Moments Within a Serious Game: A GridlockED as Medical Education (GAME) Study. *AEM Education and Training*, *5*(2), 1–6. doi:10.1002/aet2.10456 PMID:33796804

Busari, J. O., Yaldiz, H., & Verstegen, D. (2018). Serious Games as an Educational Strategy for Management and Leadership Development in Postgraduate Medical Education – An Exploratory Inquiry. *Advances in Medical Education and Practice*, *9*, 571–579. doi:10.2147/AMEP.S171391 PMID:30147389

Çalış, H. T., Cüce, İ., Polat, E., Hopcan, S., Yaprak, E., Karabaş, Ç., Çelik, İ., & Demir, F. G. Ü. (2023). An Educational Mobile Health Application for Pulmonary Rehabilitation in Patients with Mild to Moderate COVID-19 Pneumonia. In *Handbook of Research on Instructional Technologies in Health Education and Allied Disciplines*. IGI Global. doi:10.4018/978-1-6684-7164-7.ch010

Chauhan, P., Bali, A., & Kaur, S. (2024). Breaking Barriers for Accessible Health Programs: The Role of Telemedicine in a Global Healthcare Transformation. In *Transformative Approaches to Patient Literacy and Healthcare Innovation*. IGI Global. doi:10.4018/979-8-3693-3661-8.ch014

Chon, S.-H., Timmermann, F., Dratsch, T., Schuelper, N., Plum, P., Berlth, F., Datta, R. R., Schramm, C., Haneder, S., Späth, M. R., Dübbers, M., Kleinert, J., Raupach, T., Bruns, C., & Kleinert, R. (2019). Serious Games in Surgical Medical Education: A Virtual Emergency Department as a Tool for Teaching Clinical Reasoning to Medical Students. *JMIR Serious Games*, *7*(1), 1–11. doi:10.2196/13028 PMID:30835239

Cortez, L. P., Tandayu, S. K., Villan, K. R., Español, R., Tutanes, A. C., Perez, M. R., Calleja, J., & Garcia, M. B. (2022). Corona Larona: A 2.5D Mobile Game Advocating COVID-19 Safety Protocols and Mitigation Strategies. *2022 IEEE 14th International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment and Management (HNICEM)*. IEEE. 10.1109/HNICEM57413.2022.10109445

D'Aprile, G., Ligorio, M. B., & Ulloa Severino, A. (2019). How Serious Games for Health Enhance Empowerment-Related Patient Education: The Impact of Gender. *Technology*. *Knowledge and Learning*, *24*(3), 325–340. doi:10.1007/s10758-017-9344-x

Da Silva, C., Torres, A., Kapralos, B., Peisachovich, E., Dubrowski, A., Baltazar, V., Qureshi, B., & Caraballo, N. (2021). Person-Centered Virtual Serious Games: Mental Health Education. *2021 IEEE 45th Annual Computers, Software, and Applications Conference (COMPSAC)*, (pp. 1383-1384). IEEE. 10.1109/COMPSAC51774.2021.00196

Damaševičius, R., Maskeliūnas, R., & Blažauskas, T. (2023). Serious Games and Gamification in Healthcare: A Meta-Review. *Information (Basel)*, *14*(2), 1–31. doi:10.3390/info14020105

Darda, P., & Matta, N. (2024). The Nexus of Healthcare and Technology: A Thematic Analysis of Digital Transformation Through Artificial Intelligence. In *Transformative Approaches to Patient Literacy and Healthcare Innovation*. IGI Global. doi:10.4018/979-8-3693-3661-8.ch013

