International Journal of Serious Games

ISSN: 2384-8766
https://journal.seriousgamessociety.org/

Article

# How to Create Serious Games? Proposal for a Participatory Methodology

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**Keywords:**
Serious games
Simulations
Educational innovation
Higher education
Simulation games
Game-Based Learning

Received: June 2023
Accepted: October 2023
Published: November 2023
DOI: 10.17083/ijsg.v10i4.642

## Abstract

In the last years, the promotion of practical, engaging, and enjoyable learning experiences has led to a shift in educational practices in the context of Higher Education. Currently, active learning participative approaches are prioritized involving in these methods the use of technological tools. In response to this shift, simulators and serious games have emerged as effective strategies in education. Serious games offer numerous benefits, including the promotion of critical thinking, creativity, problem-solving skills, and better knowledge retention. However, it is crucial to ensure that serious games are well-designed to maintain their appeal and playful nature. The establishment of definitions, especially during the initial stages of development, can prevent rework issues and lead to faster project goal achievement. This article emphasizes the importance and proposes the establishment of a methodology for creating computer games used for purposes beyond entertainment, focusing on learning, training, behavior change, or skill development. This systematic approach increases the likelihood of generating engaging, effective, and learning-friendly games.

## 1. Introduction

In recent years, we have witnessed a technological revolution that has transformed our lifestyles and modified our paradigms. Information and communication technologies (ICTs) such as social networks, cloud computing, automation, artificial intelligence, and the Internet of Things have fundamentally altered our perception of the world. These innovations have not only transformed societal archetypes but also reshaped the skills and competencies demanded by employers, as well as revolutionized the creation, transmission, and assimilation of knowledge. Moreover, the younger generations possess distinct characteristics. Additionally, they prefer to play a more active role in their learning process, being uncomfortable with methodologies that merely involve one-way information transfer [1] [2].

In the field of education, ICTs are regarded as tools that can foster learning opportunities and develop students' skills [3]. Numerous examples of ICT utilization can be observed in educational platforms and virtual environments. Particularly, the incorporation of Serious Games (SGs) and simulators has emerged as a preferred option within classroom settings, as the participation of learners in these games has been shown to bring about changes in their attitudes, beliefs, and behaviors [4] [5]. Consequently, SGs are now employed as a strategy to support learning across various domains of study, including medicine [6], logistics [7], military training [8], nursing [9], among others.

One of the notable advantages of employing SGs is the ability to create motivational factors that significantly enhance student learning [10] [11]. Furthermore, researchers argue that SGs aid in the development of critical thinking skills [12], improve retention [13], foster creativity [14], and enhance skills associated with problem-solving and decision-making [15]. SGs integrate instructional content within gameplay, providing immersive environments where users can practice and apply knowledge and skills [16]. By leveraging game elements, such as challenges, rewards, and immersive storytelling, SGs captivate students' attention and sustain their interest over extended periods. Moreover, SGs offer a unique context for learning, situating knowledge acquisition within meaningful and practical scenarios [17]. Learning takes place within the game's environment, allowing students to directly apply and practice what they have learned. This concept of situated cognition enhances the relevance and applicability of the acquired knowledge [18].

SGs also provide opportunities for exploration, experimentation, and problem-solving. Virtual environments and simulations offer a high level of fidelity and immersion, surpassing traditional non-computer-based learning methods. Players are granted freedom within the game world, enabling them to fail, experiment, and interpret situations from multiple perspectives [19]. Additionally, SGs can facilitate collaboration and teamwork, as multiplayer games create opportunities for learners to work together, build relationships, and collectively address challenges [20]. Immediate feedback is another key benefit of SGs. As players navigate the game, they receive instant feedback on their actions and decisions, facilitating the acquisition of procedural knowledge. This feedback mechanism enhances the learning process and allows learners to reflect on their performance [21].

These were the main reasons why the University of Twente established a Department of Innovation in Social Sciences, named "The BMS Lab" (https://www.utwente.nl/en/bmslab/). The objective of this department is the development of technological platforms for research, consultancy, and services. The Lab regularly receives over 250 projects per year, ranging from the creation of serious games ("Airline Game," "7th-Generation," "Driving Simulator," "Greenhouse," "VR Supermarket," among others) to the creation of simulations and scenarios for virtual and augmented reality (“The hololens experience”, “Crisis Negotiation”, “Decision Making in Different VR Environment”, etc). A more detailed description of some of the projects that this Lab have undertaken can be found on the YouTube channel "The BMS LAB University of Twente" (https://www.youtube.com/@thebmslabuniversityoftwent4833). Additionally, games developed by them can be accessed by staff and students on a university website maintained by the BMS Lab (https://labapps.bmslab.utwente.nl/). Furthermore, The BMS Lab has also established other communication channels on social media platforms such as Facebook, Instagram, and LinkedIn (the links to these sites are on the laboratory's official website). The collaboration between programmers and faculty members (researchers and professors), and students, at this center, along with the experience gained from these projects, has led to the pursuit of processes that enable more efficient development of serious games.

This article aims to propose a methodology for creating serious games, considered as " a game in which education is the primary goal, rather than entertainment" following what stated by Michael and Chen [22] and what Coovert [23] points out with greater precision "We consider serious games those computerized games and advanced video graphics systems used

for non-entertainment purposes and whose focus is on learning and training or educational and behavioral change". The methodology proposed is the result of numerous projects and years of experience of the BMS Lab of the University of Twente. This methodology has been used and tested, both in the construction of serious games and in the creation and development of virtual and augmented reality projects. One of the most significant differentiators from other methodologies is the inclusion of end-users as part of the co-design team. Listening to their suggestions has been a tool for building empathy among team members. Furthermore, understanding the responsibilities and having different leaders for activities throughout the project has provided each team member with a greater willingness to accept ideas. The main advantage of the methodology is the creation of a common language among the different parts that make up the project. Developing definitions throughout the work allows for better conversations about requirements, and the expectations of each party are satisfactorily clarified. This has reduced friction in team discussions, promotes greater efficiency in terms of project development time, fosters creativity, and leads to higher satisfaction upon project completion.

