J. Health Inform. 2026 Janeiro-Dezembro; 18

Artigo Original

DOI: https://doi.org/10.59681/2175-4411.v18.2026.1415

Games and simulators for digital training in life support

Jogos e simuladores para treinamento digital em suporte à vida

Juegos y simuladores para entrenamiento digital en soporte vital

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ABSTRACT

Objectives: To identify serious games and simulators for learning assessment in digital life support training (Advanced Cardiac Life Support and Basic Life Support), exploring their reliability, usability, satisfaction, performance feedback, and medical students' interest. Methods: A scoping review and survey with medical students, following guidelines from the Joanna Briggs Institute and PRISMA–ScR. Results: Ten studies were analyzed, highlighting the reliability and usability of the tools, though gaps were found in validation and satisfaction assessment. Conclusion: The availability and dissemination of these tools are limited, with underexplored technological resources and insufficient validation and support materials, indicating the need for further research.

Keywords: Video Games; Life Support Care; Education Medical.

RESUMO

Objetivos: Identificar serious games e simuladores para avaliação de aprendizagem em treinamentos digitais de suporte à vida (Suporte Avançado de Vida e Suporte Básico de Vida), explorando a confiabilidade, usabilidade, satisfação, feedback de desempenho e interesse de estudantes de medicina. Métodos: Revisão de escopo e pesquisa com estudantes de medicina, conforme diretrizes da Joanna Briggs Institute e PRISMA–ScR. Resultados: Analisaram-se dez estudos, destacando a confiabilidade e usabilidade das ferramentas, embora com lacunas em validação e avaliação de satisfação. Conclusão: A disponibilidade e disseminação dessas ferramentas são limitadas, com poucos recursos tecnológicos explorados e validações e materiais de apoio insuficientes, evidenciando a necessidade de mais pesquisas aprofundadas.

Descritores: Jogos de Vídeo; Cuidados para Prolongar a Vida; Educação Médica.

RESUMEN

Objetivos: Identificar juegos serios y simuladores para la evaluación del aprendizaje en entrenamientos digitales de soporte vital (Soporte Vital Avanzado y Soporte Vital Básico), explorando su fiabilidad, usabilidad, satisfacción, retroalimentación del rendimiento e interés de los estudiantes de medicina. Métodos: Revisión de alcance y encuesta a estudiantes de medicina, siguiendo las directrices del Joanna Briggs Institute y PRISMA–ScR. Resultados: Se analizaron diez estudios, destacando la fiabilidad y usabilidad de las herramientas, aunque se encontraron brechas en la validación y evaluación de la satisfacción. Conclusión: La disponibilidad y difusión de estas herramientas son limitadas, con recursos tecnológicos poco explorados y una validación y materiales de apoyo insuficientes, lo que resalta la necesidad de más investigaciones.

Descriptores: Juegos de Video; Cuidados para Prolongación de la Vida; Educación Médica.

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Artigo recebido: 08/11/2024
Aprovado: 06/01/2026
https://jhi.sbis.org.br/

INTRODUCTION

The development of applications to support education and training has gained prominence in various areas due to the potential of interactive digital resources in the learning of students and professionals. Serious Games (SGs) and simulators, allow the replication of routine and critical situations in safe and controlled environments, enabling variations in the degree of risk, as well as the availability of different types of materials in the virtual context(1-2).

Simulators are applications developed to replicate real-world activities in a virtual environment, providing the user's experimentation and performance in the completion of tasks(4). SGs, incrementally, can be characterized as digital games designed to achieve specific objectives while providing a playful interaction between the user and the machine in a virtual environment(2). For this to occur, these applications must contain contextualized content and tasks capable of promoting user satisfaction and engagement, providing the user the desire to reuse them on their own initiative(3).

In the healthcare field, especially in the teaching and training of life support protocols like Advanced Cardiovascular Life Support (ACLS) and Basic Life Support (BLS), alternative or complementary methods to traditional teaching — including hybrid, online, or other non-traditional in-person approaches, such as those based on SGs and simulators — have been an effective strategy just like the traditional training modality using world-renowned protocols from the European Resuscitation Council (ERC) or the American Heart Association (AHA)(5).

