Thieme

How to Play a Game Properly – Enhancing Obstetrics and Gynecology Education through Gamification: A Scoping Review

Wie spielt man das Spiel richtig – der Einsatz von Gamification zur Verbesserung der geburtshilflichen und gynäkologischen Ausbildung: eine Scoping-Übersicht

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ABSTRACT

Background
Effective healthcare relies on well-trained professionals, and the quality of their training is dependent on appropriate learning methods and assessment techniques. Gamification, the use of game mechanics in non-game environments, has emerged as a promising strategy in medical education. This review explores the applicability and effectiveness of gamification in obstetrics and gynecology education.

Methods
Adhering to PRISMA guidelines, a comprehensive search was conducted on PubMed, Google Scholar, Embase, and Medline databases from January to March 2023. The search terms included "medical students OR residents OR physicians OR midwives AND games OR educational games OR serious games AND gynecology OR obstetrics". The inclusion criteria encompassed studies published in English or German from 1990 to March 2023, focusing on gamification in gynecology and obstetrics education. Data extraction and analysis were structured using the PICOS framework.

Results
The review identified various studies demonstrating the effectiveness of gamification in obstetrics and gynecology education. Gaming shows like Jeopardy significantly boosted knowledge retention and engagement. VR technologies, such as Second Life, enhanced emergency and surgical training. Improvisational games improved empathy skills, though requiring reinforcement. Video games and laparoscopy trainers showed promise in enhancing surgical skills, with gamers performing better in initial tasks. Custom-developed games like Play and Learn for Surgeons significantly improved procedural skills.

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Discussion
Gamification in obstetrics and gynecology education boosts learner engagement, knowledge retention, and practical skills. VR technologies and video games are effective for surgical training, while custom games can enhance specific procedural skills. Further research is needed to optimize and integrate gamification strategies into standard curricula, offering a modern approach to equip healthcare professionals with essential skills and knowledge.

ZUSAMMENFASSUNG

Hintergrund
Eine gute Gesundheitsversorgung beruht auf gut ausgebildeten Fachkräften. Die Qualität ihrer Ausbildung hängt aber auch von den richtigen Lernmethoden und Beurteilungstechniken ab. Gamification, d. h. der Einsatz von Spielmechanismen in spielfremden Umgebungen, hat sich in der medizinischen Ausbildung als vielversprechender Ansatz entpuppt. Dieser Übersichtsartikel untersucht die Anwendbarkeit und Leistungsfähigkeit von Gamification in der geburtshilflichen und gynäkologischen Fachausbildung.

Methoden
Unter Einhaltung der PRISMA-Richtlinien wurde von Januar bis März 2023 eine umfassende Suche in den Datenbanken PubMed, Google Scholar, Embase und Medline durchgeführt. Zu den Suchbegriffen gehörten „medical students OR residents OR physicians OR midwives AND games OR educational games OR serious games AND gynecology OR obstetrics“. Einschlusskriterien waren Studien, die zwischen 1990 und März 2023 auf Englisch oder Deutsch veröffentlicht wurden und den Einsatz von Gamification in der gynäkologischen und geburtshilflichen Ausbildung untersuchten. Datenextraktion und -analyse wurden mithilfe des PICOS-Modells strukturiert.

Ergebnisse
Diese Übersicht identifizierte verschiedene Studien, welche die Effektivität von Gamification in der geburtshilflichen und gynäkologischen Fachausbildung beschrieben. Spielshows wie Jeopardy haben die Erinnerung an das vermittelte Fachwissen und das Engagement der Lernenden signifikant verstärkt. VR-Technologien wie Second Life trugen zu einer Verbesserung des Notfalltrainings und der chirurgischen Ausbildung bei. Improvisationsspiele vertieften die Empathiefähigkeit, obwohl eine Verstärkung nötig war. Videospiele und Laparoskopietraining stellten einen vielversprechenden Ansatz bei der Verbesserung der chirurgischen Kompetenz dar, wobei Gamer bei der Erledigung von Aufgaben zunächst besser abschnitten. Eigens entwickelte Spiele wie Play and Learn for Surgeons führten zu einer signifikanten Verbesserung der Fachkompetenz.

