Gamification vs. Teaching First Aid: What is Being Produced by Science in the Area?

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A B S T R A C T

Gamification i.e., the incorporation of game design elements into non-game contexts, represents a transformative tool in health education. In this sense, the increasingly intertwined fields of technology, education, and health present opportunities for informed decision-making and the training of educators, health professionals, and policymakers. This need to improve teaching and learning methods is particularly evident in the areas of first aid and basic life support (BLS), with the aim of improving clinical results and health outcomes. Our article carried out a narrative review, focusing on the intersection of gamification, technology and first aid/BLS training with the aim of investigating the application of gamification and serious games in emergency medicine with the aim of improving motivation and theoretical and practical skills. of health professionals. In addition, this review emphasizes the role of simulation-based education in first aid skills training, highlighting its contribution to preparing first aiders for real-world scenarios. Ultimately, this review underscores the transformative potential of serious games in medical education, showcasing their effectiveness across diverse contexts. In summary, it enhances comprehension of gamification's role in healthcare and medical education, particularly in first aid training, by underscoring the adaptability and efficacy of serious games in revolutionizing medical and emergency education and healthcare. Nevertheless, it underscores that this remains a relatively underexplored area of knowledge.
Keywords: Gamification, Education, First aid, Basic life support, BLS, Healthcare.

1. Introduction

The education of healthcare professionals is of paramount importance for the safety of patients/users of health services and for the improvement of quality of life (1). In some healthcare professions, the purpose of education and continuous training, for self-management and healthcare, should be an integral part of work practices and daily experiences (1). Furthermore, it is essential to place the patient at the center of the healthcare process and

care. In this context, the use of new technologies, such as virtual reality, wearables, drone with a defibrillator etc., brings forth new possibilities for more efficient and engaging teaching and learning (1, 2). This can make the teaching/learning process more interesting and potentially effective by increasing both intrinsic and extrinsic motivation for individuals in the self-care process over the short, medium, and long term, as well as fostering professional commitment to learning (3). Consequently, this can potentially offer a greater chance of a healthier aging process and a reduced likelihood of morbidities such as cardiovascular diseases, which are strongly linked to myocardial infarction, cardiac arrest, and sudden death, and in extreme cases may require basic life support (BLS) and first aid measures (4).

In the context of making the healthcare process more engaging, undoubtedly, gamification, through various strategies, could be an alternative (1, 2). Games can enhance mental and physical well-being, assist in training healthcare professionals to use new tools, and even help individuals with physical limitations overcome their conditions (1, 3). The topic of gamification has become so significant that the World Health Organization (3) has provided a platform and framework for its discussion. In other words, the subject has gained relevance in the field of public health (3).

Gamification can be defined as the use of game design elements (points, badges, medals, leaderboards, and other rewards) in contexts outside of games to enhance user engagement, motivation, and experience (3). The goal is to make activities more enjoyable and encourage desired behaviors (1), making health behavior change easy and enjoyable rather than complicated and demanding. Gamification in healthcare can contribute to positively altering health behaviors, with potential effects and benefits on physical health and mental well-being (4). Moreover, it can also aid in teaching and learning processes.

In the context of first aid education, gamification can be a powerful tool to enhance the learning experience and increase the retention of essential skills (1, 2, 4). Serious games (games with a purpose), therefore, offer an educational and training possibility that educates and trains while entertaining and engaging users. This type of strategy can be particularly beneficial for healthcare professionals as it improves the learning outcomes for healthcare service users, creating a goal-oriented approach and providing a more dynamic and engaging mode of teaching/care (5-7). Furthermore, it may have lower costs when compared to

more traditional methods, such as using mannequins, as seen in the theoretical and practical teaching of first aid maneuvers and rescue techniques (6).

2.   Justificative and Aim

Therefore, the aim of this article was to conduct a narrative review concerning the relationship between the gamification process and health promotion/education, specifically with a focus on the teaching and learning of first aid and BLS. This review is motivated by the growing recognition of gamification as a potential transformative tool in healthcare education. As the landscape of educational methodologies evolves, understanding how gamification can enhance the effectiveness of teaching first aid and BLS becomes crucial. This narrative review seeks to contribute to the body of knowledge by systematically examining existing knowledge and providing insights into the intersection of gamification, health education, and first aid training. The importance of this research lies in its potential to inform educators, healthcare professionals, and policymakers about the efficacy and implications of integrating gamification into health education, ultimately enhancing the delivery and retention of essential life-saving skills. This article delves into the multifaceted aspects of gamification in education, exploring its theoretical foundations, practical implementation strategies, and the impact on student engagement and academic outcomes. Through a comprehensive review of existing literature, the research aims to provide valuable insights into the potential benefits and challenges associated with the application of gamification in educational and health settings, contributing to the ongoing discourse on innovative teaching methodologies.