De Jesus, M. (2013). The Impact of Mass Media Health Communication on Health Decision-Making and Medical Advice-Seeking Behavior of U.S. Hispanic Population. *Health Communication*, *28*(5), 525–529. doi:10.1080/10410236.2012.701584 PMID:22888787

de Oliveira, E. J., silva, J. C. P., Neto, F. M. M., Monteiro, B. d. S., Anunciação, W. F. d., & Neto, A. F. d. S. (2021). Doctraining Mobile: A Serious Game for Medical Students Training in Clinical Cases. *Proceedings of the 10th Euro-American Conference on Telematics and Information Systems*. IEEE. 10.1145/3401895.3401933

de Sena, D. P., Fabrício, D. D., da Silva, V. D., Bodanese, L. C., & Franco, A. R. (2019). Comparative Evaluation of Video-Based On-line Course Versus Serious Game for Training Medical Students in Cardiopulmonary Resuscitation: A Randomised Trial. *PLoS One*, *14*(4), 1–11. doi:10.1371/journal.pone.0214722 PMID:30958836

Delmas, A., Clement, B., Oudeyer, P.-Y., & Sauzéon, H. (2018). Fostering Health Education With a Serious Game in Children With Asthma: Pilot Studies for Assessing Learning Efficacy and Automatized Learning Personalization. *Frontiers in Education*, *3*, 1–22. doi:10.3389/feduc.2018.00099

Devraj, R., Colyott, L., & Cain, J. (2021). Design and Evaluation of a Mobile Serious Game Application to Supplement Instruction. *Currents in Pharmacy Teaching & Learning*, *13*(9), 1228–1235. doi:10.1016/j.cptl.2021.06.032 PMID:34330403

Dollente, D. K., Labay, J. M., Macatuno, K. S., Viray, T. D., Ramirez, R., & Garcia, M. B. (2023). Anito: Battle of the Gods - Exploring Philippines' Cultural Mythical Tales in a Cooperative and Competitive Fighting Video Game. *2023 IEEE 15th International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment and Management (HNICEM)*. IEEE. 10.1109/HNICEM57413.2022.10109470

Erisen, D. E., & Uludag, K. (2024). Estimating Biosafety of Biodegradable Biomedical Materials from In Vitro Ion Tolerance Parameters and Toxicity of Nanomaterials in Brain. In *Transformative Approaches to Patient Literacy and Healthcare Innovation*. IGI Global. doi:10.4018/979-8-3693-3661-8.ch010

Eun, S.-J., Kim, E. J., & Kim, J. (2023). Artificial Intelligence-Based Personalized Serious Game for Enhancing the Physical and Cognitive Abilities of the Elderly. *Future Generation Computer Systems*, *141*, 713–722. doi:10.1016/j.future.2022.12.017

Gandedkar, N. H., Wong, M. T., & Darendeliler, M. A. (2021). Role of Virtual Reality (VR), Augmented Reality (AR) and Artificial Intelligence (AI) in Tertiary Education and Research of Orthodontics: An Insight. *Seminars in Orthodontics*, *27*(2), 69–77. doi:10.1053/j.sodo.2021.05.003

Garcia, M. B. (2020a). Augmented Reality in History Education: An Immersive Storytelling of American Colonisation Period in the Philippines. *International Journal of Learning Technology*, *15*(3), 234–254. doi:10.1504/IJLT.2020.112170

Garcia, M. B. (2020b). Kinder Learns: An Educational Visual Novel Game as Knowledge Enhancement Tool for Early Childhood Education. *The International Journal of Technologies in Learning*, *27*(1), 13–34. doi:10.18848/2327-0144/CGP/v27i01/13-34

Garcia, M. B. (2023a). Can ChatGPT Substitute Human Companionship for Coping with Loss and Trauma? *Journal of Loss and Trauma*, *1-3*(8), 784–786. doi:10.1080/15325024.2023.2240697

Garcia, M. B. (2023b). ChatGPT as a Virtual Dietitian: Exploring its Potential as a Tool for Improving Nutrition Knowledge. *Applied System Innovation*, *6*(5), 1–18. doi:10.3390/asi6050096

Garcia, M. B., Arif, Y. M., Khlaif, Z. N., Zhu, M., de Almeida, R. P. P., de Almeida, R. S., & Masters, K. (2024). Effective Integration of Artificial Intelligence in Medical Education: Practical Tips and Actionable Insights. In *Transformative Approaches to Patient Literacy and Healthcare Innovation*. IGI Global. doi:10.4018/979-8-3693-3661-8.ch001