## 2. Literature Review

Although the benefits of utilizing serious games may seem evident, it is important to note that not all serious games operate in the same manner. Some scholars contend that poorly designed games lose both their appeal and their playful essence [24]. This issue is often attributed to the lack of adherence to design methodologies during the development of serious games, with many problems arising from the requirements definition phase [25]. Therefore, it is crucial for developers and pedagogicals to prioritize the design phase in the creation of serious games. This stage is of paramount importance as it involves defining the game's characteristics, player interactions, learning objectives, and database creation.

With the advent of new technological trends, digital games have achieved tremendous success. However, it is not just the visual aesthetics that contribute to their triumph; many successful games employ sophisticated design methodologies that elicit an emotional response from players [26]. However, Carrión et al. [25] argue that many serious games lack proper design. They further highlight that while there are numerous methodologies proposed for designing video games, the number of specific methodologies available for the design of SGs is limited.

Nadolski et al. [27] present a five-phase methodology called EMERGO for developing serious games (see Fig. 1). Each phase plays a crucial role in the overall development process and contributes to the successful creation of the game. The first phase of the EMERGO methodology is the idea presentation phase. In this phase, the designers introduce the concept and vision of the game. It is an essential step as it establishes the context, content, media usage, and pedagogical objectives of the game. This phase sets the foundation for the subsequent development stages. The second phase is the design phase, where designers dive deeper into the mechanics of the game. It involves specifying the gameplay mechanics, rules, and interactions within the game environment; this phase focuses on defining how the game will function and engage players. The third phase is the development stage in which programmers and developers take charge. The implementation phase involves testing the game with instructors and students, they enter the game portal and explore and interact with the game, providing valuable feedback and insights for further improvements. The final phase is the evaluation phase. Here, the game is measured against the specifications and objectives set during the analysis phase. Evaluation may involve assessing factors such as gameplay experience, educational effectiveness, technical performance, and user satisfaction.

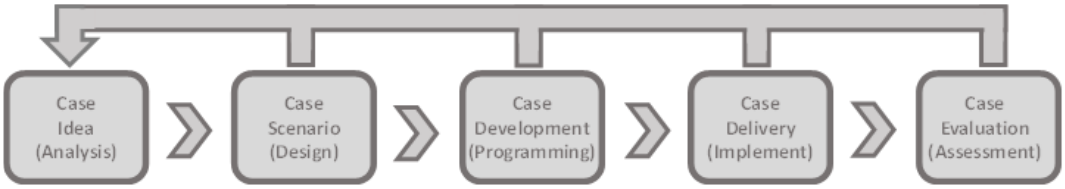


**Figure 1.** EMERGO methodology (based on Nadolski et al., 2008)

In the work by Yusoff, Crowder and Gilbert [28], a conceptual framework for serious games was presented, highlighting a comprehensive list of components that should be considered for effective learning through serious games (see Fig. 2). The framework diagram depicts the central component as the "Learning activity," with learning contents on one side and the game on the other. However, the specific relationship between these two components is not elaborated upon, leading to a limitation in the framework's usefulness for the design process of a serious game.

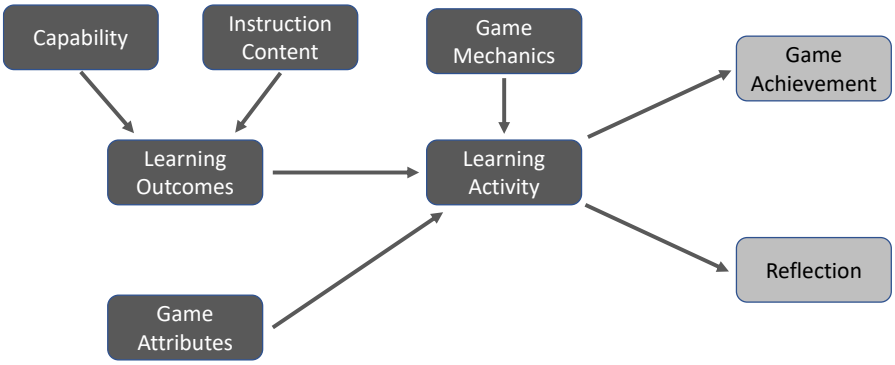


**Figure 2.** Yusoff methodology (based on Yusoff et al., 2009)

The work by Marfisi-Schottman [29] indeed introduced a six-step method for designing serious games (see Fig. 3), highlighting the involvement of various actors and the tasks to be accomplished throughout the design process. These tools likely serve as aids for communication and collaboration, enabling different team members to work together effectively and leverage their expertise in the design process.

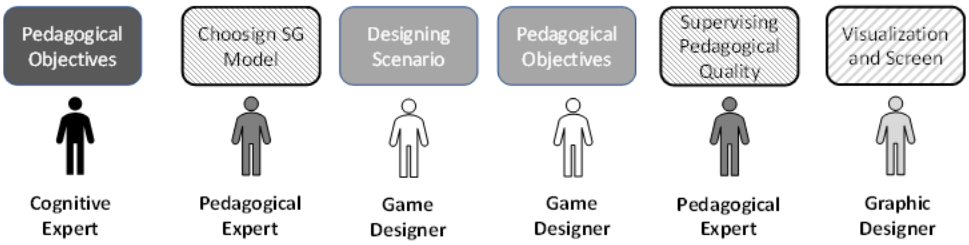


**Figure 3.** Marfisi-Schottman methodology (based on Marfisi-Schottman, 2010)

The framework introduced by Arnab et al. [30], known as LM-GM (Learning Mechanics-Game Mechanics), provides a valuable analytical tool for studying the interplay between pedagogical and game features in serious games (see Fig. 4). The LM-GM framework recognizes that serious games should strike a balance between effective learning and engaging gameplay. It identifies learning mechanics as the educational components that promote learning objectives, such as tutorials, assessments, and feedback mechanisms. On the other hand, game mechanics refers to the interactive elements that create the structure and dynamics of the game,

including challenges, rewards, and competition. Although it is not a comprehensive methodology for designing serious games, the framework offers insights into the various learning mechanics and game mechanics that can be incorporated into the design of a serious game.