In general lines, our proposal was to conduct to survey in the following sources of consultation/databases/portal: Google Scholar, PUBMED, and Science Direct. To research the articles for this, narrative review the following descriptors/keywords (Medical Subject Headings - MeSH) were used: "First Aid" AND "Gamification"; "Virtual Reality" AND "First Aid" AND "Gamification"; "Virtual Reality" AND "Sudden Death" AND "Gamification"; "BLS" AND "Virtual Reality" AND "Gamification"; "Basic Life Support" AND "Virtual Reality" AND "Gamification"; and "Artificial Intelligence" AND "First Aid" AND "Gamification". Our selection criteria were established based on previously determined keywords. After that, the selection was made according to the

presence of key words in the title and summary of the articles. From there, the articles with the most relevance and proximity to the aim of the article were determined and chosen.

In the initial phase of article selection, we identified 115 documents. In the subsequent refinement, 46 articles, deemed relevant to the theme, were selected from the initial pool of 115 based on their titles. Following a meticulous screening process to eliminate duplicates in the third title selection, we were left with 13 articles. Further narrowing down the focus, the final and fourth selection, based on abstracts, yielded a set of 11 articles. It is noteworthy that content from additional articles was incorporated to enhance and provide coherence to the text and the proposed discussion.

3. General Aspects of Gamification Applied to Education and Healthcare

Gamification is employed for diverse educational purposes, across various levels of learning, in different environments, and within a broad spectrum of learning domains (8-11). Gamification applied to education represents a dynamic and innovative approach aimed at enhancing the learning experience through the incorporation of game elements and mechanics into educational contexts. This includes the health sector (10). By integrating features such as points, badges, leaderboards, and rewards, gamification seeks to motivate and engage learners, fostering a more interactive and enjoyable educational environment. This paradigm shift in education acknowledges the intrinsic motivation that games naturally evoke and leverages it to promote sustained interest and participation in learning activities (11).

In education, gamification is a technique that introduces game-like dynamics into the educational environment, aiming to stimulate and directly engage students, enabling them to significantly enhance their curriculum, cognitive, and social skills (11). It involves the use of techniques to captivate individuals, motivate their actions, and promote learning and problem-solving. This instills in students a sense of empowerment in their approach to task completion, making tasks more appealing and fostering cooperative efforts, diligence, and other positive values typically associated with games (11).

Expanding the reasoning a little, gamification is a process aimed at increasing both intrinsic and extrinsic motivation and engaging individuals in tasks through playful activities (8, 12). Intrinsic motivation is defined as the pursuit of an activity for its inherent satisfactions rather than any separable consequences, while extrinsic motivation is driven by the acquisition of reinforcers (8, 12). When designing gamification strategies, it is crucial to tap into intrinsic motivations to maintain user engagement (12). This concept aligns with the Self-Determination Theory, where three psychological needs exist: autonomy (the extent to which an action is undertaken by an individual's own interests), competence (the sense of capability to perform a task up to a certain level), and relatedness (the feeling of connection with others while performing a task up to a certain level) (12).

In the realm of healthcare, the application of gamification and serious games is intricately linked to the rehabilitation of chronic diseases, the promotion of physical activity, and the enhancement of mental well-being (1, 10, 11). These innovative approaches leverage game-like elements to motivate individuals in their health journeys (1, 10, 11). Gamification, with its incorporation of rewards, challenges, and interactive features, proves particularly beneficial in encouraging adherence to rehabilitation programs and fostering engagement in physical activities (1, 10, 11). Additionally, serious games contribute to mental health initiatives by providing interactive platforms for cognitive stimulation and emotional well-being. This intersection of technology and healthcare not only facilitates targeted interventions for chronic conditions but also adds an element of enjoyment and motivation, ultimately contributing to more effective and sustainable health outcomes (10).