Diskussion
In der gynäkologischen und geburtshilflichen Fachausbildung förderte Gamification das Engagement bei den Lernenden, verbesserte die Erinnerung an das vermittelte Fachwissen und steigerte die praktischen Fähigkeiten. In der chirurgischen Ausbildung stellen VR-Technologien und Videospiele effektive Methoden zur Wissensvermittlung dar, und speziell angefertigte Spiele können bei der Aneignung spezifischer Fachkompetenzen behilflich sein. Weitere Forschungen werden benötigt, um Gamification-Strategien zu optimieren und sie in den Standardlehrplan zu integrieren. Während der Fachausbildung medizinischer Fachkräfte stellt Gamification einen modernen Ansatz für die Vermittlung von Fachwissen und wichtigen Fachkompetenzen dar.

Introduction

Effective healthcare relies on well-trained professionals, and the quality of their training is crucially dependent on the selection of appropriate learning methods, objectives, and assessment techniques. One innovative approach gaining traction in medical education is the incorporation of serious gaming through gamification [1]. Recognized as an effective teaching strategy in various fields, gamification is now being explored for its potential to enhance medical training [2].

The concept of serious gaming has evolved over time. Initially, it referred to games with a primary educational purpose. Today, serious games are designed to combine education and entertainment, making learning more engaging and enjoyable. This dual focus has positioned serious games as a powerful tool in transforming traditional learning into interactive and immersive experiences.

The integration of serious gaming into medical education has gained significant momentum, offering new possibilities for teaching and learning. Serious games are used in two main areas within healthcare: training healthcare professionals and educating patients. This versatility highlights the potential of serious games to address diverse educational needs [3].

Gamification involves applying game mechanics in non-game environments to improve engagement and outcomes. Unlike conventional games, serious games aim to achieve specific educational goals, with the educational content seamlessly integrated into the gaming experience. The main objectives are to impart knowledge, enhance skills, and promote targeted behavioral changes through engaging game mechanics. Key elements such as immersion in virtual environments, storytelling, visually appealing settings, and creating a flow experience—where challenges and skills are balanced—significantly contribute to the effectiveness of serious games in education [4, 5].

Traditionally, medical education has relied on didactic teaching methods like lectures. However, there is a growing emphasis on teaching practical skills, which cannot be effectively delivered through lectures alone. Innovative formats, such as bedside teaching and problem-based learning seminars, are becoming more common. Established examination formats, like the Objective Structured Clinical Examination (OSCE), support this shift. However, teaching practical skills in clinical settings is often limited by the need to protect patient privacy and time constraints [4]. Emergency situations, in particular, require rapid, precise actions, leaving little room for supervised teaching.

Simulations provide a solution by offering a controlled environment where procedures can be practiced without real-world constraints. Many universities have integrated simulations using teaching models, recognizing them as a reliable method for teaching practical skills. Advances in digital technology further enhance simulations, enabling various scenarios and providing new alternatives to traditional training models. Devices such as video game consoles, smartphones, virtual reality (VR) headsets, and online platforms can create immersive learning experiences.

The effectiveness of educational games in medical training is closely linked to the availability of technological devices and the trainers' expertise in using gamification. Selecting suitable learning methods, objectives, and assessment techniques is crucial for high-quality education. Reliable data is essential to validate the methodology and feasibility of these innovative teaching formats [4].

This systematic literature review aims to evaluate the integration of gamification into medical education as both a teaching and examination format. The review seeks to identify opportunities to optimize the teaching of medical knowledge and practical skills, enhancing the educational experience for medical students. By systematically analyzing existing research, this study aims to provide insights into the potential of gamification to revolutionize medical education, ensuring future healthcare professionals are equipped with the necessary skills and knowledge to excel in their field.

Methods

This literature review adheres to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. We aimed to systematically evaluate the current state of gamification in obstetrics and gynecology education by conducting a comprehensive search and analysis of relevant studies.

We conducted an extensive search of the PubMed, Google Scholar, Embase, and Medline databases on from January to March 2023. The search strategy was meticulously developed to encompass a broad range of relevant studies. The search terms used included: "(medical students OR residents OR physicians OR midwives) AND (games OR educational games OR serious games) AND (gynecology OR obstetrics)." We chose these keywords to capture studies related to various educational levels and healthcare roles, as well as to encompass different types of gamification and its applications in obstetrics and gynecology. The search was limited to records published from 1990 to March 2023 to ensure the inclusion of contemporary studies reflecting current trends and technological advancements. We also applied the text availability filter for abstracts to facilitate the initial screening process.