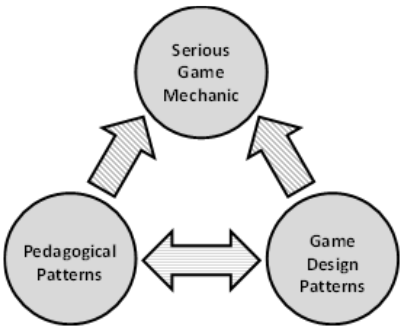


**Figure 4.** Taked from Arnab et al. [30]

Roungas introduced a conceptual model of educational serious games [31]. The author emphasized the relationship between game levels and learning outcomes within the model. According to the conceptual model, each level of the game would require the achievement of specific learning outcomes, ensuring a structured progression of learning. However, it is important to note that while Roungas' model offers a more detailed representation of the elements and their relationships in educational serious games, its complexity may pose challenges for all team members, including game designers, programmers, and subject matter experts. To mitigate this issue, clear communication, training, and collaboration among team members from different disciplines are crucial.

In their study, Cano et al. present a methodology called MECONESIS for creating serious games specifically designed for children with hearing problems [32]. The methodology consists of four phases. The analysis phase of the methodology is particularly significant. In it is the identification of the user and the analysis of the context, in addition the pedagogical objectives are defined, strategies are designed, and the technological platform is determined. The pre-production phase is related to the design of the game interface, which includes design patterns for the game interface, software patterns for implementation, and design guides. Also, there are task and scenario models associated with the game content. The production phase depends on the developer or the person who should program the game. And finally, the post-production stage, which proposes a game evaluation model, taking into consideration the end user and the expert.

In the work by De Lope et al. [33], a high-level methodology for designing serious games was presented. The methodology consisted of five phases: startup, design, production, test, and postproduction (see Fig. 5). The design, production, and testing phases followed an iterative cycle. Within the design phase, de Lope considered several key components, such as scenarios, characters, educational competences, and challenges. Notably, the game structure was conceptualized using a theater metaphor, incorporating elements such as acts, scenes, actions, and dialogue. This metaphor likely facilitated the organization and narrative flow of the game, providing a cohesive structure for the learning experience. Additionally, the methodology identified the main design tasks and associated them with different roles within the development team, including project managers, computer analytic designers, clients, writers, and educators.

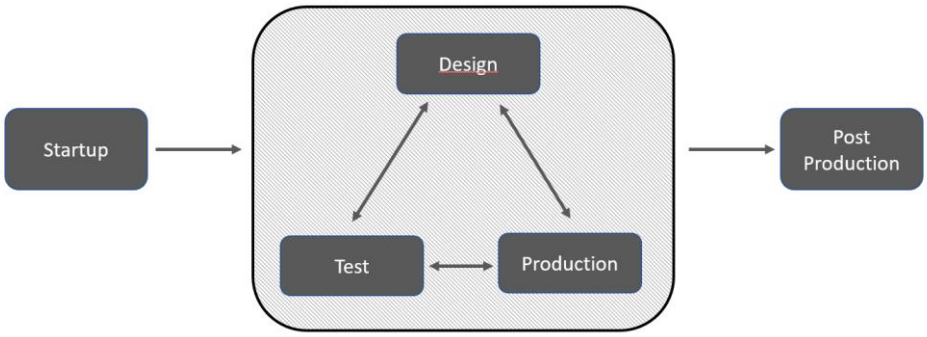


**Figure 5.** Taked from de Lope et al., 2017

Silva proposes a methodology that emphasizes the development stage of the project before the production of the game [34]. He covers a significant number of steps to define the learning mechanisms in a serious educational game. Fig. 6 shows the diagrams of the steps that the author considers important. Silva explains that the steps represented by a rounded rectangle are related to learning mechanisms or learning outcomes, while the other rectangles are associated with game features. He adds that the dashed lines signify iterative loops, where the mechanics can be refined based on user experience or learning outcomes.

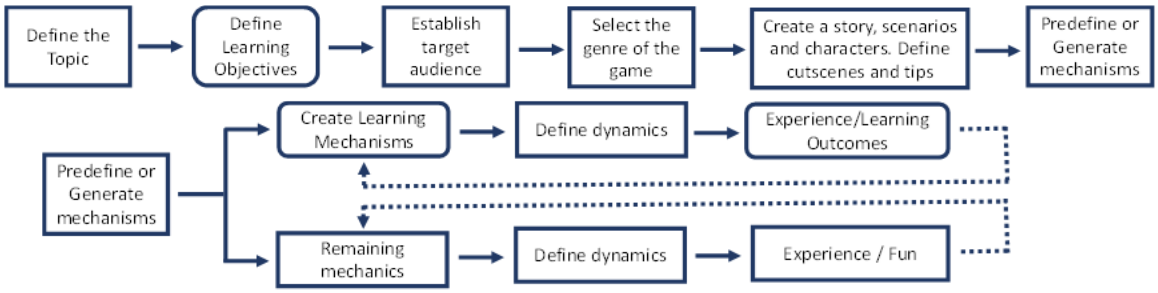


**Figure 6.** Silva Methodology Model (based on Silva, 2019)

Jaccard et al. present a block design framework for serious games, which is organized into five categories: "context and objectives," "game design," "mechanics," "learning design," and "assessment" [35]. This categorization provides a structured approach to the design process and allows for a comprehensive consideration of different aspects of serious game development (see Fig. 7). The authors propose transforming the building blocks into "cards." Each card represents a collaborative workspace dedicated to the design of the corresponding block. This card-based representation facilitates teamwork and provides a practical format for designers to collaborate and contribute to the design process. In addition, Jaccard et al. suggest that cards can be added, adapted, or removed based on the specific requirements of the intended serious game. Furthermore, the authors emphasize the importance of improving the visual representation of the connections and dependencies among different elements. The authors argue this methodology offers a better understanding of the systemic nature of the framework. The authors also suggest a multidisciplinary team and a participatory design between the different team members. However, they do not consider end users among the team members, and therefore, players do not have the possibility to make suggestions to the game design.