Training and learning in BLS and ACLS require constant content review, spaced and continuous practice, as well as feedback on the student's performance. In this context, SGs and simulators can be important allies in identifying professional skills, as they allow for the assessment of user performance and the provision of feedback on demonstrated knowledge through their interactions in the digital environment(4). It is noteworthy that training in advanced life support and technological education are strategies of the Ministry of Health for the qualification of care within Brazil's public healthcare system, known as the Sistema Único de Saúde.

Considering the relevance of SGs and simulators in the context of ACLS and BLS training, a preliminary investigation showed an absence of literature reviews focusing on digital and interactive training methods with feedback. No review protocols were found registered in the Prospective Register of Systematic Reviews (PROSPERO), and a consultation of the Open Science Framework (OSF) also failed to identify any other systematic or scoping reviews on this specific research area.

Therefore, the present study aimed to identify SGs and simulators that support learning assessment for interactive digital training in ACLS and BLS. It also sought to explore the reliability of these tools regarding their content, usability, and user satisfaction, while also identifying the types of performance feedback used within these tools. Finally, it aimed to assess the viability and user interest in utilizing such applications to complement life support learning from the perspective of medical students.

METHODS

This article presents a scoping review and a study to identify the viability and use of applications that aim to supplement life support learning for medical students. This review followed the recommendations of the Joanna Briggs Institute (JBI) from 2020. The research protocol was registered on the Open Science Framework (OSF) platform (https://osf.io/vgda3/). The PRISMA Extension for Scoping Reviews (PRISMA-ScR) guidelines were followed to ensure greater robustness and rigor in the systematization of the results.

The search utilized the Portal de Periódicos da Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES Journal Portal) and PubMed. No language restrictions were applied, and articles published between 2000 and 2023 were selected. The inclusion criteria focused on studies that covered digital training methods for ACLS and/or BLS, where users could interact exclusively through a graphical interface and receive feedback. We excluded studies featuring tools that did not fit the scope of serious games or digital simulators, as well as quiz-style games, review studies, editorials, letters to the editor, and other non-original research. The selection process was conducted independently by two researchers, who were blinded to each other's decisions. In the case of conflicting decisions, the opinion of a third researcher was considered. The search was operationalized between July 18 and September 22, 2025. For each database, a search strategy based on descriptors/keywords was used (Table 1). The term "virtual reality" (VR) was included in the search strategy to encompass studies featuring applications that use this technology. In this case, it was observed that studies dealing with related technologies, such as Augmented Reality (AR) and Extended Reality (ER), also used this term in their descriptors. The study to identify the viability and use of applications to supplement life support learning, from the perspective of medical students in Paraíba, was con-

ducted between November 2023 and February 2024. Data were collected using a structured digital questionnaire developed by members of the Academic League of Cardiology and Cardiac Surgery (LACC) and the Laboratory of Technologies for Virtual Education and Statistics (LabTEVE) at the Federal University of Paraíba (UFPB). The sampling was one of convenience, with 100 participants. Individuals with low visual acuity were not considered, nor were those who refused to sign the digital Informed Consent Form (ICF) or did not answer mandatory items on the data collection instrument. For data analysis, descriptive statistics were considered. This research was submitted to and approved by the Research Ethics Committee of the Center for Medical Sciences at the Federal University of Paraíba under approval number 6484233 and Certificate of Ethical Appreciation number 70812923.7.0000.8069.

Table 1: Search terms used in the databases.