The growing interest in implementing gamification within the healthcare sector stems from several critical factors. Among these are the disparities in access to healthcare resources, challenges associated with patient adherence to diverse treatment modalities, and the steadily increasing costs of healthcare. This heightened cost is, in part, a consequence of the global population's progressive aging (1, 10, 11). The multifaceted nature of these challenges underscores the need for innovative solutions, and gamification has emerged as a promising strategy (1, 10, 11). By integrating game-like elements into healthcare practices, gamification not only addresses issues of accessibility and adherence but also introduces a dynamic approach to mitigate the financial burdens associated with an aging population (1, 10, 11). Thus, the application of gamification in healthcare serves as a proactive response to these complex challenges, offering the potential to enhance

4. Application of Gamification and Serious Games in Emergency Medicine

Emergency nurses and physicians play a critical role at the forefront of the healthcare system, serving as crucial assets in a variety of capacities (13-15). In addition to their primary responsibilities, emergency nursing and medicine staff are increasingly assuming leadership and management roles in pre-hospital and emergency services (13-15). This broad involvement covers critical aspects such as disaster planning and management, highlighting the multifaceted nature of its contributions (13-15). As leaders in the field of emergency medicine and nursing, these professionals not only respond to acute medical and health situations, but also actively engage in strategic decision-making, resource allocation, and coordination of efforts to ensure an effective and efficient emergency responses (13-15). This evolving role underscores the comprehensive skill set required of emergency nurses and physicians, positioning them not only as front-line healthcare providers, but also as integral contributors to the broader healthcare infrastructure and to community resilience in times of crisis (8, 10, 14, 16).

However, for this to happen with quality in an assertive manner, adequate education and training is required and aligned with current teaching/learning methodologies. In this context, medical education is undergoing rapid transformation, with game-based learning gaining prominence as an innovative approach (10, 14). The integration of serious games and gamification offers educators alternative methods to enhance the medical teaching process. These modalities contribute to education by incorporating elements such as feedback, testing, and spaced repetition, fostering active participation, autonomy, and positive learning experiences for students. Effectively implementing game-based learning has the potential to immerse medical students in impactful learning experiences and enhance their academic performance (17).

For example, Gue et al. (2022) conducted a study to introduce competition into the emergency medicine residency training curriculum (9). The aim was to assess the impact of gamification on residents' motivation, engagement, and perceived challenge compared to traditional didactics. Utilizing a mixed methods approach, they conducted a pre- and post-intervention survey study in a community-based emergency medicine residency program. Results from the surveys, which included 100%

participation from eligible residents, revealed statistically significant increases in motivation, engagement, and challenge with gamification. Residents also expressed overwhelmingly positive perceptions about gamification's applicability. However, the study did not establish a significant association between gamification and in-training exam scores. While the findings are promising, further research, particularly theory-based, broader-scale, prospective studies, is necessary to determine the potential impact of increased motivation and engagement on examination scores and, more crucially, healthcare outcomes. This study marks a pioneering exploration of a longitudinal game in an emergency medicine residency program, highlighting the need for continued investigation in the realm of medical education.

In addition, Chen et al. (2023) explored the impact of gamified emergency care training on nurses' self-assessed emergency care competencies, aiming to overcome limitations associated with traditional Cardiopulmonary Resuscitation (CPR) training (15). The researchers conducted at a regional hospital in central Taiwan, the research involved 194 nurses, focusing on factors associated with competencies. The participants, primarily ≤30 years old (50.5%), exhibited positive correlations between user need, perceived usefulness and ease of use, usage attitude, and emergency care competencies. Notably, perceived usefulness emerged as the primary factor influencing competencies. The findings highlight the potential of gamified training in enhancing nurses' emergency care skills and suggest implications for designing effective nursing competency standards and training programs in acute care facilities.

Finally, Rajagopal et al. (2020) conducted an evaluation of healthcare professionals, including prehospital specialists, nurses, medical students, residents, and physicians, seeking training in mass casualty incident triage (16). The study focused on the Simple Rapid Triage and Treatment (START) system, essential for efficiently categorizing patients in multi-casualty scenarios. Through the utilization of simulation and gamification, the educational exercise aimed to enhance participants' knowledge and comfort with START screening. Objectives included mastering START categories, discussing signs associated with physical examination, assigning roles in a multiple casualty scenario, accurately categorizing patients, and managing limited resources. The gamification aspect involved role assignments, team dynamics, and a competitive environment, complemented by low-fidelity

simulation. Positive responses from informal feedback, group discussions, and an anonymous survey underscored the exercise's remarkable effectiveness, engagement, and relevance. Participants expressed a desire for annual implementation, emphasizing the exercise's value in reinforcing triage concepts and emergency medicine practice. The study's success was evident through positive feedback, highlighting the significance of resource management, START screening review, trauma management, and the overall impact of the exercise. The received feedback will be instrumental in ongoing efforts to refine and improve the educational approach.