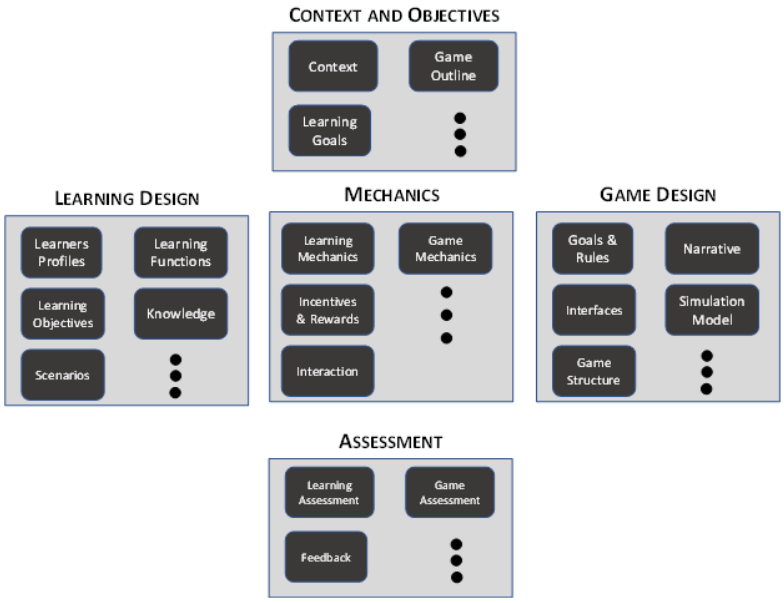


**Figure 7.** Jaccard Methodology Model (based on Jaccard et al, 2021).

Table 1 summarizes some of the characteristics of the methodologies presented in this section.

**Table 1.** Characteristics Extracted from Various Serious Game Design Methodologies

| Author | Year | Educational Level | Requirements | What does the team evaluate? | Role of End-Users |
|---|---|---|---|---|---|
| Nadolski | 2008 | Higher Education | Not Considered | Methodology | Evaluate the game |
| Yussof | 2010 | Higher Education | Not Considered | Not specified | Evaluate the game |
| Marfisi-Schottman | 2010 | Higher Education | Considered | Methodology | Not specified |
| Arnab | 2015 | Higher Education | Considered | Methodology | Not specified |
| Roungas | 2016 | Not specified | Considered | Methodology | Not specified |
| Cano | 2016 | Special Education | Considered | Methodology | Evaluate the game |
| De Lope | 2017 | Not specified | Considered | Methodology in each stage | Evaluate the game |
| Silva | 2019 | Not specified | Considered | Methodology | Evaluate the game |
| Jaccard | 2021 | Not specified | Considered | Methodology and Platform | Evaluate the game |

As can be seen, recent methodologies place a greater emphasis on game design and evaluation of the methodology by team members is requested. In the case of the methodology proposed by Jaccard, in addition to the methodology, a platform has been developed to facilitate co-design among the different team members. However, in all the described methodologies, end-users can only provide feedback at the end of the process, when they evaluate the game.

It is worth noting the authors' lack of specificity regarding the educational level where the games have been developed, which suggests that the methodologies can be used for the creation of serious games at any educational level.

## 3. Proposal for a Participatory Methodology

The project begins with the formation of a multidisciplinary team, consisting of skilled software development professionals, pedagogy experts, and game design specialists. It is imperative that this team has the opportunity to collaborate with a group of end-users or other stakeholders involved in the project. This team must have periodic meetings and collaborate in each of the stages that make up this methodology. Furthermore, it is convenient to understand that each phase is led by one of the indicated members or teams who must be present in all the activities included in each phase. In order to indicate the teams that should be involved in each activity of the methodology, we have placed a small emblem next to each of the steps. These emblems are described in Fig. 8.

On the other hand, a methodology that consists of five stages is also suggested, which is described in Fig. 9. Even though the methodology could be interpreted as a linear process, it is convenient to understand that in each step there is always the possibility of returning to some previous phase. In particular, it is quite likely that the evaluation phase will lead us back to the design phase.

It is convenient to conceptualize participatory design as a creative practice that enables meaningful contributions to the formulation and resolution of a problem by a substantial group of individuals. In other words, it is the joint creation of value between designers and end-users through equitable collaboration among all stakeholders aiming to address a specific challenge [36]. Furthermore, it is important to note that a participatory design does not represent a consultation, but rather a direct collaboration in which the voices of users and other interested parties are integrated into the project. It is very important that each team member has the ability to empathize with the needs of the other team members, and above all, with the end user [37].

