

# A Conceptual Framework for the Development of Effective Serious Games for Learning

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**Abstract:** Currently, the interest in using serious games as a tool for learning and teaching in traditional educational processes has increased significantly. Therefore, serious games for learning are gaining increasing attention from researchers and domain experts (educators), as they are both looking for methods and tools to improve the quality of learning. Even though there are many existing design frameworks, models, and methodologies that offer valuable insights into the possibilities and limitations of serious games for learning, they focus mostly on high-level aspects and requirements of these games. Therefore, they do not fully help in understanding how such aspects can be concretely fulfilled. In this research, we investigate, characterize, and categorize the functional requirements and aspects needed for developing effective serious games for learning. This investigation aims to construct a conceptual framework to fill the gap in the current design frameworks. The proposed conceptual framework is used to understand the game's structure and behavior with a focus on both aspects of serious games (educational and entertainment aspects), in other words, providing a way to think about the relationships between serious game components and the learning objectives of the game. The main contributions of the proposed conceptual framework are to facilitate and support the design and development process of these games as well as to enhance the collaborative work within a multidisciplinary development team. Finally, to show the feasibility and applicability of the conceptual framework, a practical example is presented to demonstrate the use of this framework. Furthermore, we conducted an evaluation process for implementing the conceptual model. The evaluation shows promising results in helping participants, particularly those with gaming experience, to understand and identify the roles of each component in the game and recognize the game's learning objectives. This will eventually lead to design and develop effective learning games in a flexible and easy-to-use way.

**Keywords:** Serious Games for Learning, Serious Games Development, Serious Games Design, Conceptual Framework, Design Model.

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## 1. Introduction

Designing an effective serious game for learning is a challenging task, which requires a lot of knowledge and diverse skills. Development teams don't only have to deal with the inherent technical complexity of the game design but also have to be able to integrate learning activities in a way that is educationally effective and enjoyable at the same time (Silva 2019; Zarranonandia et al. 2015). Furthermore, the complexity and development of current computer games, in terms of representation, interaction mechanisms, and rules, might prevent domain experts from being capable to develop their serious games or even from participating in their design due to the lack of technical knowledge and the domain vocabulary (Avila-Pesantez 2019). Therefore, the development process of a serious game must be entrusted to a highly professional game development team, which is typically associated with high costs. Thus, the challenge here is to facilitate the development of an effective serious game for learning in a flexible, easy-to-use way and adapt the game's learning content, thereby helping reduce the effort and costs associated with the development process. To address this challenge, we develop a conceptual framework that facilitates the design and development of effective serious games and helps collaboration among stakeholders. This is achieved by investigating various requirements across serious games and highlighting the important components to develop a conceptual framework. The proposed framework is developed in three separate stages: first, analysis of existing methodologies and models for designing serious games; second, identifying the functional requirements across serious games; and finally, providing a conceptual framework. The Proposed conceptual framework consists of three models: one for describing the game structure, another for describing the behavioral dynamics of the game, and a third aims at enhancing user experience within serious gaming environments.

In our research, the framework and its models encompass high-level concepts for expressing games and pedagogical aspects to provide the development team with access to high-quality and up-to-date components. Finally, to evaluate the framework's applicability, it was used to design a serious game that aims to learning children how to read the clock. The aim is to demonstrate how effectively the model can be employed to design an efficient serious game for learning. Furthermore, we conducted an evaluation process for implementing the conceptual model. The evaluation shows promising results in helping participants, particularly those with gaming experience, to understand and identify the roles of each component in the game, and recognize the game's learning objectives.

Therefore, as a first step towards this goal, we introduce in this paper a conceptual framework that is organized in a modular way and with different design perspectives. In order to help the development team, the requirements that are often considered in the literature as significant in producing engaging, fun, and educational game experiences, have been included in the model through a set of design components. Furthermore, the components of the framework offer support in the reuse of their foundational building blocks to produce different forms of the same game, which can be used to match different learning purposes, in a quick and flexible way. Moreover, it enhances the collaborative work within a multidisciplinary team.