The inclusion criteria for the review were as follows:

1. Studies published in English or German to ensure accessibility and comprehensibility.
2. Studies focusing on medical students, residents, physicians, or midwives involved in gynecology and obstetrics education.
3. Research that involved the use of games, educational games, or serious games as part of the educational intervention.
4. Studies that provided comparisons between gamification methods and traditional teaching formats.
5. Studies that evaluated outcomes related to knowledge gain, skill development, and practical application in gynecology and obstetrics.
6. Various study designs were included, such as prospective studies, retrospective studies, observational studies, and intervention studies.

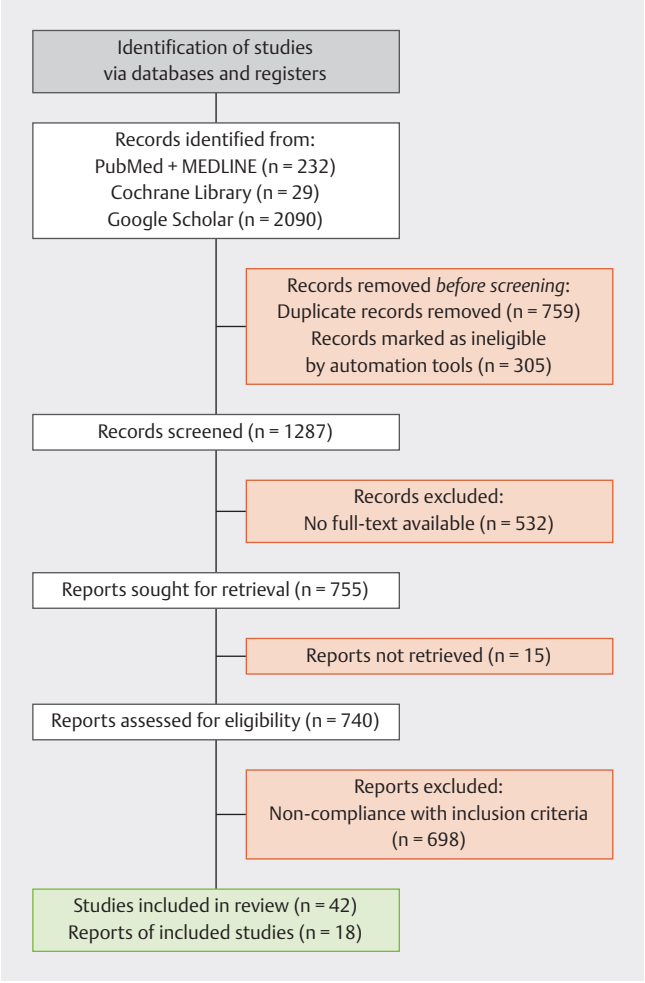
We excluded studies that did not meet these criteria, such as those not focused on obstetrics and gynecology or those that did not include a comparative element between gamification and traditional educational methods.

The review process is shown in ▶ **Fig. 1**.

The initial database search yielded numerous records, which were then screened based on titles and abstracts by two independent reviewers. Each reviewer assessed the records against the inclusion criteria. In cases where there was disagreement or uncertainty regarding a study's eligibility, the reviewers discussed the study in a consensus meeting to reach a final decision. This process ensured that the selection of studies was thorough and unbiased. For a comprehensive assessment, we employed the PICOS (Participants, Intervention, Comparison, Outcome, Study type) framework (▶ **Table 1**). This structured approach helped in systematically categorizing and analyzing the selected studies. ▶ **Table 1** outlines the data extraction focused on identifying the study population, the type of gamification intervention used, the nature of the comparison with traditional methods, and the outcomes measured. We extracted detailed information about study design, sample size, duration of the intervention, and key findings related to knowledge enhancement and practical skills develop-

▶**Table 1** PICOS scheme for the study.