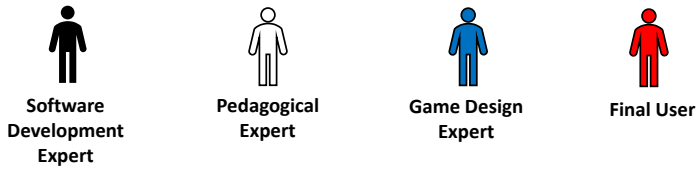


**Figure 8.** Emblems used to indicate the teams involved in each activity of the project.

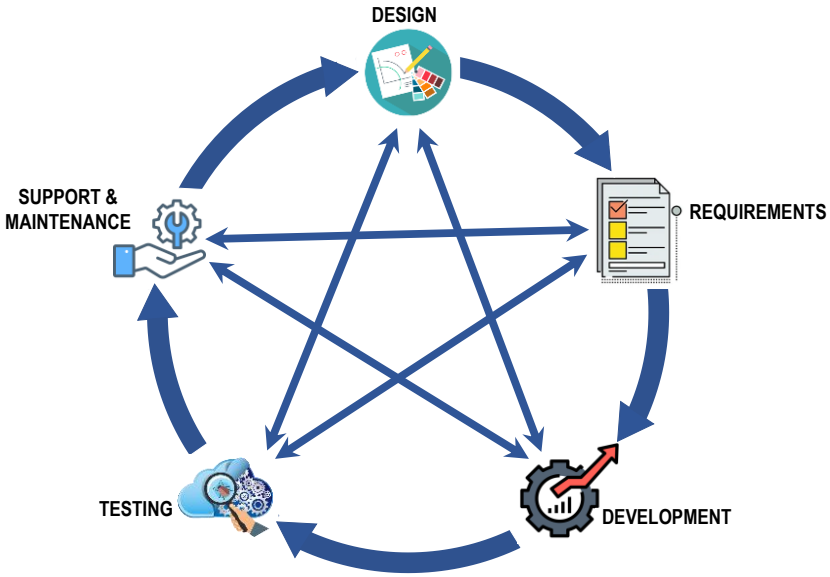


**Figure 9.** Proposal for a New Participatory Methodology.

### 3.1 The Design Phase

The project's inception arises from the desire to facilitate learning. The project's goal can be to enhance knowledge dissemination, improve comprehension of a topic, develop players' skills, make learning meaningful for participants, among other objectives. This is why it is suggested that a pedagogical expert lead this phase of the project. This pedagogical expert does not necessarily have to be a teacher or someone from academia. By pedagogical expert, we mean a person who has a deep understanding about educational processes and can design, analyze, and plan materials that enhance learning.

The authors propose dividing this stage into three essential components: a) pedagogical aspects, b) game concept development, and c) game screens design and data generation. The pedagogical expert is considered the primary responsible party in this stage of the process and should lead each of the tasks within these areas. A visual representation of this phase is presented in Fig. 10.

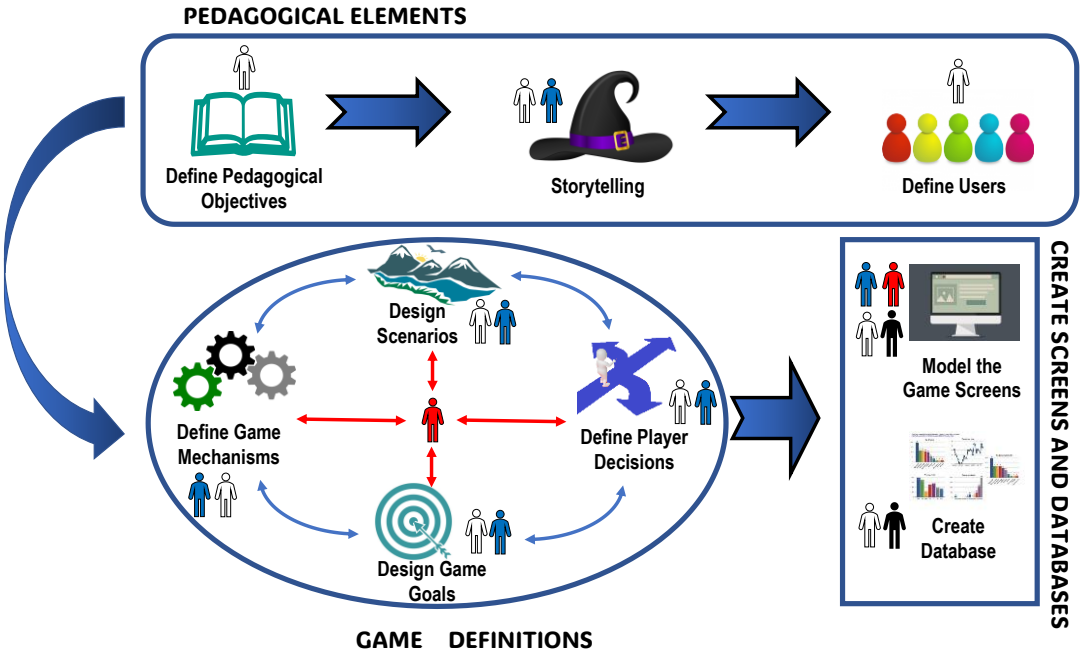


**Figure 10.** Proposal for the Design Phase.

#### *3.1.1 Pedagogical Elements*

In the first three elements of this phase, the pedagogical expert takes the lead in providing the necessary definitions for the content, the story, and the target audience.

*Formulation of pedagogical objectives:* The pedagogical expert specifies the content that the serious game will address. This includes determining the specific knowledge or skills that need to be taught or developed through the game. The pedagogical expert's expertise in the subject matter ensures that the game's content aligns with educational objectives. To specify the desired scope of using the game, it is recommended to employ Bloom's taxonomy [38]. Starting with the fundamental verbs in taxonomy is advisable. It is also possible to declare the aim of developing specific competencies in students. These objectives serve as guiding principles for game development and are crucial for defining whether the game meets the client's requirements.

*Creation of Storytelling:* The development of the story should be a collaborative effort between the pedagogical expert and the game expert. The story must be compelling, fostering student

engagement and a commitment to finding solutions. The challenges and tasks within the game should align with the content being studied. Ensuring congruence between players' decisions and their corresponding effects in the game is essential. When consequences align with the real world, students can achieve deeper learning. The story should be compelling, presenting challenges and opportunities for learning within the game. Storytelling provides context for players and introduces relevant topics within the game.

*Define Users:* Defining the user profile is vital, as it should be relevant to the story. This involves understanding the characteristics, prior knowledge, and familiarity of the intended players with the subject matter. If users have limited familiarity with the problem, meticulous storytelling with precise explanations becomes crucial. Conversely, if users are well-versed in the concepts addressed by the game. The pedagogical expert's insights help shape the level of detail and instructional design approaches to cater to the needs of the specific audience.