5. Simulation As a Strategy for Training First Aid and BLS Skills

Simulation-based education represents a valuable teaching strategy within the realm of medical education, offering a secure practice environment for both learners and patients (13, 18-21). Additionally, it goes beyond traditional teaching methods, presenting opportunities for learners to acquire not only technical skills but also essential non-technical skills such as leadership, teamwork, and communication (13, 18-21). While simulation-based education and game-based learning share overarching educational goals, they differ in their approaches. Game-based learning integrates game elements into non-game contexts to enhance engagement and improve teaching outcomes. In contrast, simulation-based education encompasses a diverse range of models, including partial-task simulators, screen-based computers, standardized patients, and high-fidelity mannequin simulators (8, 16, 19, 22, 23). This variety of tools allows learners to practice clinical skills without compromising patient safety, highlighting the distinct advantages of simulation in medical education (17).

Simulation serves as a strategic cornerstone in the training of first aid and BLS skills, offering a dynamic and immersive educational platform. This approach transcends conventional instructional methods by creating lifelike scenarios that closely mirror real-life emergencies (11,16,19,22,23). Participants engage in hands-on simulations, enabling them to apply theoretical knowledge in a practical setting. The simulation environment allows for the development of critical decision-making skills, honing participants' ability to think quickly and effectively under pressure, a crucial aspect of responding to medical emergencies. Additionally, the interactive nature of these simulations promotes muscle memory and procedural

familiarity, ensuring that individuals are better prepared to execute life-saving techniques in real-world situations (8, 16, 19, 22, 23). Post-simulation debriefings further enhance the analytical aspect of this training, providing participants with opportunities for self-reflection, constructive feedback, and continuous improvement (8, 16, 19, 22, 23). In essence, leveraging simulation as a training strategy for first aid and BLS skills proves invaluable in creating well-prepared and confident responders capable of navigating emergency situations with competence and precision (8).

Drummond et al. (2017) conducted a randomized controlled trial conducted at a French medical faculty (8). For this, the efficacy of an online course and a serious game as pretraining methods for medical students in the context of simulation-based mastery learning on sudden cardiac arrest management was compared. Eighty-two second-year medical students participated, with 79 assessed for the primary outcome. The serious game, Staying Alive, featured a 3D realistic environment, while the online course utilized a PowerPoint lecture. Results revealed no significant difference in the median training time required for students to reach the minimum passing score between the serious game group (20.5 minutes) and the online course group (23 minutes). Notably, achieving appropriate chest compression proved challenging for students in both groups. Subsequent evaluation after 4 months demonstrated a significant decrease in median training time for both methods, though no individual-level correlation was found between performances in the two sessions. The study concludes that the serious game did not outperform the online course in pretraining medical students for cardiac arrest management, and the lack of correlation over time suggests certain aspects of cardiac arrest management may only be partially learned and retained through simulation-based training.

Another study (21) showed that even amidst the constraints imposed by the COVID-19 pandemic on mass public events, the University of Maribor, Faculty of Health Sciences in Slovenia, innovatively orchestrated a public training event for children and adolescents in BLS. The event aimed to convey the fundamentals of BLS through a gamified experience. Leveraging the "Quality CardioPulmonary Resuscitation (QCPR) race" within the "QCPR Training" mobile application, participants engaged with Bluetooth-connected manikins, visualizing real-time chest compressions, and competing in a race format enriched with gamification features such as time pressure, rewards, leaderboard standings, and trophies. Over 90

participants reported high levels of enjoyment, interest, and perceived competence, endorsing the gamified approach to BLS training. This innovative use of gamification in public education events, facilitated by commercially available manikins and mobile applications, presents a promising avenue for enhancing BLS learning experiences for diverse age groups.

Tobase et al. (2017) carried out a study with the aim to assess student learning in an online BLS course with immediate feedback devices during cardiorespiratory arrest simulations (23). Using a quasi-experimental before-and-after design, the online intervention was administered to 62 participants, predominantly female, in their first and second college years. Results indicated a significant improvement from a pre-test mean score of 6.4 to 9.3 in the post-test. Practical skills, evaluated through simulation with feedback devices, demonstrated a mean score of 9.1, equivalent to proficient basic CPR. Noteworthy metrics included a mean compression cycle duration of 43.7 seconds, 20.5 compressions per second, 167.2 compressions, a compression depth of 48.1 millimeters, ventilation volume of 742.7, and a flow fraction percentage of 40.3. The study concludes that the online course positively contributed to BLS learning, emphasizing the importance of technological innovations like simulation and feedback devices in teaching and standardizing CPR maneuvers.