Garcia, M. B., & Garcia, P. S. (2023). Intelligent Tutoring System as an Instructional Technology in Learning Basic Nutrition Concepts: An Exploratory Sequential Mixed Methods Study. In *Handbook of Research on Instructional Technologies in Health Education and Allied Disciplines*. IGI Global. doi:10.4018/978-1-6684-7164-7.ch012

Garcia, M. B., Garcia, P. S., Maaliw, R. R. III, Lagrazon, P. G. G., Arif, Y. M., Ofosu-Ampong, K., Yousef, A. M. F., & Vaithilingam, C. A. (2024). Technoethical Considerations for Advancing Health Literacy and Medical Practice: A Posthumanist Framework in the Age of Healthcare 5.0. In *Emerging Technologies for Health Literacy and Medical Practice*. IGI Global. doi:10.4018/979-8-3693-1214-8.ch001

Garcia, M. B., Revano, T. F., Jr., Loresco, P. J. M., Maaliw, R. R., III, Oducado, R. M. F., & Uludag, K. (2022). Virtual Dietitian as a Precision Nutrition Application for Gym and Fitness Enthusiasts: A Quality Improvement Initiative. *2022 IEEE 14th International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment and Management (HNICEM)*. IEEE. 10.1109/HNICEM57413.2022.10109490

Garcia, M. B., & Yousef, A. M. F. (2022). Cognitive and Affective Effects of Teachers' Annotations and Talking Heads on Asynchronous Video Lectures in a Web Development Course. *Research and Practice in Technology Enhanced Learning*, *18*, 1–23. https://rptel.apsce.net/index.php/RPTEL/article/view/2023-18020. doi:10.58459/rptel.2023.18020

Georgieva-Tsaneva, G. N. (2019a). Innovative Methods in Medical Education in Bulgaria: Video Materials and Serious Games. [iJET]. *International Journal of Emerging Technologies in Learning*, *14*(16), 165–171. doi:10.3991/ijet.v14i16.10607

Georgieva-TsanevaG. N. (2019b). Serious Games and Innovative Technologies in Medical Education in Bulgaria. *TEM Journal, 8*(4), 1398-1403. doi:10.18421/TEM84-42

Gomes Lisboa de Souza, A., Pystina, X., & Thomann, G. (2022). Serious Game Design Principles for Motor Evaluation of Patients with Neurological Diseases. *Proceedings of the Design Society*, *2*, 1351–1360. doi:10.1017/pds.2022.137

Gürer, S., Surer, E., & Erkayaoğlu, M. (2023). MINING-VIRTUAL: A Comprehensive Virtual Reality-Based Serious Game for Occupational Health and Safety Training in Underground Mines. *Safety Science*, *166*, 1–13. doi:10.1016/j.ssci.2023.106226

Hale, S. J., Wakeling, S., Bhalerao, A., Balakumaran, J., Huang, S., Mondoux, S., Blain, J. B., & Chan, T. M. (2021). Feeling the Flow With a Serious Game Workshop: GridlockED as Medical Education 2 Study (GAME2 Study). *AEM Education and Training*, *5*(3), 1–7. doi:10.1002/aet2.10576 PMID:34124522

Hamari, J., Shernoff, D. J., Rowe, E., Coller, B., Asbell-Clarke, J., & Edwards, T. (2016). Challenging Games Help Students Learn: An Empirical Study on Engagement, Flow and Immersion in Game-Based Learning. *Computers in Human Behavior*, *54*, 170–179. doi:10.1016/j.chb.2015.07.045

Hayes, K. A., Brown, E. M., Nonnemaker, J., Juster, H., Ortega-Peluso, C., Farrelly, M. C., & Davis, K. (2023). Effectiveness of a Media Campaign Promoting Health Care Provider Tobacco Dependence Treatment. *Preventive Medicine Reports*, *36*, 1–7. doi:10.1016/j.pmedr.2023.102403 PMID:37753382

