

# What do we Evaluate in Serious Games? A Systematic Review

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**Abstract:** Serious games have emerged as an invaluable tool in education, revolutionizing the way students learn and engage with complex concepts. These games combine entertainment with educational content, creating immersive and interactive experiences that enhance learning outcomes. This strategy has positioned themselves as a powerful educational tool recommended for the new generations due to their benefits in terms of motivation, engagement, active learning, development of skills, and adaptation to diverse learning styles. By integrating serious games into educational programs, educators can enhance meaningful learning, foster relevant skills, and prepare students to tackle the challenges of the 21st century. The evaluation of serious games is important for various reasons. For example, it helps determine if a serious game meets its educational objectives and truly promotes learning and the development of specific skills. It also provides feedback on the design, gameplay, effectiveness, and other aspects of the serious game, allowing developers to identify strengths and areas for improvement to optimize the learning experience. Evaluations help determine if the serious game appropriately caters to the needs and characteristics of users, if it is suitable for the target group, if it is accessible to individuals with different abilities, and if it provides an appropriate level of challenge to promote engagement and learning. Ultimately, evaluations provide validation and credibility to serious games as educational tools. This study shows a systematic review of the factors that appear most frequently evaluated, the methodology used, and discusses the possibility of adding new factors and points out the need to consider the opinion of other users to improve the evaluation of these resources.

**Keywords:** Educational innovation, Higher education, Serious games, Game-Based learning, Simulations

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## 1. Introduction and Literature Review

Serious games (SG) have gained increasing attention over the years as they provide a unique way of engaging individuals in learning and training activities (Bellotti, Berta and Gloria, 2010). Learning games have been developed to provide an entertaining and engaging way for individuals to acquire knowledge and skills, while also promoting retention and transfer of learning. These games are designed to facilitate learning in a fun and interactive way, with a focus on enhancing engagement and motivation (Cheng, Huang and Hsu, 2020; Naul and Liu, 2020; Meij, Veldkamp and Leemkuil, 2020). On the other hand, there are authors who affirm that SGs help students to develop critical thinking skills (Madani, Pierce and Mirchi, 2017), improve retention (Bergeron, 2008), increase creativity (Riedel and Hauge, 2011), develop problem-solving skills and decision making (Pacheco-Velazquez, 2022).

One advantage of learning games is that they can provide a safe and controlled environment for learners to practice and apply newly acquired skills and knowledge. For example, simulations can be used to provide learners with an opportunity to practice complex tasks in a realistic setting, without the risks associated with real-world applications (Pacheco-Velazquez and Aguilar-Avalo, 2019; Deshpande and Huang, 2011). Furthermore, games can provide immediate feedback to learners, allowing them to learn from their mistakes and adjust their strategies accordingly (Bellotti et al., 2013).

Learning games can also be tailored to the individual needs and preferences of learners. Individualization, which refers to the customization of the game to the learner's abilities, preferences, and learning style, has been found to enhance engagement and motivation, leading to more effective learning outcomes (Hamari and Tuunanen, 2014; Dobrovsky, Borghoff and Hofmann, 2019). This approach can also help to address the challenges of catering to the diverse needs of learners with varying levels of knowledge and skills (Pacheco-Velazquez and Viscarra-Campos, 2019).

It is important to take individual differences between players into account when designing a SG. Different people learn at different speeds and through different learning styles. Furthermore, players may use different strategies and play styles during the game, and their range of skills and abilities may vary (Xu et al., 2019; Sottillare and Gilbert, 2011). It's also important to recognize that the player interacting with the game is dynamic, which can

lead to issues like loss of motivation or predictability. Considering the individual characteristics and the learning style of the players can affect the perception of the effectiveness of the game (Lindberg and Laine, 2018).