6. Application of Gamification and Serious Games in BLS and First Aid

In recent years, the integration of gamification and serious games has emerged as a transformative approach in the domain of BLS and first aid training. This paradigm shift leverages game design elements to engage learners in a dynamic and interactive educational environment, fostering motivation and enhancing the acquisition of critical life-saving skills (4-6, 13, 16, 23, 24). As technology continues to advance, the intersection of gamification and first aid education opens new possibilities for innovative and effective learning methodologies (4-6, 13, 16, 23, 24). This article explores the application of gamification and serious games in the context of BLS and first aid, delving into the theoretical foundations, practical implementations, and potential benefits of these immersive approaches. Through a comprehensive review and analysis, we aim to contribute valuable insights to the evolving landscape of health education, ultimately promoting more accessible, engaging, and impactful methods for training in BLS and first aid. Below in the Table 1 are the studies selected for this narrative review.

Table 1

Studies that explored the relationship between gamification and first aid/BLS

Reference	Country	Study type	Target population	Main results
The effect of game-based learning on basic life support skills training for undergraduate dental students (24)	Turkey	Original article	Undergraduate dental students	In the serious game group, post-test scores for BLS were significantly higher than pre-test results. No statistically significant difference in overall hands-on training scores was observed between the serious game and traditional learning groups. Students in both groups evaluated hands-on training on the manikin positively and with high levels of participation.
Virtual Simulation Games as an Educational Tool for University First Responders in Canada: A Usability Study (22)	Canada	Original article	Campus Emergency Response Teams and First Response Team members	The results indicate strong endorsement for the ease of use and utility of virtual simulation games. When adopting virtual simulation training methods, attention to internet bandwidth is crucial. There is a noted deficiency in understanding the specific scope of practice for "Campus Emergency Response Teams" members regarding capillary glucose monitoring, highlighting the need for improved training practices in the future.
Validation of an educational game about first aid for schoolchildren (20)	Brazil	Original article	Health professionals (nurses/doctors) specialists in pediatrics and elementary school teachers.	The ultimate iteration of the game is showcased in a board format, featuring four constructible pawns and a deck of 117 cards encompassing questions, alerts, and challenges. Through two rounds of the Delphi method, a comprehensive Content Validation Index exceeding 0.95 was achieved, with all items registering scores surpassing 0.8.
A Serious Game on the First-Aid Procedure in Choking Scenarios: Design and Evaluation Study (5)	Spain	Original article	High school students	The results of this study revealed that players found the game enjoyable. No statistical differences were identified when accounting for player gender, video game preferences, or prior experience in choking emergencies. Analyzing the knowledge levels of these students before and after playing the game, we observed that all indicators related to responding to a choking emergency were significantly enhanced through this serious