#### *3.1.2 Game Definition*

The definition of the game is a crucial aspect in this design phase, and it is precisely in this part where participatory design is highly beneficial. It is essential to listen to the voices of pedagogical experts, game design specialists, but also to hear from the end-users. This is the phase where innovation should come into play, where meanings and narratives are created, meaningful objectives are established for the participants, and, above all, openness to suggestions from all project stakeholders is encouraged. In this stage, while involving the programmer to understand the game mechanics is advisable, the focus is not on computational development but rather on determining the rules, mechanics, objectives, and game scenarios, as well as defining the roles or roles of the participants.

The creation of drawings, scenarios, cards, or other elements is suggested to enable designers and participants to experience the game mechanics. There is no need for any software development in this set of activities. The primary goal at this moment is the game definition, allowing players to experience the rules, modify objectives, generate new scenarios or challenges, and establish the participants' capabilities. Each decision should be experienced by end-users, and their feedback should drive changes in the design. To enhance user involvement, it is advisable to motivate them, establish respectful listening as a behavioral policy, promote brainstorming as the source of innovation, and keep users informed about changes in mechanics or scenarios.

*Define Game Mechanisms:* This component holds significant importance. The definition of game mechanisms encompasses not only how players create strategies and make decisions but also how they advance and navigate the available options. The pedagogical expert ensures that these mechanisms align with the learning objectives, while the game expert ensures they are engaging and challenging. Collaboration with the developer in these discussions is essential for technological development. Introducing unexpected events that challenge players' creativity can be highly motivating, as repetitive operations throughout the game tend to be less engaging for participants. Additionally, specifying the game's nature, such as individual or collaborative, asynchronous or synchronous, and the impact of one player's decisions on other participants or the overall scenario, is recommended. It is advisable to document and define the game rules comprehensively.

*Design Scenarios:* A game can consist of a continuous story or be divided into different scenarios, each with distinct features, facts, situations, or characters. Scenarios offer opportunities to introduce new variables, decisions, interactions, challenges, or increased difficulty levels. Collaboration between the pedagogical expert and the game expert is crucial in this phase to determine which variables should be incorporated and how they relate to

existing ones. The developer's presence in these discussions is important to understand the necessary technological considerations.

*Design Game Goals:* The pedagogical expert defines the game's objectives, and it is essential to ensure that the rules are clear to all players before they start the game. Describing how to win or what players need to achieve for success is crucial. The actions players take within the game should align with the game's objectives. Assigning scores to players' performance can provide feedback on their proficiency and knowledge relative to other players. Aligning game goals with learning goals is imperative.

*Define Player Decisions:* This aspect focuses on generating engagement and enjoyment while ensuring alignment with the pedagogical objectives. The decisions or actions that players undertake should demonstrate the skills or knowledge they have acquired. Each interaction with the game presents an opportunity for players to showcase their learning. Well-designed games offer a scoring system directly correlated with the proficiency of the participant.

#### *3.1.3 Screens and Databases*

In the final part of the design phase, the collaborative work of the three experts is crucial to ensure a comprehensive and effective design. Before proceeding to the requirements phase, it is important to establish agreements and consensus on the following aspects:

*Model the Game Screens:* This step involves designing the visual interfaces and elements that players will interact with during the game. It is essential to consider all the necessary components that players will need access to when performing actions. The pedagogical expert should communicate any specific data, notifications, or relevant information that should be displayed on the screens. This input from the pedagogical expert helps guide the other team members in proposing how the information or events should be presented on the different screens. By collaboratively designing the game screens, the team can ensure that the necessary information is effectively conveyed to the players, enhancing their engagement, and understanding of the game.

*Define Databases:* This component plays a crucial role in providing feedback to the participants, contributing to a better learning experience. The team should define the data that needs to be captured and stored in the databases. This information can include the decisions or actions taken by the players that demonstrate their acquisition of knowledge or development of skills. The educational game aims to provide information to both tutors and participants regarding their achievements. The team should decide whether it is necessary to save the player's decisions throughout the game or if only the final score needs to be recorded. Additionally, it is important to determine whether players will have access to the results of other players, allowing them to compare their performance. By defining the databases and feedback mechanisms, the team ensures that players receive valuable information about their progress and can track their learning journey within the game. The authors suggest considering a thorough examination of the existing literature on Learning Analytics for Serious Games. This literature offers practical guidance on capturing, storing, and analyzing various types of data for multiple purposes, including providing feedback and adapting the game [39] [40].

As a summary, the main objective of this project phase, as well as some of the key elements to be obtained upon its completion, are presented in Table 2.

**Table 2.** Objectives and Products of the Design Phase

| The Design Phase | | |
|---|---|---|
| Objective: This stage involves defining the educational intentions and the scope of the game. The objectives guide the game's scenarios, mechanics, and goals. It is essential to establish how players interact with the game and define the player's actions that allow us to observe their learning. | | |
| Some Expected Outcomes | | |
| Stating learning goals | Creating the storytelling | Establish game mechanisms |
| Develop interaction with the game | Defining game rewards & incentives | Designing scenarios |
| Creating visual interfaces | Defining scores | Brainstorming |
| Game Prototype | Pilot test results | Learning analytics options |

### 3.2 The Requirements Phase

Sometimes, the requirements phase can be included within the design phase of the SG development process. This phase is crucial for gathering and documenting the necessary specifications and functionalities of the game (See Fig. 10).