Ingadottir, B., Jaarsma, T., Klompstra, L., Aidemark, J., Askenäs, L., Bahat, Y., Ben Gal, O., Berglund, A., Berglund, E., Höchsmann, C., Plotnik, M., Trappenburg, J. C. A., Schmidt-Trucksäss, A., & Strömberg, A. (2020). Let the Games Begin: Serious Games in Prevention and Rehabilitation to Improve Outcomes in Patients With Cardiovascular Disease. *European Journal of Cardiovascular Nursing*, *19*(7), 558–560. doi:10.1177/1474515120934058 PMID:32538132

Isles, I., Castro, A. G., Cosme, J. R., Pagsolingan, R. F., Ulanday, J. R., Ramos, R., & Garcia, M. B. (2023). Stella Vee: An Isometric Action-Adventure Video Game Raising Awareness of Issues Surrounding Intellectual Property and Copyright. *2023 IEEE 15th International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment and Management (HNICEM)*. IEEE. 10.1109/HNICEM57413.2022.10109470

Jaunay, L.-B., Zerr, P., Peguin, L., Renouard, L., Ivanoff, A.-S., Picard, H., Griffith, J., Chassany, O., & Duracinsky, M. (2019). Development and Evaluation of a New Serious Game for Continuing Medical Education of General Practitioners (Hygie): Double-Blinded Randomized Controlled Trial. *Journal of Medical Internet Research*, *21*(11), 1–10. doi:10.2196/12669 PMID:31746775

Kazi, K. S. L. (2024). Computer-Aided Diagnosis in Ophthalmology: A Technical Review of Deep Learning Applications. In *Transformative Approaches to Patient Literacy and Healthcare Innovation*. IGI Global. oi:10.4018/979-8-3693-3661-8.ch006

Khan, Z., & Kapralos, B. (2017). A Low-Fidelity Serious Game for Medical-Based Cultural Competence Education. *Health Informatics Journal*, *25*(3), 632–648. doi:10.1177/1460458217719562 PMID:28728458

Kostenius, C., Hallberg, J., & Lindqvist, A.-K. (2018). Gamification of Health Education: Schoolchildren's Participation in the Development of a Serious Game to Promote Health and Learning. *Health Education*, *118*(4), 354–368. doi:10.1108/HE-10-2017-0055

Lamnai, A., & mhouti, A. E. (2023). Serious Games for Improving Training and Skills Acquisition in Medicine and Health Professions. *Digital Technologies and Applications*, 967-975. doi:10.1007/978-3-031-29857-8_96

Linnenluecke, M. K., Marrone, M., & Singh, A. K. (2019). Conducting Systematic Literature Reviews and Bibliometric Analyses. *Australian Journal of Management*, *45*(2), 175–194. doi:10.1177/0312896219877678

Lowry, M., Trivedi, N., Boyd, P., Julian, A., Treviño, M., Lama, Y., Heley, K., & Perna, F. (2022). Making Decisions About Health Information on Social Media: A Mouse-Tracking Study. *Cognitive Research: Principles and Implications*, *7*(1), 1–15. doi:10.1186/s41235-022-00414-5 PMID:35867169

Lu, S., Wang, F., Li, X., & Shen, Q. (2022). Development and Validation of a Confined Space Rescue Training Prototype Based on an Immersive Virtual Reality Serious Game. *Advanced Engineering Informatics*, *51*, 1–10. doi:10.1016/j.aei.2021.101520

Luluquisin, T., Castillo, K. M., Ligayo, K., Wong, J. K., Obille, I. V., Garcia, M. B., & Perez, M. R. (2021). *Beast Chasers: A 3D PC-based Third Person Action RPG Game used to Spread Societal Issue Awareness*. WCSE. doi:10.18178/wcse.2021.06.030