Criteria	Inclusion criteria
Population	Medical students, (assistant) physicians in gynecology, clinical staff in gynecology
Intervention	Games, educational games, serious games
Comparison	Comparison of the different forms of gamification and traditional teaching formats
Outcome	Analysis of knowledge gain and practicability in gynecology
Study Design	Prospective studies, retrospective studies, observational studies, intervention studies



▶ **Fig. 1** This systematic literature review was conducted according to the preferred reporting items for systematic reviews and meta-analyses (PRISMA) guidelines. The figure displays the review process, at the end 42 of 2351 articles have been included.

ment. The extracted data were synthesized qualitatively. We grouped studies based on the type of gamification intervention and compared the outcomes with traditional teaching methods. Where possible, we conducted a narrative synthesis to highlight common themes, benefits, and limitations of gamification in obstetrics and gynecology education. Quantitative data, such as pre- and post-intervention test scores, were tabulated to illustrate the impact of gamification on knowledge and skills.

Results

The systematic review identified a diverse array of studies that explored the application of gamification in obstetrics and gynecology education. These studies demonstrated the potential of gamified learning to enhance knowledge retention, practical skills, and learner engagement across various educational levels, from medical students to practicing clinicians. The results are categorized based on the types of gamification interventions used, including gaming shows, virtual reality (VR) technologies, improvisational games, video games and laparoscopy trainers, and custom-developed educational games. Each category highlights the distinct advantages and challenges associated with different gamification approaches.

The studies included in the review are shown in ▶ **Table 2**.

Gaming shows

Games in the form of a competition with the chance of winning have been proven to increase knowledge. In a Jeopardy game, Power Point presentations can be replaced quickly and cheaply. In this game format, the right questions are sought in response to various possible answers. The answers are divided into different levels of difficulty with different chances of winning. A randomized controlled trial was conducted at the University of Michigan in which third-year medical students completed either a standard lecture or a Jeopardy-style educational game on the topic of ectopic pregnancy. Pre- and post-tests were conducted, as well as a satisfaction survey in the form of questionnaires. Both learning units were designed according to the Association of Professors of Gynecology and Obstetrics (APGO) learning objectives. The game categories were epidemiology and differential diagnosis, risk factors, signs/symptoms, diagnosis and treatment. The result showed a significant increase in knowledge in both groups ($n = 104$), ($p < 0.001$), whereby the increase in knowledge was almost identical. It should be noted that the participants in the Jeopardy game rated the interaction between lecturers and teachers, as well as the retention of information and the fun factor higher than in the standard lecture [6]. The same concept was used in another study with 38 gynecology residents. These were also randomly divided into two groups, one of which received the content on reproductive infectious diseases (RID), sexually transmitted infections (STI) and the management of the serious long-term consequences of STIs in the Jeopardy concept, while the other group received this content in a traditional didactic curriculum. The Jeopardy group had significantly higher median scores on the posttest of the survey questionnaires regarding knowledge gain as well as higher scores in the assessment of self-confidence than the group with the traditional didactic curriculum [7]. A similar game show was already described in 1996, in which the most important content about lactation was taught to residents [24].

Practical skills – VR technologies and other digital learning applications

Virtual training rooms are already well established, especially in emergency medicine. Ohio State University established a complete emergency room via the immersive learning environment Second Life, a free and freely accessible computer software. Both the examinees and the examiners are projected in the form of an avatar. The examiner can take on the role of the patient directly and communicate with the examinee via headset and computer. Diagnostic data (initial and repeated vital signs, laboratory reports and diagnostic imaging) can be displayed in real time by the examiner in the virtual examination room. In a randomized study, the attitudes and performance of emergency medicine residents were compared between a traditional oral exam and a virtual

▶**Table 2** Data originated from full-text articles is presented in a table to illustrate the various interventions and the heterogenous studies in medical education and OBGYN.