The paper is structured as follows: in the second section, we provide a brief overview of existing literature related to serious games, with a specific focus on those, which introduce methodologies, frameworks, and models for designing serious games. In the third section, we introduce the conceptual framework, and we discuss and evaluate the applicability and feasibility of the proposed conceptual framework in the fourth section. Finally, we present the conclusions of the work in the fifth section.

## 2. Literature Review

To uncover the factors influencing the success or failure of serious games for learning and to address their design issues, researchers have developed models, frameworks, and methodologies for investigating and analyzing these games. Examining these frameworks helps in comprehending how serious games achieve their both aspects and also in revealing the connection between the game's design process and the underlying pedagogical aspects, as well as how the game is played. Understanding this issue is crucial as it allows for examining the components of serious games, providing insights into their mechanisms, and ultimately contributing to the development of better serious games for learning.

The six-facet framework proposed by Marne et al. (2012) outlined a conceptual framework for serious game design by assigning specific types of expertise to each facet. It aimed to resolve design challenges and enhance stakeholder communication using a design pattern library. However, while the framework clarified the roles of team members, it lacked a proper methodology for the actual game design process. The Activity Theory-based Model of Serious Games (ATMSG) was introduced by Carvalho et al. (2015) to understand the relationship between serious game components and educational objectives. This model applied activity theory, dividing a serious game into three components: gaming, learning, and instructional, each with corresponding actions, tools, and goals. The ATMSG was implemented in two phases: activity analysis and action analysis, further broken down into four steps. Although the model offered valuable insights for serious games, it was more suited for analysis rather than design. Lope et al. (2017) introduced a comprehensive five-phase methodology (startup, design, production, testing, and post-production) for serious game design. The iterative cycle of Salen and Zimmerman's design process (2003) was incorporated in the design, production, and testing phases. Furthermore, they identified components during the design phase, such as scenarios, characters, educational competencies, and challenges, using a theater metaphor (acts, scenes, actions, dialogues). Their methodology clarified the tasks of various roles in the design process, but it still required more specificity in translating learning content into the game. Pesántez et al. (2017) systematically reviewed serious game design approaches, identifying eleven methodologies. They structured the design process into four phases: analysis, design, development, and evaluation. Each phase is identified with factors, with emphasis on pedagogical and didactic aspects important to serious game design. However, it lacked detailed guidance on integrating these aspects into a game's design. Spyridon and Refanidis (2019) outlined a conceptual methodology based on a task repository that defined task dependencies and skill requirements. Their approach featured an adaptive schema using artificial intelligence to adjust learning tasks based on the player's prior knowledge. Rather than being a design methodology, this framework focused on creating an adaptive learning process for serious games. Continuing the goal of facilitating the design of serious games for learning, several authors have introduced libraries, models, and frameworks for serious games for learning, such as Arnab et al. (2015); Rongas & Dalpiaz (2015); Lope et al. (2017); Moya et al. (2016); Robson et al. (2015). These efforts aim to offer more structured approaches to designing serious games; however, there remains a need for clearer methodologies that effectively integrate educational content.

In conclusion, while numerous frameworks and models for serious game design exist, there is a general need for clearer methodologies that explicitly detail how educational content should be integrated into the game design. Each of the frameworks and models contributes unique insights into the analysis and structure of serious games, yet they often fall short of providing comprehensive design processes. For this reason, there is a need for means and models that bridge the gap between theoretical frameworks and technical designs. This bridging is necessary to alleviate the cost of developing serious games for learning by providing tools that facilitate the design process

easier and quicker, producing high-quality designs, to making the benefits of game-based learning available to a wide audience.

### 3. The Conceptual Framework

In the process of this research, and as part of my PhD work, an investigation is conducted to address the functional requirements for developing serious games for learning. The aim is to identify common requirements across serious games of various genres and topics to enhance reusability and leverage their potential applicability across different learning domains. This identification aims to derive components that contribute to both the effectiveness of serious games in learning and their potential for reuse in similar game genres based on these identified requirements. The criteria for identifying requirements are (i) relevance to the learning effectiveness and (ii) reusability across various games and learning domains, at least within the same genre of the game. The investigation resulted in a list of functional requirements for serious games that directly or indirectly affect players' motivation and learning success.