Mackert, M., Lazard, A., Champlin, S., Liang, M.-C., Mabry, A., Stroever, S., Guadagno, M., & Watkins, L. (2014). "Take Time. Save Lives. Clean Hands Protect." A Comparison of Two Hand Hygiene Health Promotion Posters. *American Journal of Infection Control*, *42*(5), 530–532. doi:10.1016/j.ajic.2014.01.017 PMID:24773789

Miller, J. C., Fernando, E. Q., Miranda, J. P. P., Bansil, J. A., Hernandez, H. E., & Regala, A. R. (2024). Extended Reality Technologies in Physical Fitness for Health Promotion: Insights from Bibliometric Research. In *Emerging Technologies for Health Literacy and Medical Practice*. IGI Global. doi:10.4018/979-8-3693-1214-8.ch005

Miranda, J. P. (2024). Mobile Applications in Advancing Health Literacy: A Scoping Review of Methodologies, Participants, and Challenges. In *Transformative Approaches to Patient Literacy and Healthcare Innovation*. IGI Global. doi:10.4018/979-8-3693-3661-8.ch003

Mohammadzadeh, N., Gholamzadeh, M., Zahednamazi, S., & Ayyoubzadeh, S. M. (2023). Mobile Health Applications for Children's Oral Health Improvement: A Systematic Review. *Informatics in Medicine Unlocked*, *37*, 1–11. doi:10.1016/j.imu.2023.101189

MonteiroR. J. S.OliveiraM. P. C. A.BelianR. B.LimaL. S. d.SantiagoM. E.GontijoD. T. (2018). DECIDIX: Meeting of Paulo Freire Pedagogy With Serious Games in the Field of Health Education With Adolescents. *Collected Health Science, 23*(9), 2951-2962. https://doi.org/ doi:10.1590/1413-81232018239.12782018

Mun, Y., Oprins, E., van den Bosch, K., van der Hulst, A., & Schraagen, J. M. (2017). Serious Gaming for Adaptive Decision Making of Military Personnel. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, *61*(1), 1168–1172. doi:10.1177/1541931213601776

Mustafa, A. S., Alkawsi, G. A., Ofosu-Ampong, K., Vanduhe, V. Z., Garcia, M. B., & Baashar, Y. (2022). Gamification of E-Learning in African Universities: Identifying Adoption Factors Through Task-Technology Fit and Technology Acceptance Model. In F. Portela & R. Queirós (Eds.), *Next-Generation Applications and Implementations of Gamification Systems* (pp. 73–96). IGI Global. doi:10.4018/978-1-7998-8089-9.ch005

Nurhayati, H., & Arif, Y. M. (2023). Math-VR: Mathematics Serious Game for Madrasah Students using Combination of Virtual Reality and Ambient Intelligence. *International Journal of Advanced Computer Science and Applications*, *14*(5), 233–239. doi:10.14569/IJACSA.2023.0140524

Ofosu-Ampong, K., Agyekum, M. W., & Garcia, M. B. (2024). Long-Term Pandemic Management and the Need to Invest in Digital Transformation: A Resilience Theory Perspective. In *Transformative Approaches to Patient Literacy and Healthcare Innovation*. IGI Global. doi:10.4018/979-8-3693-3661-8.ch012

Panja, S. (2024). Information Retrieval Systems in Healthcare: Understanding Medical Data Through Text Analysis. In *Transformative Approaches to Patient Literacy and Healthcare Innovation*. IGI Global. doi:10.4018/979-8-3693-3661-8.ch009

Parel, D., Costuna, E. K., Morelos, J. M., Cabelis, S. A., Ramos, R., Perez, M. R., & Garcia, M. B. (2022). Escape from Oblivion: A 3D Hack and Slash Survival Horror Video Game for Promoting Awareness of Persistent Depressive Disorder. *2022 IEEE 14th International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment and Management (HNICEM)*. IEEE. 10.1109/HNICEM57413.2022.10109542