Reference	Intervention/ Gamification	Study design	Location	Participants	Number	Method	Publication year
O'Leary et al. [6]	Game show	Randomized controlled	University Michigan (USA)	Medical students	104	Survey	2005
Butler et al. [7]	Game-Show	Randomized controlled	Brigham and Women's Hospital Boston (USA)	residents	38	Survey	2020
Bou Nemer et al. [8]	Gaming Lab (Labor Games)	Interventional	University of Miami (USA)	Medical students	97	Survey	2016
Cai et al. [9]	Improvising game	Interventional	Women and Infants Hospital New England (USA)	Medical students	22	Survey	2019
Mc Grath et al. [10]	Virtual patients – simulation	Randomized controlled	State University Wexner Medical Center, Columbus, Ohio (USA)	Residents	35	Survey and examiner's assessement	2015
Uribe-Ocampo et al. [11]	Serious game (SIM-GIC) – Virtual patients – simulation	Feasibility	Department of Simulation in Healthcare, Universidad Pontificia Bolivariana, Medellin (Columbia)	Medical students and residents	/	Data collection	2019
Ebner et al. [12]	Virtual ultrasound simulation app	Observational	University of Ulm (Germany)	Medical students	66	Survey, measured time and examiner's assessment	2019
Jean et al. [13]	Serious game VR-technology	Feasibility	Gynecology Surgery, Hospital Jeanne de Flandre, University of Lille (France)	residents	/	/	2016
Parham et al. [14]	VR-Simulation, Computer-Hardware	Feasibility	Zambia and Malawi	residents	/	/	2019
Benda et al. [15]	Serious game	Randomized controlled	multicentered	Residents, midwives, labor nurses	36	Survey and examiner's assessement	2020
Sharifzadeh et al. [16]	Serious Game	Interventional	Masshad University of Medical Science, Zahedan University of Medical Sciences (Iran)	Experts and residents	13 + 46	Survey	2021
Alvare et al. [17]	CT brush/Cancer Zap – serious game	Feasibility	University of Manitoba (Canada)	/	/	Feasibility	2015
Ashley et al. [18]	Robotic and laparoscopic surgery training	Randomized controlled	University of Vermont (USA)	Medical students	31	Measured time	2019
Ju et al. [19]	Playstation or Wii Training	Randomized controlled	University of North Carolina (USA)	residents	42	Examiner's assessement	2012
Borahay et al. [20]	Laparoscopic box trainer	Cross-sectional	University of Texas Medical Branch at Galveston, Texas (USA)	High school students vs. residents	28	Survey examiner's assessement	2014
Chalhoub et al. [21]	Smartphone games	Randomized controlled	Saint Joseph University, Beirut (Lebanon)	Medical students	45	Measured time Examiner's assessement	2018
Öge et al. [22]	Video games and laparoscopic skills	Cross-sectional descriptive	University of Texas Medical Branch at Galveston, Texas (USA)	Medical students	22	Measured time Examiner's assessement	2015
Fanning et al. [23]	Video games and laparoscopic skills	Randomized controlled	Pennsylvania State University (USA)	Medical students and residents	30	Measured time Examiner's assessement	2010

simulation using Second Life. There were no differences in the ratings between the virtual and traditional groups. Only the assessment of clinical competence was found to have a moderate effect size in favor of the Second Life group. In addition, the virtual format was preferred and experienced as less intimidating [10].

A low-cost VR simulation was designed to train trainee surgeons to perform a radical abdominal hysterectomy. The simulation consisted of commercially available computer game hardware (1500 US dollars). The aim was to use this low-cost alternative to speed up the training of surgeons and improve the quality of operations [14].

At the University of Miami, a "gaming lab" was set up to prepare students for a clinical traineeship in obstetrics and gynecology, in which the students went through seven stations to acquire practical skills. The stations included reading fetal heart sounds, knot tying, intraoperative knot tying/suturing, measuring cervical dilatation, amniotomy, estimating fetal weight and estimating blood loss. This format should provide a cost-effective alternative to VR-based clinical preparation courses. The evaluation of self-assessment questionnaires (n = 97) showed a significant increase in knowledge and a subjectively better feeling of preparation for the clinical traineeship [8].

The aim of this study was to compare an online course and a serious game to prepare medical students for simulation-based mastery learning on the management of sudden cardiac arrest. The serious game used was Staying Alive, which included a realistic 3 D environment, and the online course included a PowerPoint lecture. The serious game used in this study was not superior to an online course for training medical students in the treatment of cardiac arrest. The lack of correlation between student performance assessed during two training sessions four months apart suggests that some elements of cardiac arrest management, such as compression depth, can only be partially learned and retained after simulation-based training [25].