**Table 1: The List of Functional Requirements**

Category	The functional requirements	References
<b>Pedagogy/Learning</b>	FR1: A serious game should provide interaction mechanisms focused on objects, feature task-centered goals, and offer the opportunity for learning or playing within social groups. FR2: A serious game should provide the ability to present learning objectives through repetitive tasks. FR 3: To incorporate learning objectives, a serious game should offer interaction mechanisms. FR 4: A serious game should be designed in a way that supports the progressive introduction of new skills during the play.	Carvalho et al. 2015; Kazimoglu et al. 2010; Annetta 2010; Riedel et al. 2015.
<b>Rules</b>	FR 5: The design of a serious game must adhere to a set of game rules.	Carvalho et al. 2015; Batko 2016.
<b>Interaction &amp; Communication</b>	FR 6: A serious game should enable communication and interaction with other components and/or players.	Carvalho et al. 2015.
<b>Assessment</b>	FR7: In a serious game, there should be the capability to offer feedback on the user's behavior. FR8: A serious game should offer the ability to display information. FR9: A serious game must have an assessment component	Arnab et al. 2015; Annetta 2010; Boyle et al. 2016; Shoukry et al. 2014; Bellotti et al. 2013; Gardner 2012.
<b>Goal</b>	FR10: A serious game has to include tasks that can be solved. FR 11: A serious game should have to be clear and understandable goals.	Bellotti et al. 2013; Gardner 2012; Paraskeva & Mysirlaki2010; Kickmeier-Rust & Albert 2012.
<b>Adaptation</b>	FR12: A serious game must have an adaptive component to measure the performance of players' learning progress, thus adapting the game to the ability and the current skill level of players. FR13: A serious game should have various levels of difficulty in solving tasks.	Silva 2019; Chandler 2020; Prensky 2001; Kickmeier-Rust et al. 2008; Soflano & Connolly 2015; Cox et al. 2012; Lomas et al. 2013.
<b>Representation</b>	FR14: A serious game should have the ability to display at least videos or to play audio. FR15: A serious game should have a user profile component to identify the player in the game. FR16: In a serious game, there should be both objects and characters, allowing players to interact with them.	Lainema & Henriksen 2015; Kazimoglu et al. 2010;

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These requirements serve as the foundation for designing the conceptual framework, which is organized into clusters of components within seven functional categories: pedagogy/learning, rules, interaction and communication, assessment, goals, adaptation, and representation. These categories have been analyzed, resulting in the extraction of 16 functional requirements for developing serious games. Table 1 presents the complete list of derived functional requirements.

These functional requirements are used as the foundation for constructing components within the models of a conceptual framework. Consequently, each requirement has been analyzed individually, and hence, model components supporting the fulfilment of these requirements have been derived.