There are many factors that contribute to explaining the effectiveness of SG. In an investigation carried out by Calderon and Ruiz (2015) eighteen factors are listed: aesthetics and design; social impact; interface; player efficacy, motivation, behavior, attitude, emotions, satisfaction, enjoyment, commitment, acceptance, and performance; playability, learnability, and understandability; utility; and educational aspects. In addition to these factors, other studies have identified elements such as feedback, challenge, interactivity, and immersion as key components of SG effectiveness (Soflano, Connolly and Hainey, 2015; Boyle et al., 2016). Other authors have added to all these factors the importance of the setting, the integration of the game with learning, interaction, feedback, and game design (Faizan et al., 2019; Marsh, 2011).

However, there are still several unresolved issues regarding SGs. For instance, some researchers have supported the notion that there is no established methodology for measuring the effectiveness of SGs (Hersh and Leporini, 2019; Serrano-Laguna et al., 2018). Moreover, several factors are poorly defined, leading to confusion about how to measure them (Fokides et al., 2019b). Other researchers have argued that the evaluation of SGs' functional components remains unclear (Zhonggen, 2019) or that it is biased (Connolly et al., 2012). Perhaps the most significant challenge is evaluating SGs. Given the complex nature of their development involving experts from various fields, it is essential to have robust evaluation frameworks that consider all relevant factors, or at least as many as possible (Fokides et al., 2019a). However, this task is nearly impossible due to the diverse genres of SGs, covering different subjects and targeting various user groups.

A very important consideration is to understand what is meant by the effectiveness of a SG. Some authors have focused their studies on specific factors. For example, the impact of SG on engagement and motivation (Kiunsi and Ferwerda, 2019). Others evaluated the role of interface, workload, and usability (Thorpe, Nesbitt and Eidels, 2019). Or the transfer of knowledge acquired during gameplay to real-life situations, which has been highlighted by researchers (Blumberg et al., 2013). Fokides (2019b) affirm that the existing literature on SG is fragmented in terms of the SG that were studied (including their learning content and genre), the context in which they were studied (including target groups and settings), and the factors that were considered. Moreover, there is a lack of research that considers many salient factors. As a result, more research is needed to determine which features are significant in shaping SG learning effectiveness, which can help to resolve ongoing debates about the role of certain factors.

## 2. Methodology

This study presents a systematic review of scientific literature on SG, focusing on the evaluation factors that researchers have used to assess different SG. The review was conducted following the guidelines of the PRISMA statement for conducting systematic reviews (Moher et al., 2009; Welch et al., 2016). The following sections will detail the different phases of the review process.

### 2.1 Systematic Literature Review

In this work, a systematic review of the published scientific literature on SG and their evaluation has been carried out. For its preparation, the guidelines of the PRISMA declaration for the correct performance of systematic reviews have been followed (See Fig. 1). The elaboration process will be detailed in its different phases.

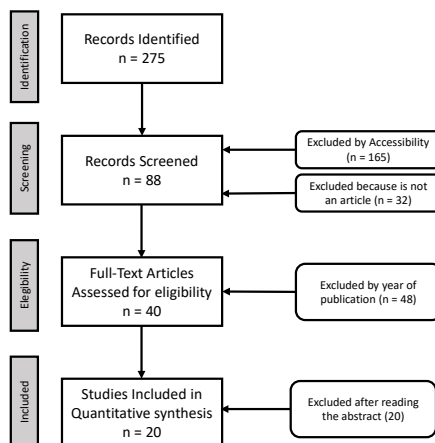


Figure 1: Prisma Flow Diagram

## 2.2 Screening of Documents

*Phase 1. Identification:* The first searches were carried out in April 2023. The search was performed on the SCOPUS databases using the following parameters: TITLE-ABS-KEY: ( ( scale OR survey ) AND ( factors AND serious AND games ) ). The initial search yielded 275 documents.

*Phase 2. Screening:* The search was then narrowed down to only include documents marked as "All Open Access" resulting in 110 documents. Further narrowing the search to only include journal articles resulted in 88 documents.

*Phase 3. Eligibility:* The search was limited to articles published within the last three years (2021 to present), resulting in a final set of 40 documents.

*Phase 4. Included:* After reading the abstract, we recorded 20 documents.