Patibandla, L., Rao, B. T., & Murty, M. R. (2024). Revolutionizing Diabetic Retinopathy Diagnostics and Therapy through Artificial Intelligence: A Smart Vision Initiative. In *Transformative Approaches to Patient Literacy and Healthcare Innovation*. IGI Global. doi:10.4018/979-8-3693-3661-8.ch007

Penedo, F. J., Fox, R. S., Walsh, E. A., Yanez, B., Miller, G. E., Oswald, L. B., Estabrook, R., Chatterton, R. T., Mohr, D. C., Begale, M. J., Flury, S. C., Perry, K., Kundu, S. D., & Moreno, P. I. (2021). Effects of Web-Based Cognitive Behavioral Stress Management and Health Promotion Interventions on Neuroendocrine and Inflammatory Markers in Men With Advanced Prostate Cancer: A Randomized Controlled Trial. *Brain, Behavior, and Immunity*, *95*, 168–177. doi:10.1016/j.bbi.2021.03.014 PMID:33737170

Pietrafesa, E., Bentivenga, R., Lalli, P., Capelli, C., Farina, G., & Stabile, S. (2021). Becoming Safe: A Serious Game for Occupational Safety and Health Training in a WBL Italian Experience. *Methodologies and Intelligent Systems for Technology Enhanced Learning, 10th International Conference. Workshops*, (pp. 264-271). Springer. 10.1007/978-3-030-52287-2_27

Pilueta, N. U., Grimaldo, H. D., Jardiniano, M. F., & Garcia, M. (2022). Chessbot: A Voice-Controlled Chess Board with Self-Moving Pieces. *AIP Conference Proceedings*, *2502*(1), 040001. doi:10.1063/5.0108986

Ramaswamy, S., Gilles, N., Gruessner, A. C., Burton, D., Fraser, M. A., Weingast, S., Kunnakkat, S., Afable, A., Kaufman, D., Singer, J., Balucani, C., & Levine, S. R. (2023). User-Centered Mobile Applications for Stroke Survivors (MAPPS): A Mixed-Methods Study of Patient Preferences. *Archives of Physical Medicine and Rehabilitation*, *104*(10), 1573–1579. doi:10.1016/j.apmr.2023.05.009 PMID:37295706

Ramos, M. (2024). Emerging Technologies in Radiotherapy: Advances in Health Literacy and Healthcare Practice. In *Transformative Approaches to Patient Literacy and Healthcare Innovation*. IGI Global., doi:10.4018/979-8-3693-3661-8.ch005

Revano, T. F., Garcia, M. B., Habal, B. G. M., Contreras, J. O., & Enriquez, J. B. R. (2018). Logical Guessing Riddle Mobile Gaming Application Utilizing Fisher Yates Algorithm. *2018 IEEE 10th International Conference on Humanoid, Nanotechnology, Information Technology,Communication and Control, Environment and Management (HNICEM)*, (pp. 1-4). IEEE. 10.1109/HNICEM.2018.8666302

Sara, M.-C., & Guay, L.-M. (2014). Toward a Social-Constructivist View of Serious Games: Practical Implications for the Design of a Sexual Health Education Video Game. In D. Stobbart & M. Evans (Eds.), *Engaging with Videogames: Play* (pp. 1–16). Theory and Practice. doi:10.1163/9781848882959_002

Schulz, R., Smaradottir, B., Prinz, A., & Hara, T. (2020). User-Centered Design of a Scenario-Based Serious Game: Game-Based Teaching of Future Healthcare. *IEEE Transactions on Games*, *12*(4), 376–385. doi:10.1109/TG.2020.3033437

Sharifzadeh, N., Kharrazi, H., Nazari, E., Tabesh, H., Edalati Khodabandeh, M., Heidari, S., & Tara, M. (2020). Health Education Serious Games Targeting Health Care Providers, Patients, and Public Health Users: Scoping Review. *JMIR Serious Games*, *8*(1), 1–16. doi:10.2196/13459 PMID:32134391