				game.
Let the kids play: gamification as a CPR training methodology in secondary school students. A quasi-experimental manikin simulation study (6)	Spain	Randomized block quasi-experimental study	Secondary school students	Gamification may be a better method for teaching CPR to young people compared to more traditional methods. The gamification-focused methodology resulted in significantly higher scores in CPR quality when compared to more traditional methods.
Comparing the Effects on Learning Outcomes of Tablet-Based and Virtual Reality–Based Serious Gaming Modules for Basic Life Support Training: Randomized Trial (25)	Turkey	Randomized Trial	First semester students at the Professional School for Paramedics	The pre-test results indicated that students in both the tablet and VR groups possessed similar prior knowledge. A significant difference was observed between the average pre-test and post-test results in both groups. The post-test average scores were significantly higher in both groups. Notably, the difference between the pre-test and post-test results was significantly greater in the VR group, and these findings were statistically significant.
Developing a Gamified First Aid Training Application for Children (18)	Norway	Original article	Children aged 6 to 7	Understanding basic first aid principles is crucial, yet the challenges posed by physical and cognitive limitations can add stress, particularly for children attempting techniques like CPR. However, experts who contributed to the development of the app reached a consensus that children should commence learning first aid at an early age. At a minimum, this involves recognizing acute situations and understanding how to contact emergency services.
Development of a virtual simulation game on basic life support (19)	Brazil	Original article	Students and healthcare professionals	The game was developed on 13 screens, nine of which presented BLS content, and the others, general guidelines for advancing the game. The experts' five suggestions were accepted by the researchers, most related to the issues of organization, clarity, and vocabulary. No item was considered inappropriate by the judges. In the evaluation using the Likert scale, the game was considered in all analyzes to be excellent content for a virtual learning object.
Kids (learn how to) save lives in the school with the serious game Relive (7)	Italy	Original article	School children	At the study's outset, students exhibited cardiac compressions with an average depth of 31 mm and a frequency of 95 cpm. During the competition phase, these metrics increased to an average depth of 46 mm and a frequency of 111 cpm. In the retention phase, students sustained improvements with an average depth of 47 mm and a frequency of 131 cpm. Notably, the Relive training session positively influenced both compression depth and speed during the competition phase, and this effect persisted through the retention phase. Additionally, gender and body mass index (BMI) impacted compression depth, with males and those with higher BMI showing significantly greater compression depth. Seventy-three percent of students enhanced their CPR knowledge, as evidenced by improved Multiple Choice Question scores. Participants found Relive to be user-friendly and capable of providing effective feedback.
Serious game versus online course for pretraining medical students before a simulation-based mastery learning course on cardiopulmonary resuscitation (8)	France	Randomized Controlled Trial	Medical students	The median training time needed for students to reach the minimum passing score was similar between the two groups: 20.5 minutes in the serious game group versus 23 minutes in the online course group. Achieving an adequate degree of chest compression was the most difficult requirement for students in both groups to meet. Four months later, the average training time decreased significantly in both groups.
Using a serious game to complement CPR instruction in a nurse faculty (13)	Spain	Randomized controlled trial	Nursing undergraduate students	Students who used LIfe Support Simulation Activities - LISSA achieved significantly better learning acquisition scores than those who attended traditional classes. Student performance in the main stages of the CPR protocol was better for students who used LISSA.

7. Discussion

The utilization of serious gaming in medical education is a subject of growing interest with several studies offering valuable insights. The role of serious gaming in medical education, especially for emergency skills training, is to enhance engagement and proficiency through interactive and simulated learning experiences. For example, Aksoy (25) conducted a study to compare the effect (pre- and post-test) of participants' knowledge level after using a tablet-based serious game and a virtual reality-based serious game, for BLS. This study reveals that both tablet-based and VR-based serious games for BLS are effective, with VR-based gaming showing a more significant impact on learning outcomes. The integration of serious gaming with VR enhances interactivity and fosters a heightened sense of presence, a result of increased immersion levels. However, its adoption in medical education remains relatively

limited, with only a few applications currently in use. Nevertheless, VR-based serious gaming modules show significant promise for diverse applications within medical education. This research indicates a positive impact of serious gaming on the learning outcomes of digital learners. However, further investigations are essential to comprehensively evaluate the effectiveness of serious gaming in healthcare training (25). It is necessary to highlight that the role of serious gaming in healthcare training is to provide engaging and immersive learning experiences, fostering skill development and decision-making in a simulated environment.

Borgund and Babic (18) aim to create a mobile application to introduce children to first aid early in life, presenting a high-fidelity prototype of a mobile game designed for this purpose. The study underscores the significance of interactive elements and gamification in sustaining high motivation for learning, fostering a positive and engaging environment for children. Insights from interviews with first aid training experts informed the development of a high-fidelity prototype, promoting exploration and addressing a serious subject in a non-frightening manner. Testing involving both experts and users yielded valuable feedback on practical usage and usability. The response to this form of interactive first aid learning for children was positive, suggesting a promising future for such educational tools. Gamification sustains high motivation for learning by creating a positive and engaging environment for children.

Costa et al. (19) validate a virtual learning object in the format of a "Role Playing Game" for BLS, emphasizing the importance of such technology in supporting the teaching of essential skills for academics and health professionals. The Virtual Learning Object, designed as a simulated educational game with 13 screens, including 9 dedicated to BLS content and others offering general guidelines for progressing through the game, has been endorsed as a pedagogical strategy by experts in the field. This approach aims to engage students in a playful and interactive manner, offering a simulated professional practice experience while fostering reflection and critical thinking. Rooted in the updated references from the American Heart Association and Ausubel's pedagogical theory of Meaningful Learning (*connect new information to the student's existing knowledge to make learning more meaningful and lasting*), the Virtual Learning Object provides an opportunity for experiential learning in a context resembling real-life situations.