Data Source	Search Strategy
PubMed	("Advanced Cardiac Life Support"[Mesh] OR "Advanced Trauma Life Support Care"[Mesh] OR "Cardiopulmonary Resuscitation"[Mesh] OR " Life Support Care"[Mesh]) AND ("Computer Simulation"[Mesh] OR "Simulation Training"[Mesh] OR "Virtual Reality ACLS Simulator" OR "Virtual Reality ACLS Simulator" OR "CPR Virtual Simulator" OR "Cardiology Virtual Simulator" OR "ACLS Serious Game" OR "CPR Serious Game" OR "Simulador em Realidade virtual para SAV" OR "Simulador em realidade virtual para RCP" OR "Jogo sério ACLS" OR "Jogo sério para RCP" OR "Cardiac Arrest Virtual simulator" OR "Cardiology simulator" OR "Education, Medical"[Mesh] OR "Internship and Residency"[Mesh])
CAPES Journal Portal	("Advanced Cardiac Life Support" OR "Advanced Trauma Life Support Care" OR "Cardiopulmonary Resuscitation" OR " Life Support Care") AND ("Computer Simulation" OR "Simulation Training" OR "Virtual Reality ACLS Simulator" OR "Virtual Reality ACLS Simulator" OR "CPR Virtual Simulator" OR "Cardiology Virtual Simulator" OR "ACLS Serious Game" OR "CPR Serious Game" OR "Simulador em Realidade virtual para SAV" OR "Simulador em realidade virtual para RCP" OR "Jogo sério ACLS" OR "Jogo sério para RCP" OR "Cardiac Arrest Virtual simulator" OR "Cardiology simulator" OR "Education, Medical" OR "Internship and Residency")

Source: Author's data, 2024.