Sipiyaruk, K., Gallagher, J. E., Hatzipanagos, S., & Reynolds, P. A. (2018). A Rapid Review of Serious Games: From Healthcare Education to Dental Education. *European Journal of Dental Education*, *22*(4), 243–257. doi:10.1111/eje.12338 PMID:29573165

Stellefson, M., Paige, S. R., Chaney, B. H., & Chaney, J. D. (2020). Evolving Role of Social Media in Health Promotion: Updated Responsibilities for Health Education Specialists. *International Journal of Environmental Research and Public Health*, *17*(4), 1–7. doi:10.3390/ijerph17041153 PMID:32059561

Stofella, A., & Fadel, L. M. (2022). Fidelity and Play Model: Balancing Seriousness. In O. Bernardes & V. Amorim (Eds.), *Handbook of Research on Promoting Economic and Social Development Through Serious Games* (pp. 1–20). IGI Global. doi:10.4018/978-1-7998-9732-3.ch001

Strada, F., Lopez, M. X., Fabricatore, C., Diniz dos Santos, A., Gyaurov, D., Battegazzorre, E., & Bottino, A. (2023). Leveraging a Collaborative Augmented Reality Serious Game to Promote Sustainability Awareness, Commitment and Adaptive Problem-Management. *International Journal of Human-Computer Studies*, *172*, 1–17. doi:10.1016/j.ijhcs.2022.102984

Tariq, M. U. (2024a). Advanced Wearable Medical Devices and their Role in Transformative Remote Health Monitoring. In *Transformative Approaches to Patient Literacy and Healthcare Innovation*. IGI Global. oi:10.4018/979-8-3693-3661-8.ch015

Tariq, M. U. (2024b). Enhancing Cybersecurity Protocols in Modern Healthcare Systems: Strategies and Best Practices. In *Transformative Approaches to Patient Literacy and Healthcare Innovation*. IGI Global. oi:10.4018/979-8-3693-3661-8.ch011

Thapliyal, K., Thapliyal, M., & Thapliyal, D. (2024). Social Media and Health Communication: A Review of Advantages, Challenges, and Best Practices. In *Emerging Technologies for Health Literacy and Medical Practice*. IGI Global. doi:10.4018/979-8-3693-1214-8.ch017

Toit, S. d., & Goosen, L. (2024). Transformative Technologies for Supporting Children with Fetal Alcohol Syndrome and Autism Spectrum Disorders. In *Transformative Approaches to Patient Literacy and Healthcare Innovation*. IGI Global. doi:10.4018/979-8-3693-3661-8.ch008

Tomé, A., Rosa, M. C. N., & Silva, E. (2024). Advancing Health Literacy in the Technological Era: The Role of Serious Games in Promoting Body Awareness Among Older Adults. In *Transformative Approaches to Patient Literacy and Healthcare Innovation*. IGI Global. doi:10.4018/979-8-3693-3661-8.ch004

Tori, A. A., Tori, R., & Nunes, F. L. S. (2022). Serious Game Design in Health Education: A Systematic Review. *IEEE Transactions on Learning Technologies*, *15*(6), 827–846. doi:10.1109/TLT.2022.3200583

Torres, A., Kapralos, B., Silva, C. d., Peisachovich, E., & Dubrowski, A. (2021). A Scenario Editor to Create and Modify Virtual Simulations and Serious Games for Mental Health Education. *2021 12th International Conference on Information, Intelligence, Systems & Applications (IISA)*, (pp. 1-4). IEEE. 10.1109/IISA52424.2021.9555531

Valderama, A. M., Tuazon, J. B., & Garcia, M. B. (2022). Promoting Student Thinking and Engagement Through Question-Based and Gamified Learning. *2022 IEEE 14th International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment and Management (HNICEM)*. IEEE. 10.1109/HNICEM57413.2022.10109470

Vallefuoco, E., Mele, M., & Pepino, A. (2019). A Serious Game to Support Decision Making in Medical Education. *New Trends in Image Analysis and Processing – ICIAP 2019*, 237-243. Springer. doi:10.1007/978-3-030-30754-7_24