Drummond et al. (8) aimed to compare an online course and a serious game for pretraining medical students before simulation-based mastery learning on the management of sudden cardiac arrest. Interestingly, the study finds no significant difference in training time between the two methods, challenging assumptions about the superiority of serious games in this context. The serious game used in this study was no better than an online course to pretrain medical students in the management of cardiac arrest. The absence of any correlation between student performance assessed during two training sessions separated by 4 months suggests that some elements in cardiac arrest management, such as compression depth, can only be partially learned and retained after simulation-based training.

Akaltan et al. (24) investigate the impact of serious game training on the performance of undergraduate dental students during BLS training and concluding that the serious game platform enhances both knowledge and skill acquisition. Serious games in medical emergency management for dentists complement traditional lecture-style teaching and are a preferred learning method for undergraduate dental students. The study indicates that using a serious game-based training platform for BLS improves BLS knowledge and skills assessments among dental students. These findings emphasize the importance of incorporating serious games for diverse learning objectives, demonstrating their positive impact on the learning outcomes of digital learners. Further research is recommended to explore the broader effects of serious games in health education. The serious games-based training platform for BLS has proven to enhance the BLS performance of undergraduate dental students, highlighting the beneficial impact of digital learning on game-based education outcomes.

Boada et al. (13) describe and evaluate the use of a serious game to teach and learn CPR skills, as a tool to complement CPR teaching for Nursing students and show that students using the LISSA serious game performed better in learning acquisition scores than those following traditional classes. Currently, CPR training in nursing education follows the traditional model and consists of a theoretical introduction and individual procedural training based on a manikin. The main limitation of current approaches is that they only consider some parts of the CPR protocol, especially the CPR maneuver. From the results it is possible to conclude that the use of a serious game improves students' knowledge and skills in CPR.

Future perspectives will focus on the design of new scenarios and the introduction of new characters into the game.

Boada et al. (5) delve into the benefits of serious games, employing them as a means to disseminate fundamental knowledge regarding asphyxiation recovery procedures. Their contribution extends to the exploration of serious games tackling scenarios involving CPR and choking. The researchers introduce a specific serious game crafted to mitigate the risk of choking incidents, showcasing its efficacy in enhancing players' understanding of first-aid measures in choking emergencies. In summary, the study underscores serious games as a viable and effective strategy for promoting and instructing non-experts on essential first aid procedures related to choking incidents. Serious games serve as a viable and effective strategy for instructing non-experts on essential first aid procedures related to choking incidents, providing an engaging and practical learning experience that enhances retention and application of life-saving skills.

The gamification methodology proves more effective than traditional teaching approaches for learning and teaching CPR among secondary school students, as it not only enhances engagement but also offers a dynamic and immersive learning experience, contributing to better retention of life-saving skills.

In this sense, Otero-Agra et al. (6) evaluate the effectiveness of the gamification methodology for learning/teaching CPR compared to traditional teaching methodologies for secondary school students and highlighting the superiority of gamification in achieving higher CPR quality and correct rates. The conclusion was that gamification methodology yielded superior CPR quality compared to non-tested methods of academic training, which included instructor or visual feedback. Hence, gamification merits consideration as an alternative teaching approach for BLS, especially in younger individuals.

Crane et al. (22) focus on assessing the usability of virtual simulation games for campus emergency response teams. The study highlights the games' strong support for ease of use and overall usefulness, while also noting considerations like internet bandwidth and the need for a clear understanding of Campus Emergency Response Teams. Virtual simulation games developed were found to be user-friendly and valuable as supplementary educational tools for Campus Emergency Response Teams. The study underscores the benefits of virtual training, including replication, standardization, and flexibility, addressing the challenge of sustaining skill-based competencies. Virtual training proves cost-effective, on-demand, and provides relevant information to training teams on first aid responses. Future research could explore tailoring virtual games for specific Campus Emergency Response Teams roles and investigate the long-term retention of skills acquired through virtual training.

Dutra et al. (20) validated the educational game, called "Life in game", for teaching first aid to school-aged children, achieving 95% approval from experts in two Delphi rounds. Serving as an innovative pedagogical tool, the game offers a dynamic approach compared to traditional methods. To enhance effectiveness, it is recommended to validate the game with the target audience and incorporate their feedback. Inclusivity is vital, involving not only children but also parents and the broader community. Integration into ongoing educational initiatives is crucial, and an online version is suggested for wider outreach. "Life in game" promotes social interaction and entertainment while imparting first aid knowledge, creating an engaging learning experience with challenges to capture attention and reinforce learning.