Improvisational game

The Women and Infants Hospital of Rhode Island conducted a prospective cohort study in which gynecology residents underwent one hour of empathy training with four improvisational games. A survey on empathy was conducted before and up to six months later. According to the survey questionnaire, all 22 residents improved their empathy skills and their way of working as a result of the workshop immediately after the training but fell back to their initial values after six months. However, an improvement in working practices as a result of the workshop remained over this period [9].

Video games/laporoscopy trainer

At Pennsylvania State University, a comparison was made between 15 adolescent experienced video game players and 15 gynecology residents with no video game experience on a laparoscopic simulator. The experienced video gamers were significantly faster at performing the three laparoscopic tasks, suggesting that the virtual reality skills provided by video gaming are reflected in improved laparoscopic skills of the video trainee [23].

Another study compared the effects of two cohorts, Playstation 2 vs. Wii, in terms of their skills in the laparoscopy trainer. Both video games improved performance speed in the bead transfer course and in suturing [19]. The authors suggest using video games as a cost-effective preparation for the laparoscopy trainer and laparoscopic activity. The video games could be a cost-effective alternative to the laparoscopy trainer.

A comparison of a cohort of students trained in video gaming also showed no differences between students and gynecology residents, who were experienced in laparoscopy in simple courses in the laparoscopy trainer [20]. However, the video-gaming student cohort required significantly more time for more complex tasks.

The serious game Touch Surgery (TS) and the virtual reality (VR) trainer Lap Mentor were compared in a hernia operation. The results show that TS provided an additional benefit to improve performance on the VR trainer for task 1, but not for task 2. A transfer of skills from the VR trainer to the TS could not be demonstrated [26]. VR and TS should therefore initially be used in combination with TS in multimodal training in order to ensure optimal training conditions.

A total of 45 medical students with no previous surgical experience were divided into three groups: Player (n = 20), Control (n = 10) and Intervention (n = 15). They completed the laparoscopic skills testing and training model developed by the European Academy of Gynecologic Surgery in two sessions. All five intervention participants were asked to play a different smartphone application game every day for two months between the two sessions. A significant advantage of gamers over non-gamers was found in session 1 ($p = 0.002$). There was no significant difference between the two non-gamer groups ($p = 0.96$) or between the three intervention subgroups ($p > 0.05$). The performance of all participants improved between sessions. There was no significant difference in performance between the control group and the gamers ($p = 0.121$), nor between the intervention group and the gamers ($p = 0.189$). A significant advantage was found in the development of laparoscopic skills in the intervention group compared to the control group ($p = 0.035$) [21]. In conclusion, previous video-gaming experience is a significant factor for better laparoscopic skills when using the virtual reality simulator for the first time. Recent and regular smartphone gaming practice significantly improves laparoscopic skills in non-gamers, regardless of the type of game. Smartphone gaming appears to positively influence some specific laparoscopic skills more than others [21].

This was also observed in a descriptive cross-sectional study with 22 participants. Medical students with video-gaming experience and without video-gaming experience were compared in simulated robot-assisted surgical techniques. During training, the video-gaming groups performed better in terms of the completion time of the individual exercises ($p > 0.05$), while the non-video-gaming group achieved better results in three other exercises. However, none of the differences were found to be statistically significant ($p > 0.05$), and there were no statistical differences between the two groups ($p > 0.05$) in overall scores based on time to complete exercises, economy of movement, collision with instruments, use of excessive instrument force, instruments out of field of view and range of master workspace [22]. Similar results were obtained in a study of 31 medical students who were divided

into a robotic surgery and a laparoscopic group in a randomized controlled trial. The results were not statistically significant with or without previous gaming experience. All non-experienced participants were able to achieve the same scores through box training [18].

This data suggests that video gaming, smartphone app, regular gaming and serious gaming, can be useful as preparation for laparoscopy training, but cannot replace laparoscopy box training. Video gaming does not adequately teach the skills required for more complex movement sequences [20, 21, 26].

Twenty-nine participants (medical students or residents in surgical specialties) volunteered to perform three exercises of increasing complexity in a laparoscopic box trainer that simulated eye-hand coordination tasks in a videoendoscopic surgical laboratory environment. Fourteen subjects participated in a two-week exercise program of four weeks duration with an inanimate trainer. Fifteen subjects did not practice with the laparoscopic trainer during the four weeks. Both groups were tested after demonstrating three exercises at the beginning and end of the four-week period, with all subjects performing the exercises in seclusion. Both groups increased their level of performance (time and accuracy) over the four weeks, but the improvement was significantly greater in the exercising subjects [27].