Wattanasoontorn, V., Boada, I., García, R., & Sbert, M. (2013). Serious Games for Health. *Entertainment Computing*, *4*(4), 231–247. doi:10.1016/j.entcom.2013.09.002

Weidmann, A. E., Sonnleitner-Heglmeier, A., & Dartsch, D. C. (2023). Effect of Patient Education Videos on Modifying Medication-Related Health Behaviours: A Systematic Review Using the Behaviour Intervention Functions. *Patient Education and Counseling*, *117*, 1–10. doi:10.1016/j.pec.2023.107992 PMID:37788537

Wong, J. Y.-H., Ko, J., Nam, S., Kwok, T., Lam, S., Cheuk, J., Chan, M., Lam, V., Wong, G. T. C., Ng, Z. L. H., & Wai, A. K.-C. (2022). Virtual ER, a Serious Game for Interprofessional Education to Enhance Teamwork in Medical and Nursing Undergraduates: Development and Evaluation Study. *JMIR Serious Games*, *10*(3), 1–12. doi:10.2196/35269 PMID:35834309

Yousef, A. M. F., Huang, R., Tlili, A., Garcia, M. B., Mahmoud, A. G., & Metwally, A. H. S. (2023). Small Bites, Big Impact: The Power of Nanolearning. *7th International Conference on Smart Learning Environments*, (pp. 108-116). Springer. 10.1007/978-981-99-5961-7_12

ADDITIONAL READING

Almeida, R. P. (Ed.). (2022). *Handbook of Research on Improving Allied Health Professions Education: Advancing Clinical Training and Interdisciplinary Translational Research*. IGI Global. doi:10.4018/978-1-7998-9578-7

Arnab, S., Dunwell, I., & Debattista, K. (Eds.). (2013). *Serious Games for Healthcare: Applications and Implications*. IGI Global. doi:10.4018/978-1-4666-1903-6

Bredl, K., & Bösche, W. (Eds.). (2013). *Serious Games and Virtual Worlds in Education, Professional Development, and Healthcare*. IGI Global. doi:10.4018/978-1-4666-3673-6

Garcia, M. B., & de Almeida, R. P. (Eds.). (2024). *Emerging Technologies for Health Literacy and Medical Practice*. IGI Global. doi:10.4018/979-8-3693-1214-8

Garcia, M. B., Lopez Cabrera, M. V., & de Almeida, R. P. (Eds.). (2023). *Handbook of Research on Instructional Technologies in Health Education and Allied Disciplines*. IGI Global. doi:10.4018/978-1-6684-7164-7

Zheng, R. Z., & Gardner, M. K. (Eds.). (2017). *Handbook of Research on Serious Games for Educational Applications*. IGI Global. doi:10.4018/978-1-5225-0513-6

KEY TERMS AND DEFINITIONS

Artificial Intelligence: A branch of computer science that deals with creating computers or computer systems capable of performing tasks that typically require human intelligence. This includes activities such as learning, reasoning, problem-solving, perception, and language understanding.

Clinical Skills Training: A specialized area of health education focused on developing skills required for clinical practice. This training can be enhanced through serious games that provide realistic simulations, aiding in the mastery of necessary clinical procedures.

Gamification: The incorporation of game elements and principles into non-gaming contexts. This approach is used to boost engagement, increase productivity in organizations, enhance learning experiences, and improve assessment methods.

Health Education: A discipline concerned with improving health knowledge, skills, and attitudes among individuals and communities. It often utilizes innovative methods, including serious games, to effectively convey health-related information.

Immersive Learning: An educational approach that employs virtual reality or other technologies to create a fully immersive and interactive learning environment. This method enhances the learning experience by making it more engaging and realistic.

Serious Games: Digital interactive applications with a primary purpose beyond mere entertainment. These games are designed to educate, train, or influence behavior by combining engaging gameplay with educational or training objectives.

User Interface: The part of a computer system or software that allows users to interact with it. This includes both the input devices used to control the system and the software that interprets and responds to user inputs.