The combination of terms that yielded the best results was the following: TITLE-ABS-KEY((scale OR survey) AND (factors AND serious AND games)) AND ( LIMIT-TO ( OA,"all" ) ) AND ( LIMIT-TO ( DOCTYPE,"ar" ) ) AND ( LIMIT-TO ( PUBYEAR,2023) OR LIMIT-TO ( PUBYEAR,2022) OR LIMIT-TO ( PUBYEAR,2021) )

A summary of the inclusion and exclusion criteria is shown in Table 1.

**Table 1: Inclusion and Exclusion Criteria**

Inclusion Criteria	Exclusion Criteria
Open Access	Year of Publication: 2020 or before
Article in Journal	

## 3. Results

A summary of the results we found in the systematic review is presented in Table 2.

**Table 2: Summary of results**

Author and Year	Study application topic	People considered in the study	Methodology (Data Source)	Variables under study
<b>You et al., 2023</b>	Medicine. Health Care.	Women with cancer	Self-reported surveys and data collected from tablets.	Engagement
<b>Brill et al., 2022</b>	Psychiatry, Medicine, Health Care.	Patients with gambling disorder	Magnetic resonance imaging.	Emotional Control
<b>Mittmann et al., 2022</b>	Computer Science, Mental Health.	The study focuses on pre-adolescent children (10 to 12 years of age)	Surveys and questionnaires	Social Skill Trainings and Social and Emotional Learning
<b>Wong et al., 2022</b>	Nursing.	Higher education students in nursing and medicine	Scoring system with specific mechanisms	Teamwork and learning outcomes
<b>Van Gaalen et al., 2022</b>	Education.	Higher education students in dental and medical studies.	Selection and prioritization of factors on game preferences.	Identification of preferences for game features.
<b>Mystakidis &amp; Christopoulos, 2022</b>	Education.	Teachers from STEM area.	Mixed research study involving a validated survey questionnaire instrument and an online debriefing session	Benefits of using technology in the classroom

Author and Year	Study application topic	People considered in the study	Methodology (Data Source)	Variables under study
Tanner et al., 2022	Finances, Ethics.	Higher education students in banking and finance	Using a study pre-test post-test questionnaire	Promote moral sensitivity in business. To examine the role of social pressure.
Bennis, Kandali & Bennis, 2022	Education.	PhD students	Surveys and questionnaires	Students Motivation. Generation of an adaptable learning game.
Herne et al., 2022	Information Technology, Education, Health Care.	Stroke survivors	Results and score obtained in the simulator	Engagement
Janssen et al., 2022	Health Care.	Adult patients undergoing chemotherapy	Semi-structured interviews	Breaking up the monotony of treatment.
El Machtani El Idrissi et al., 2022	Health Care.	Older adults with major neurocognitive disorder	System usability scale and Semi-structured interviews	Usability of the game
Swinnen et al., 2021	Mental Health. Behavioral Sciences.	High Schools Students	Qualitative data and notes. Semi-structured interviews.	Awareness, empathy, commitment.
Gijzen et al., 2021	Health Care.	General population	Questionnaires and surveys.	Behaviour changes.
Suppan et al., 2021	Environmental.	Architecture undergraduate students	Questionnaire survey and participant observation complemented by interviews	Behaviour changes. Learning.
Gao, Guo and Jiang, 2021	Bioengineering.	Volunteer specialists in risk management/architecture/engineering with more than 5 years of experience	Surveys and qualitative data.	Behaviour of users in a risk environment.
Cavalcanti et al., 2021	Psychology. Health Care.	Adolescents between 11 and 15 years	Surveys and questionnaires. Comparison of results between people who completed and did not complete the game.	Improved self-esteem, affect balance, emotional symptoms, behavioural problems, and hyperactivity
De La Barrera et al., 2021	System Innovation. Informatics. Artificial Intelligence. Machine Learning.	General population from different continents	Comparison of game outcomes between people who played the game the most times (engagement).	Identification of behaviour patterns. Behaviour changes. Engagement.
Hollerit et al., 2021	Technology. Applied Sciences. Neuroscience.	General population divided into two groups according to their age.	Data obtained from the near-infrared brain function imager	Games have a positive training effect on reducing cognitive function decline.
Ge et al., 2021	Education.	Students from introductory	Application of pre and post questionnaires.	Improve learning. Meaningful learning.