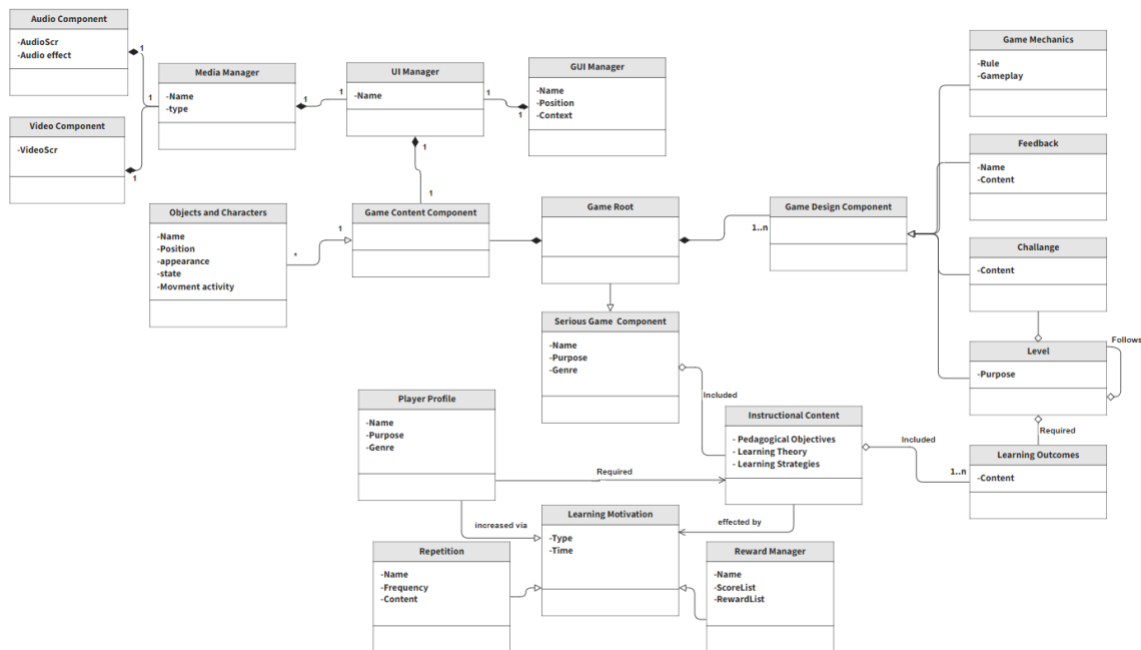
The outcome of this process is a conceptual framework of serious games for learning. It allows the design of the structure and the behavior of a serious game. Table 2 presents the components of the framework and the corresponding requirements, from which the component has been derived.

**Table 2: The Framework Components of Serious Games**

Model Components		Derived from requirements #	
The Game-Root		No derivation needed	
Serious Game	Instructional Content	FR2, FR4, FR5, FR10, FR11.	
	Player Profile	FR14, FR15	
	Learning Motivation	FR9	
	Repetition	FR2	
Game Content	UI Manager	GUI Manager	FR8
		Media Manager	FR14
	Objects& Character	FR15, FR3	
Game Design	Reward Manager	FR9	
	Feedback	FR7	
	Game Mechanics	FR1, FR6	
	Challenge, Level, Learning Outcomes	FR2, FR12	
State		No derivation needed	
Activity (Actions)		FR3, FR10	
Event		No derivation needed	
Assessment (Task)		FR7, FR9	

### 3.1 The Conceptual Model of Serious Games Structure

The first model in our framework is a conceptual model, describing the primary structure of a serious game for learning. The model identifies the roles of all components and achieves the desired educational goals. This structure describes how a serious game is constructed, detailing the layout of the game world, the inclusion of objects and characters, and the dynamics of player interaction. Figure 1 offers an overview of the serious game structure model, illustrating the components and their relationships. This model adheres to the familiar concept seen in UML class diagrams.