There is no significant difference in performance when comparing students with an inclination towards mechanical activities, video games, experiences. Therefore laparoscopic box trainings are a relatively inexpensive way of acquiring basic eye-hand coordination skills, regardless of previous experience [27].

Developed educational games

There are serious games designed specifically for teaching and training purposes. Simulations are particularly suitable for rare emergency situations to enable training for the initial case. The game Play and Learn for Surgeons (PLS) was specially developed for a teaching study. In this game, the ligation of the uterine artery and the uterine ovarian artery (UAL and UOAL) was taught. In this study, gynecology residents were divided into control and intervention groups [16].

Overall, PLS significantly improved residents' skills in UAL ($p = 0.018$) and UOAL procedures ($p < 0.001$). These results underline that serious games may be an effective and cost-effective approach for training obstetrics and gynecology residents for UAL and UOAL procedures.

In a further study, a serious game was compared with a conventional simulation.

In this study, a mixed methods approach was used to evaluate the effectiveness of the new serious game-based training method and to assess participants' perceptions. Participants were randomly assigned to traditional simulation training in a center with mannequins or to serious game training. They then took part in an obstetric in-situ simulation scenario to assess their learning. Participants also completed a post-training perception questionnaire.

The primary outcome of this study was participant performance in an in-situ mannequin simulation scenario following a washout period after training. No significant statistical differences in overall performance were found between the mannequin-based and serious-game-based groups, although the study was not adequately analyzed to determine non-inferiority. Survey questions were tested for significant differences in participants' perceptions of the teaching method, but none were found. Qualitative feedback from participants indicated important areas for improvement, with a focus on the realism of the game.

In conclusion the developed serious game training tool has potential utility for training individuals who do not have access to large simulation centers; however, further validation is needed to demonstrate whether this tool is as effective as mannequin simulation [15].

There are attempts to create a virtual reality in the delivery room. Virtual glasses can be used to facilitate the learning of pregnancy and birth pathologies. A serious game specially developed for this case enabled us to combine the actions with a graphic universe. The universe is fully modeled in 3 D and based on photographic references. Oculus Rift was used to immerse the player in virtual reality. Each action in the game was linked to a certain number of points, which could be either positive or negative. In the first phase, the learner is immersed in the role of a doctor in an action scene. In the second phase, the learner is asked to make a diagnosis. Once the diagnosis has been made, various treatments are suggested [13].

Digital serious games that require no additional devices can easily be made available to a large group. Open educational resources in particular should be considered for training and further education purposes during development. It is a cost-efficient solution for teaching content individually.

The serious game CT-Brush is a game in which students have to find a tumor in a CT image with as few movements as possible. In the game, a tumor is searched for by clicking the mouse. A standard MART algorithm (Multiplicative Algebraic Reconstruction Technique) is used. The user selects a subset of the radiation. The image appears when the player moves the CT brush over an initially empty scene, with the dose increasing with each "mouse movement" [17].

Newly developed mobile augmented reality ultrasound simulator apps are also used for ultrasound education and training in sonography. For example, it has been shown that the use of the mobile app improves the quality of kidney measurements by medical students [12].

Discussion

The results of the systemic review suggest that with the help of gamification, courses that previously involved little interaction with students in particular can benefit from an increase in interaction. Small interactions, such as a PowerPoint-based game, can increase the learning effect and impress with the fun factor [6, 7, 24].

Studies have also shown that clinical skills are easier to test in a virtual scenario. Emergency care in particular can benefit from virtual rooms. Situations that are very fast and well-rehearsed in reality can be replayed more slowly for students [10].

Minimally invasive therapy is increasing significantly, so surgical training concepts need to be adapted. Laparoscopy trainers have become established for training hand-eye coordination and for

learning how to use laparoscopy instruments. Studies have shown that laparoscopy training can be further optimized using smartphone games or commercial video games, which seem to focus primarily on improving hand-eye coordination.