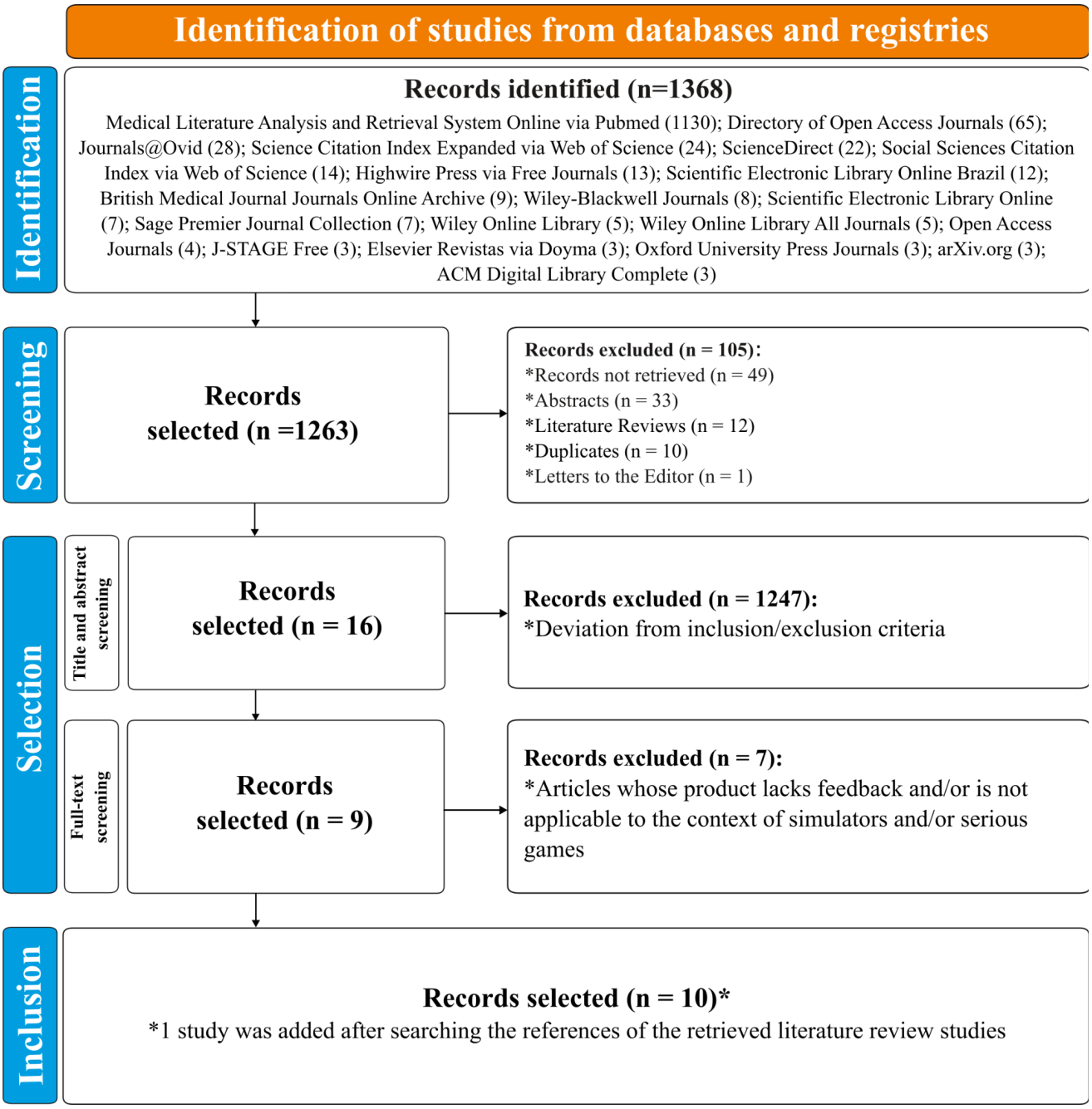
RESULTS AND DISCUSSION

The initial database search yielded a total of 1,368 articles. Following the screening of titles and abstracts, this number was reduced to 16 articles (Figure 1). Ultimately, 10 studies were selected to form the final sample of this work.

The selected articles discuss SGs or simulators for BLS and ACLS training. The identified tools incorporate decision-making with user feedback, and, although not explicitly stated in the texts, it is hypothesized that all of them use Artificial Intelligence (AI) techniques, specifically knowledge-based systems (KBS), for this decision-making or for evaluating user performance. This hypothesis could be explained by the applications' use of feedback based on binary decisions, a method of decision making typically associated with rule-based systems, such as KBS. An KBS defines rules that follow a conditional "if…then…else" structure to provide feedback to the user(6). This approach differs from complex models, such as machine learning, which, although promising, require greater computational infrastructure and higher costs, and at times lack transparency in their decisions(18).

Some studies featured applications in a hybrid modality, meaning they use unconventional devices for interaction or visualization. These devices can provide haptic sensations, such as vibration or resistance to user movements from haptic devices, or real tactile sensations

Figure 1: Flowchart of the search and study selection process.



Source: Author's data, 2024.

Some studies featured applications in a hybrid modality, meaning they use unconventional devices for interaction or visualization. These devices can provide haptic sensations, such as vibration or resistance to user movements from haptic devices, or real tactile sensations when high-fidelity mannequins are used. These applications implement ER technologies, which encompass both VR and Augmented AR. It's worth clarifying that VR refers to interactive, computer-generated, three-dimensional graphical environments that allow the user to interact with virtual elements properly registered three-dimensionally with the real physical space. In contrast, AR refers to simulations where users are transported to a virtual reality enriched with elements that are part of the real world(19). The platforms on which the applications were run fell into three specific types: computers (PC or notebook), mobile devices, and all-in-one headsets. The latter platform refers to headsets that have their own integrated processing capabilities (e.g., Meta Quest or Oculus Rift).

For data extraction, two tables were created based on the study's objectives. The first of these (Table 2) synthesized information regarding the modality, platform, software type, setting, assessment type, assessment technique, response format, and the intended scope for each SG, simulator, and/or application. The scope of the database review was supplemented by a product search using the Google search engine to identify digital tools for ACLS and BLS training that could be classified as an SG or simulator. During this process, "Simsave" (https://www.simsave.com.br/) was identified and added to Table 2 as S11.

To improve the visualization of the assessment types in the studies found, classifications were used. These were established from an integrative literature review that had a strong focus on the technical evaluation of individuals(4). This evaluation can be classified into three types: real-time alert/segmentation mechanisms, user activity logs, and progress indicators. With real-time alert/segmentation mechanisms, the user receives automatic feedback on their performance in the simulator through multimedia resources like sounds, images, and, in some cases, alerts directed to the tutor. In user activity logs, the simulator produces a report of the individual's activities after the tool's use is finished. This report shows the user's scores, as well as their strengths and weaknesses. Finally, progress indicators, which also act as motivational tools, aim to evaluate if the user has reached the expected level of performance. This is achieved by giving points for correct actions or by gating progress to subsequent activities.