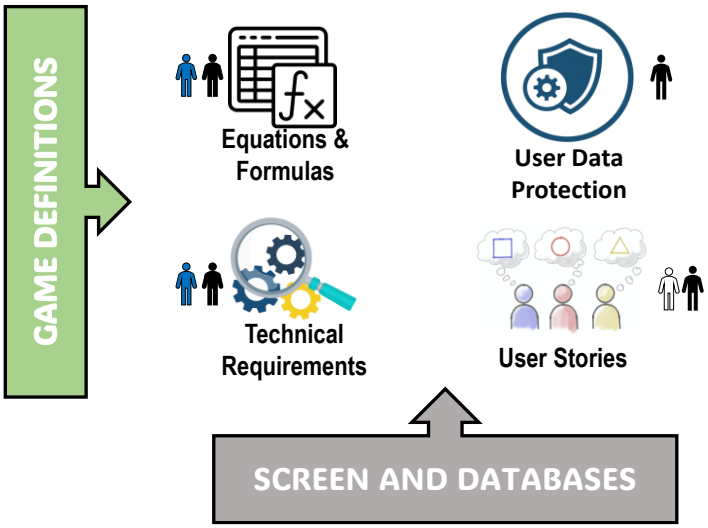


**Figure 11.** The Requirements Phase.

*User Stories:* User stories are narratives that describe the interactions between different types of users and the game. It is important to consider that there may be various classes of users, such as players, students, teachers, and game creators. Regularly each different role must consider different attributes. User stories are narratives that describe the interaction between the users and the game. They outline the specific actions, behaviors, or tasks that players will engage in while using the game. User stories help to capture the perspective and needs of the players, guiding the development team in creating a user-centered experience.

*Technical Requirements:* Technical requirements encompass the specific technological aspects that the game must meet. This includes hardware and software specifications, compatibility requirements, and any technical constraints or dependencies. These requirements ensure that the game is designed and developed in a way that aligns with the available resources and technical capabilities.

*Equations or Formulas:* In certain serious games, specialized calculations or formulas may be necessary to support specific functionalities or simulations within the game. The requirements phase involves identifying and creating these equations or formulas that are integral to the game mechanics or learning objectives.

*User Data Protection:* With the increasing importance of data privacy, the protection of users' personal data is a crucial consideration in game development. During the requirements phase, mechanisms for safeguarding user data should be established. This involves defining data protection protocols, compliance with relevant regulations, and implementing security measures to ensure the confidentiality and integrity of user information.

Table 3 presents the objectives and some of the deliverables expected within this requirement phase.

**Table 3.** Objectives and Products of the Requirements Phase

| The Requirements Phase | | |
|---|---|---|
| Objective: In this phase, a formal document (contract) is created among the different team parties outlining the game's objectives, identifying the features and functionalities to be considered, analyzing technical limitations, and specifying the mechanics and project's scope. | | |
| Some Expected Outcomes | | |
| Defining user types and privileges | Specify the programming language | Establish technical requirements |
| Develop calculations and formulas (if necessary) | Creation of a formal contract among the pedagogical team, the design team, and the developers | Ensure compliance with personal data protection regulation |

### 3.3 The Development Phase

The development phase is a more technically focused stage where the technology team takes the lead. During this phase, project management and code development are the main areas of focus (see Fig. 12). The development phase may also include tasks such as integration testing, unit testing, and bug fixing.

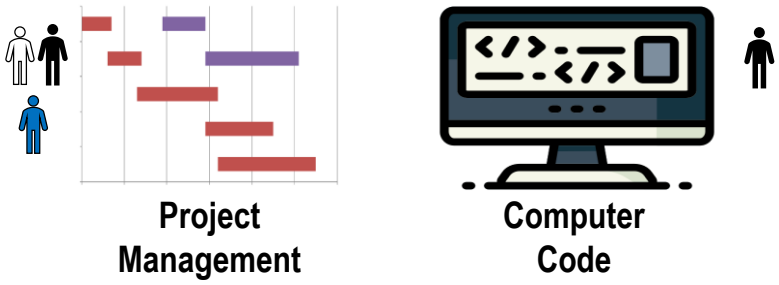


**Figure 12.** The development phase.

*Project Management:* It is advisable to create a progress calendar that outlines the weekly milestones to be achieved. It is important to adhere to this calendar as closely as possible to ensure timely progress.

*Code Development:* It is important for the developers to work closely with the other experts involved in the project, to ensure that the game meets the educational objectives and technical requirements set out in the design phase. Communication between the different parties is essential to ensure that the game is developed according to the established guidelines and that

it meets the needs of the intended audience. As previously commented, it is important to consider integration testing, unit testing and bug fixing. Integration testing involves verifying that different parts of the game work together seamlessly, while unit testing involves testing individual units of code to ensure they function correctly. Bug fixing is also an important part of the development phase, as it involves identifying and resolving issues that arise during the testing process.

Table 4 briefly summarizes the expected deliverables in the project's development phase.

**Table 4.** Objectives and Products of the Development Phase

| The Development Phase | | |
|---|---|---|
| Objective: In this phase, the code is developed for building the game based on the requirements and specifications defined in previous stages. It is the tangible construction process of the game, where the initial ideas and concepts are translated into a playable experience. | | |
| Some Expected Outcomes | | |
| Establish the progress schedule. | Integrate sound effects and music. | Create graphics and screens. |
| Design and develop the user interface. | Creation of manuals describing the game's functionality. | Integration of technical elements. |

### 3.4 The Testing Phase

During the testing phase, various types of testing are conducted to ensure the quality and effectiveness of the serious game. These include technological testing, game fun testing, and pedagogical testing (see Fig. 13).


**Figure 13.** The testing phase.

*Technological Testing:* It focuses on verifying that the game functions properly from a technical perspective. It involves checking if all the required features and mechanisms work as intended, ensuring that calculations and results are accurate, and identifying and fixing any technical errors or bugs. This testing evaluates the work of the development and programming team and aims to ensure the game meets the technical requirements set out in the design phase.

*Game Fun Testing:* Involves gathering user opinions and feedback to assess the entertainment value, level of challenge, and overall fun factor of the game. By listening to the players' observations and suggestions, improvements can be made to enhance the gaming experience. This testing primarily evaluates the work of the game expert in creating an engaging and enjoyable game.