Author and Year	Study application topic	People considered in the study	Methodology (Data Source)	Variables under study
		Psychology courses in Higher Education		
Hummel et al., 2021	Rehabilitation. Health Care	Older adults with major neurocognitive disorder	System usability scale and semi-structured interviews	Usability of the game

#### 4. Discussion, Conclusions and Future Works

Serious games find their primary applications in the areas of Health Care (50%) and Education (20%). In the realm of Health Care, the development of these games often incorporates technologies such as virtual reality or augmented reality. The number of research studies on SG in the healthcare field (medicine, nursing, or related areas) seems representative. The use of these games to prevent certain types of mental illness or to create attachment and loyalty to a treatment seems like a very interesting application of these resources.

The distribution of data sources in serious game research indicates that in 30% of the cases, the data is collected from users who belong to some type of school system, particularly higher education students. These students are often participants in educational interventions that utilize serious games to enhance learning experiences and develop specific skills within academic settings.

Additionally, in another 30% of the cases, the participants are patients who use the serious game. This highlights the significant role of serious games in the Health Care area, where they are employed as therapeutic tools or interventions to support patient care, rehabilitation, and health-related outcomes.

The data presented indicates that in the majority of cases (55%), data in serious game research is collected through questionnaires, surveys, or semi-structured interviews. These methods are commonly used to gather subjective feedback, attitudes, and perceptions of participants, providing valuable insights into their experiences and perceptions related to the game-based intervention.

In only 10% of the cases, a scoring system has been developed within the serious game itself, allowing for the measurement of the game's results. This scoring system is likely designed to objectively assess participants' performance, progress, or achievements within the game, providing quantifiable data on their in-game actions and outcomes.

Interestingly, in another 10% of cases, the data is measured using some form of tool that allows for the measurement of the participants' brain function. This could involve the use of neuroimaging techniques such as EEG (electroencephalography) or fMRI (functional magnetic resonance imaging) to study participants' brain activity during gameplay. This approach provides valuable neurophysiological data, enabling researchers to understand how the brain responds to serious games and the cognitive processes involved in the learning experience.

The diverse methods of data collection in serious game research reflect the multidisciplinary nature of the field and the different objectives researchers aim to achieve. While questionnaires and interviews provide insights into participants' perspectives and attitudes, scoring systems within the game enable objective performance measurement, and neuroimaging techniques offer a deeper understanding of the cognitive processes underlying the learning experience. This variety of data collection approaches enhances the overall comprehension and evaluation of serious game effectiveness and its impact on learning outcomes.

An important finding in the systematic review is that although SG is associated with educational purposes, most studies (more than 50% of them) look at changes in player behavior, motivation, or involvement. That is, most of these studies do not focus on measuring the gains associated with user learning, but rather on observing increased engagement, increased motivation, attitude changes, or behavior pattern changes.

The systematic review conducted on various studies involving the use of SG reveals a predominant focus on measuring the effectiveness of the games rather than the specific characteristics associated with them. Among the studies reviewed, only two investigations include user feedback on factors such as feedback, interactivity,

flow, challenge, attention, interest, involvement, clear instructions, among others (Herne, 2022; Van Gaalen et al., 2022).

It is also worth noting that, among these 20 articles, just one of these studies (Mystakidis & Christopoulos, 2022) considers making an evaluation of the tutors or teachers involved. It is crucial to evaluate not only the effectiveness of the SG on the end-users, but also on the educators who are using the game in their teaching. This can provide insight into how the game can be improved to better support the educators' teaching goals and help them to effectively integrate the game into their curriculum. It also highlights the need for more research to be conducted on the impact of SG on educators and their teaching practices.

Finally, the authors consider that a good practice would be to conduct more studies considering the opinions of the people who coordinate the use of these resources (teachers, tutors or coaches). Surely their experience could be useful for improving these tools. It is also suggested to create elements that allow us to measure the opinions of users in terms of fun and engagement with the SG.

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