Based on a review of the selected articles, similar points were identified and related to a set of guiding questions. This allowed for a synthesis of the studies' characteristics in light of these questions, as shown in Table 3. The six guiding questions were: Q1: Was content validation of the finalized application performed by BLS and ACLS experts? Q2: Does the study include test and control groups? Q3: Was there randomization of participants for group composition? Q4: Was usability validation performed? Q5: Was a structured satisfaction assessment conducted? Q6: Is the application available to the public?

Table 2: Selected Studies.

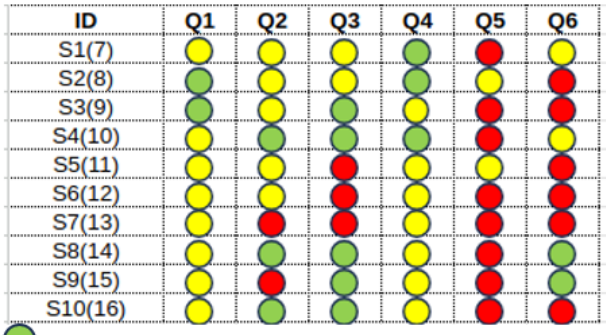
ID	Modality	Platform	Software Type	Environment	Assessment Type	Assessment technique	Feedback Type	Users	Content	Scope
S1(7)	Digital	Mobile	SG	2D	• Progress indicators	KBS	• Motivational phrases	General public	ERC	BLS
S2(8)	Hybrid	PC	Simulator	Augmented Reality	• User activity log	KBS	• Activity log report	Physician/Nurse	AHA	BLS
S3(9)	Hybrid	PC	Simulator	Virtual Reality	• Real-time alert/segmentation mechanisms	KBS	• Real-time feedback on performance	Physician/Nurse	AHA	ACLS
S4(10)	Digital	PC and Mobile	SG	2D	• Real-time alert/segmentation mechanisms • User activity Log • Progress indicators	KBS	• Real-time audio and visual effects • Final report.	General public	ERC	BLS
S5(11)	Hybrid	All-in-one headset.	Simulator	Extended Reality	• Progress indicators • Real-time alert/segmentation mechanisms • User activity Log	KBS	• Real-time audio and visual effects • Performance report and assessment	Physician	AHA	BLS
S6(12)	Digital	All-in-one headset and PC	SG	Virtual Reality	• User activity log	KBS	• Report on errors and correct actions	Nurse	ERC	ACLS
S7(13)	Digital	PC	SG	3D	• Real-time alert/segmentation mechanisms	KBS	• Real-time audio and visual effects	General public	ERC	BLS
S8(14)	Digital	PC and Mobile	SG	3D	• User activity log • Real-time alert/segmentation mechanisms • Progress indicators	KBS	• Scores • Performance reports • Motivational messages	General public	ERC	BLS
S9(15)	Digital	All-in-one headset.	Simulator	Virtual Reality	• User activity log	KBS	• Report	Physician	AHA	ACLS
S10(16)	Hybrid	All-in-one headset.	Simulator	Augmented Reality	• Real-time alert/segmentation mechanisms	KBS	• Compression quality parameters	Physician	ERC	BLS
S11	Digital	PC and Mobile	Simulator	Virtual Reality	• Progress indicators • User activity log	KBS	• Activity log report	Physician/Nurse	AHA	ACLS

Source: Author's data, 2024.

The development process for technologies geared toward academia, particularly those involving the training and skill development of health professionals, requires an interdisciplinary approach. This is crucial, as these tools are used to prepare professionals and students for procedures that will be performed on humans in real-life situations. Therefore, content validation by specialists is essential before a product is commercialized or released to the public, with the utmost attention given to the accuracy of the content.