*Pedagogical Testing:* Focuses on evaluating the educational aspects of the game, including the learning outcomes and skill development in students. This testing often involves having a control group and an experimental group to measure the impact of the game on learning. Additionally, pedagogical indicators such as student motivation and engagement can be measured to assess the educational value of the game.

Table 5 briefly summarizes the goals and products in the project's testing phase.

**Table 5.** Objectives and Products of the Testing Phase

| The Testing Phase | | |
|---|---|---|
| Objective: | In this stage, the functionality of the software is evaluated and verified. Additionally, it is advisable to ensure that it meets the established pedagogical and entertainment objectives. In this phase, it is not only advisable to listen to end users but also to internal project users. | |
| Some Expected Outcomes | | |
| Creation of user surveys on the overall gaming experience. | Generate quizzes to assess the achievement of pedagogical objectives. | Conduct interviews and focus groups with end users. |
| Conduct interviews and focus groups with internal users. | Generate quizzes or surveys to assess the development of pedagogical competencies. | Implement (based on results) adjustments and improvements in the game. |

### 3.5 The Support and Maintenance Phase

Support and maintenance are crucial aspects to consider for a serious game that is intended to be used by a large number of users. Fig. 14 shows the elements that must be considered in the support and maintenance phase.

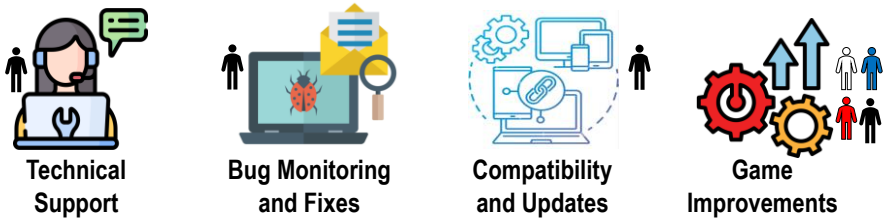


**Figure 14.** The support and maintenance phase.

*Technical Support:* As with any software, it is essential to have a dedicated technical support team in place to address user issues and help when needed. This support could be in the form of a helpdesk, email support, or even a dedicated online community where users can ask questions and receive timely responses. The support team should be knowledgeable about the game and its technical aspects to effectively troubleshoot and resolve any reported issues.

*Bug Monitoring and Fixes:* Despite thorough testing, it is common for software to have bugs or unexpected issues. Regular monitoring of the game's performance is necessary to identify and address any bugs that may arise. This includes tracking user-reported issues, analyzing error logs, and conducting regular maintenance to fix bugs and improve the overall performance and stability of the game.

*Compatibility and Updates:* The game should be designed to be compatible with various browsers and platforms, considering the evolving technology landscape. Regular updates and maintenance may be required to ensure that the game remains functional and optimized across different devices and browsers. This includes addressing compatibility issues, applying security patches, and making necessary improvements to keep pace with technological advancements.

*Game Improvements:* This is a crucial aspect of the iterative process in game development. By actively seeking and incorporating feedback and suggestions from participants, developers can enhance the game or simulation to create a better user experience and achieve the desired

educational outcomes. Participant feedback serves as a valuable source of insights into what works well in the game, what can be improved, and what new features or content can be added. The suggestions provided by participants can cover a wide range of areas, including gameplay mechanics, user interface, graphics, audio, level design, narrative elements, learning content, and overall engagement. Developers should carefully analyze and evaluate these suggestions to determine their feasibility and alignment with the educational objectives of the game.

Finally, Table 6 outlines the objectives of this last stage. As in the previous tables, some of the expected deliverables for this phase are also provided.

**Table 6.** Objectives and Products of the Support and Maintenance Phase

| The Support and Maintenance Phase | | |
|---|---|---|
| Objective: This phase focuses on ensuring that the serious game continues to meet its objectives and provides a quality experience to users over time. | | |
| Some Expected Outcomes | | |
| Monitoring for potential errors, technical glitches, or operational issues. | Performing periodic updates. | Technical assistance and user support are provided to end-users. |
| Ongoing data collection on game performance and user feedback continues. | Content updates (if necessary). | Maintain high data security and user privacy standards. |

## 4. Conclusions

The recognition of the potential benefits of using computer games as educational tools has increased interest in their development. While there are proposed methodologies for game development, these methodologies have not incorporated end-users as a significant part of the project's co-creation team. This article aims to address this gap by providing a detailed description of game construction, emphasizing the importance of proper planning and understanding of pedagogical objectives, incorporating the voices of end-users to make changes in game design and mechanics, and fostering greater empathy among the different teams involved in the project.

The authors emphasize that many projects fail, or experience delays due to insufficient attention to the design phase. Therefore, it is suggested that before developers start creating requirements, the entire team is aware of the game mechanics, the goals players pursue, the constraints participants face in each scenario, but primarily, they listen to the voices of users to enhance game enjoyment.

While a significant challenge in this collaboration process is the potential language barrier among different team members, understanding the game mechanics will establish a common language and promote teamwork to develop shared ideas and a cohesive vision. By offering practical guidelines and specific discussions on each phase of game construction, this article aims to raise awareness of the critical nature of this stage and streamline the work. Through collective efforts and incorporating the end-user's voice as a source of creativity, the team can create educational games that are engaging, effective, and tailored to the needs of the target audience, maximizing the use of information and communication technologies.

Ultimately, the goal of this article is to promote the successful integration of educational games in the classroom, harnessing the documented benefits and addressing the needs of the modern student. By emphasizing the importance of meticulous design and collaborative work, the authors aim to enhance the overall quality and success rate of educational game projects.

## Acknowledgments


- The authors would like to thank the financial support from Tecnologico de Monterrey through the "Challenge-Based Research Funding Program 2022". Project ID # I005 - IFE001 - C2-T3 – T.


## Conflicts of interest

The authors have no conflicts of interest to declare.

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