Finally, Semeraro et al. (7) assessed the impact of the serious game Relive on schoolchildren's CPR awareness, demonstrating its effectiveness in enhancing both knowledge and skills. The studies collectively underscore the potential of serious gaming in medical education, spanning contexts from BLS to emergency response team training. Comparisons with traditional teaching methods offer valuable insights into the strengths and considerations of this innovative educational approach. The Relive Tournament Mode, specifically, proved highly effective in improving awareness, knowledge, and CPR skills among schoolchildren without prior experience. It demonstrated sustained competence even three months post a single competition session, highlighting its user-friendly nature and effectiveness in providing feedback. The platform shows promise as a valuable tool for disseminating CPR knowledge and skills within school environments. The role of serious gaming in medical education is to enhance practical skills, decision-making, and engagement through interactive simulations.

8. Conclusion

The studies conducted by various authors highlight the potential and versatility of serious gaming in medical

education. From BLS training to emergency response team education, these investigations demonstrate the effectiveness of serious gaming in diverse applications. Integrating gamification principles into first aid and BLS training enhances engagement, motivation, and knowledge retention among students of different levels. Striking a balance between enjoyable and educational content is crucial, ensuring that gamified elements align with learning objectives. This approach transforms training into an interactive and dynamic process, fostering a positive learning environment. Embracing gamification opens avenues for innovative teaching methods, empowering students with essential skills and confidence in real-life emergency situations. These studies collectively affirm serious gaming as a valuable tool in medical education, offering insights into its strengths and considerations across various contexts. As technology advances, further research and integration hold promise for enhancing healthcare professional training and improving emergency response outcomes. In summary, the incorporation of gamification not only enhances the learning experience but also contributes to more effective skill acquisition and retention, preparing individuals to respond confidently in real-life emergencies. However, there are still few studies in this very relevant area.

8.1. *Practical applications*

The practical applications of integrating first aid and BLS skills with gamification are crucial for several reasons. Incorporating gamification into first aid and BLS training can enhance the participants' decision-making abilities and response times in emergency situations, as they learn to apply critical skills under simulated pressure. Here are some ways in which gamification can be applied to first aid education:

Scenario-Based Games
- Develop realistic scenarios where individuals apply first aid and BLS skills to solve problems or address medical emergencies.
- Create interactive simulations or role-playing exercises to engage students in practical situations.
- Provide instant feedback based on the effectiveness of responses and skills.

Points and Rewards
- Assign points for completing different levels of first aid training or mastering specific skills.

- Introduce a reward system, such as badges or certificates, to recognize and celebrate achievements.
- Establish friendly competitions to further motivate students.

Leaderboards
- Implement leaderboards to display students' progress, promoting a sense of competition and accomplishment.
- Encourage healthy competition by acknowledging top performers and fostering a sense of community.

Create Stories and Narratives
- Develop a narrative or storyline that guides students through their first aid and BLS training journey.
- Use the narrative to contextualize information, making it more relatable, memorable, and impactful.

Quizzes and Interactive Challenges
- Incorporate quizzes and interactive challenges that test knowledge and first aid skills.
- Provide immediate feedback on quiz performance and opportunities for students to improve.

Progress Tracking
- Implement a progress monitoring system that allows students to see their development over time.
- Break down first aid and BLS training into manageable modules and show students their achievements as they progress.

Collaborative Learning
- Promote collaboration among students by incorporating team-based challenges or projects.
- Encourage peer learning and communication through forums or discussion panels.

Mobile Apps and Gamified Platforms
- Utilize mobile apps or online platforms offering gamified first aid training modules.
- Leverage technology to create an engaging and interactive learning experience.

Authors' Contributions

Conceptualization: RLV, TR, and JSH; Investigation: RLV; Methodology: RLV, TR, MSA, CABL, BK, and JSH; Data curation: RLV; Writing-original draft: RLV;

Writing-review and editing: RLV, TR, MSA, CABL, BK, and JSH; and Supervision: RLV, TR, and JSH.

All authors are responsible for the contents of the manuscript and have seen and approved its final version.

Transparency Statement

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Declaration of Interest

The authors report no conflict of interest.

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Ethics Considerations

All procedures were carried out according to the strictest ethical principles.

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