Most applications focused primarily on the conceptual training of ACLS or BLS protocols. Of the 10 articles that made up the review sample, only studies E2 and E3 reported that the developed applications underwent structured content validation. The other articles mentioned some form of content validation, but these were not well-structured or methodologically sound, which is why they were classified as insufficient for Q1 in Figure 4. Regarding usability assessment (Q4), only S1, S2, and S4 documented having performed one. As for satisfaction assessment (Q5), only two studies mentioned it, but without providing details. In this regard, the tests for Q1, Q4, and Q5 are essential for an application to succeed in its purpose: to ensure users have a tool with reliable content and functional quality that also generates satisfaction, thus facilitating their learning of the content.

Table 3: Selected studies characteristics classification.



Source: Author's data, 2024.

All articles verified the effectiveness of the applications to supplement ACLS or BLS training. However, only in studies S4, S8, and S10 was this done using test and control groups (Q2).

Of the 11 studies presented in Figure 3, seven (S2, S4-S6, S8-S9) utilized user activity logs as a method for evaluation or feedback. A study(4) found this approach to be effective in encouraging users to reflect on their actions, which hinders the common practice of trial and error often seen in applications that use real-time alert and segmentation mechanisms.

It is worth highlighting the relevance of making the tools mentioned in the studies available, as this allows other researchers to use them and conduct new research aimed at technological development, thereby promoting advancement in the field of application. It was observed that only four studies (S1, S4, S8, and S9) made their applications accessible to the public, either for free or commercially. However, only studies S8 and S9 still have operative links.

It is worth noting that some technological limitations prevent the practical training of cardiac massage, which is an essential component of a cardiorespiratory arrest and is encompassed by ACLS and BLS protocols. Based on this, only mannequin-based studies (S2, S5, and S10) allow for the user to be evaluated on the depth, recoil, and ergonomics of the compressions. Furthermore, S3, S8, and S9 enable the incorporation of more than one professional within the simulation, although there is no noticeable assessment of team communication.

Complementary to the literature review, a survey was conducted with 100 medical students from the state of Paraíba, Brazil, to understand their perceived interest or need regarding the use of these tools. When asked about their interest in an application for practicing ACLS or BLS, 76% of participants showed interest, with this percentage rising to 96% for applications in a game format, such as serious games. It is also worth noting that 58% of these individuals reported that using resources on mobile devices during their undergraduate course has enhanced their academic performance. Given the popularity of mobile devices, the findings from the student survey demonstrate that using these devices as a learning tool can enhance academic performance. Based on this, studies S1, S4, and S8 also featured tools compatible with this platform. Therefore, in addition to making training more accessible, the development of ACLS and BLS training applications for mobile devices may allow for a greater diffusion of knowledge when compared to the other platforms addressed in Table 3. It is worth noting that only the tool from study E8 is available for free, which could be a restrictive factor for access to new educational methodologies.

CONCLUSION

The review focused on studies about ACLS and BLS in general, excluding nuances such as life support in trauma or for specific age groups. There are still significant gaps in the development of robust educational Serious

Games (SGs) and simulators, as they lack structured validations for efficacy and often do not provide support materials for instructors. Although the analyzed tools are based on international protocols from the AHA and ERC, which ensures their reliability, the majority of the reviewed studies showed a lack of usability and satisfaction testing. This compromises their potential for application in educational settings(17).

The forms of feedback present in these tools highlight the need for a deeper approach. The goal is to make the feedback capable of fostering a student's critical reflection on their errors, thereby improving their professional practice. Various AI techniques can contribute to such analyses, depending on the variables addressed by the application(6).

The survey with medical students showed interest in mobile learning tools, suggesting that SGs for mobile platforms are an accessible option for development in this field. However, advanced technologies like vibration and AI are still underexplored in ACLS and BLS SGs and simulators, with some tools limited to technological prospects. In summary, interactive digital training shows potential for educational applications, but there is a need for evaluation techniques that can address the complexity and multidimensionality of the health-disease process.

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