It has long been known that gamers are initially superior to non-gamers in laparoscopy, but these advantages are leveled out in laparoscopic training [20, 21, 22]. This underlines the need for widespread access to laparoscopic boxtraining. As preparation for an operational training curriculum, video and smartphone games can be integrated into a multimodal concept.

Looking at the surgical training of gynecologists, for example, virtual learning of surgical steps and techniques is expected to lead to faster and improved surgical training [13, 16]. Here, too, the focus is on preparation for emergency operations, e.g. for rapid hemostasis. Serious gaming appears to be a way of practicing surgical steps that cannot be performed regularly in routine operations and preparing them for emergencies.

However, if there is already an established simulation, such as resuscitation training, the data suggests that a VR-supported scenario does not show any added value here, especially in the long term [13, 25].

These findings suggest that teaching formats with minimal interaction can significantly benefit from the incorporation of serious gaming. However, for learning practical skills incrementally, real-world simulators appear to be superior to VR-supported simulations, particularly when established training scenarios exist.

In procedural training, especially in high-risk situations such as in delivery rooms, students benefit from the ability to slowly play through and repeat scenarios. The primary advantage of VR-based scenarios or games is their accessibility. Compared to high-fidelity simulations, VR-based serious gaming can be widely distributed to trainees at a lower cost.

Regular practice of scenarios is crucial, particularly when routine situations can escalate into emergencies. The selection of the appropriate level of gamification or simulation should be guided by the specific learning objectives. In emergency situations where procedural skills are the primary focus, and participants are dispersed across different locations, VR serious games accessible on various devices are preferable due to their broad availability.

For scenarios where the primary goal is to enhance interpersonal behavior and communication within a team, real-world mannequin simulations, potentially in realistic environments, may be the most effective method.

Limitations and Future Perspectives

There is a critical need for more high-quality longitudinal studies to evaluate the sustained impact of gamification on learning outcomes in medical education. Such studies should focus on assessing long-term knowledge retention, skill development, and the enhancement of professional competencies over time. By tracking learners' progress and performance across extended periods, one can gain deeper insights into the effectiveness of gamification in fostering lasting educational benefits and its potential to improve clinical practice and patient care. To accurately measure the effectiveness of gamification in medical education, the development of standardized assessment tools is essential. These tools would allow for consistent evaluation of learning outcomes across various studies and educational settings. Standardized metrics can facilitate comparison and aggregation of data, enabling more robust conclusions about the efficacy of gamification. Such tools should be designed to assess not only immediate learning gains but also long-term retention, application of skills, and overall professional development. While gamification offers numerous benefits, it is important to explore and address potential drawbacks and challenges. Future research should examine issues such as screen time management, ensuring that learners are not exposed to excessive screen use that could lead to burnout or other negative health effects. Cost implications should also be considered, as developing and implementing gamified learning tools can be expensive. Additionally, maintaining a balance between entertainment and educational value is crucial to ensure that the primary focus remains on learning objectives. Understanding these factors will help in designing more effective and balanced gamification strategies. Developing strategies to integrate gamification with traditional educational methods can enhance the overall learning experience. Hybrid models that combine the strengths of both gamified and conventional approaches may provide the most effective training solutions. For instance, using gamified simulations to practice procedural skills while incorporating traditional lectures for theoretical knowledge could offer a comprehensive learning experience. Such integration can cater to diverse learning preferences and reinforce knowledge and skills through multiple modalities. Customizing gamification approaches to fit specific educational contexts, learner demographics, and cultural settings can significantly enhance their effectiveness. Tailored strategies that consider the unique needs and preferences of learners are likely to yield better outcomes. For example, gamification elements designed for residents in a high-pressure clinical environment may differ from those suited for undergraduate medical students.

Conclusion

The effective use of VR-based scenarios, high-fidelity mannequin simulations, serious gaming, and traditional teaching methods depends on clear learning objectives and increased interactivity. Integrating these methods into multimodal educational approaches requires careful consideration of the number of trainees, the scenario type, and trainees' prior knowledge. Serious games should be part of a comprehensive training curriculum to impact educational outcomes. Large-scale studies should explore the combined use of educational games, simulations, hands-on training, and VR and real-world scenarios, systematically integrating these into university and residency curricula for long-term educational benefits.

Conflict of Interest

The authors declare that they have no conflict of interest.

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