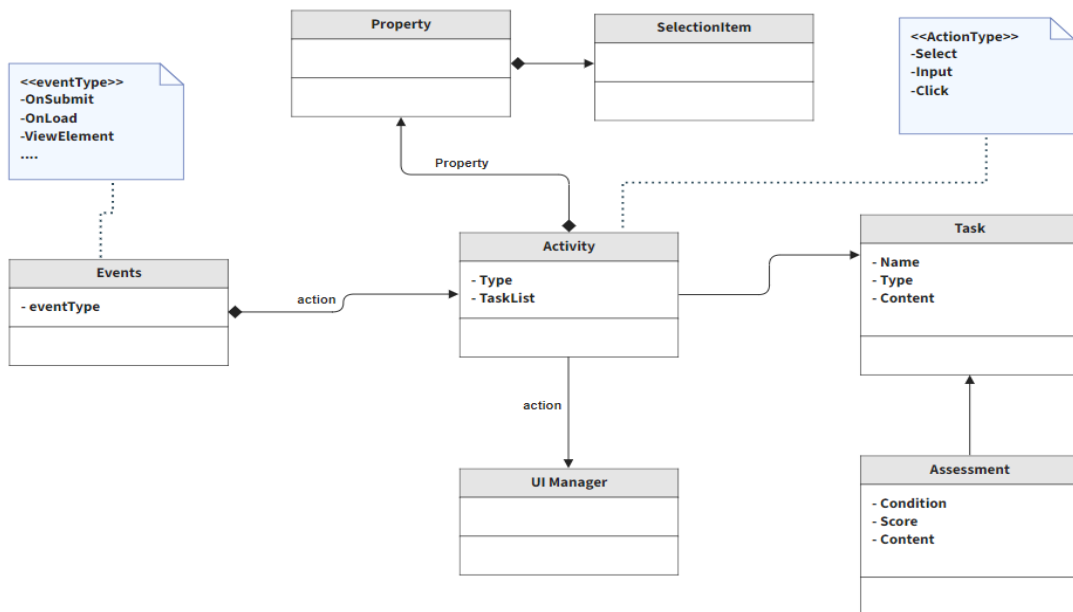
**Figure 1: Structure Model of Serious Games for Learning**

The Game Root is the central point for all other components. It includes the Game Design Component, representing development decisions regarding game mechanics and feedback; the Game Content Component encapsulates the structural elements. A serious game, considered a sub-component, inherits one or more characteristics from computer games but it is designed for educational purposes. Learning objectives are achieved through instructional content defined in terms of learning outcomes, outlining the knowledge players are expected to gain.

The Game Design Component includes objects and characters to represent interactive or decorative elements within the game. The UI Manager, which has two subcomponents, GUI Manager and Media Manager, controls the display of information for players. Game design identified the necessary to coordinate components into games: mechanics that dictate behavior, challenges that keep engagement of players during the gameplay, levels that break goals into tasks, and feedback that responds to player actions. A serious game component specifies the components that affect the learning process, such as player profile and instructional content defined in terms of learning outcomes. Learning objectives, strategies, and curriculum are critical aspects of learning structure. The Learning Motivation, Repetition, and Reward Manager components manage player motivation, repetition to reinforce learning, and rewards for successful behavior.

### 3.2 The Behaviour Model of Serious Game

The second model in our framework describes the behavioral dynamic of serious games. Behavioral dynamics refer to the interaction between game components, outlining the expected functionality of a game. This model describes the interaction design, thereby facilitating the analysis, design, and development of software interfaces. This, in turn, enhances the productivity and effectiveness of the serious game and simplifies the design process. Figure 2 illustrates the dynamic model of a serious game.



**Figure 2: The Serious Game Behavioral Model**

The dynamic model captures the structure of the serious game, describing the user interface (UI) and its components. The UI Manager includes all elements of the game’s main functionality. Activity representing user actions such as input, selection, and interaction. Each activity has an Action-Listener that triggers events based on user actions. Events are used to express the interaction between Activity and the GUI. Task elements, like multiple-choice questions, are linked to assessment elements that evaluate results and provide feedback or rewards.

The adaptation method in the game monitors players' learning progress and adjusts content and difficulty accordingly. Players can initially choose their desired difficulty level, with predetermined game content tailored accordingly. Alternatively, the game can offer tasks of varying difficulty, dynamically selecting the appropriate task based on the player's previous performance.

### 3.3 User Experience of Serious Games

User experience (UX) is a psychological concept focused on users' emotions, thoughts, and reactions when interacting with a system (Hassenzahl, 2018). In serious games, UX is crucial as it deals with players' immediate responses and helps developers create more effective games.

Several models provide insights into UX for serious games. Sin et al. (2014) conducted a study on the UX of serious games, highlighting five motivating factors that encourage players to engage with these games: control type, updates, challenge, content, and fun. Similarly, Engl and Nacke (2013) proposed a three-layer abstraction game experience model, including the game system's playability, the player experience that emerges from interaction with the system, and the gameplay experience formed by external and internal factors. Law and Sun (2012) introduced a framework with four key dimensions-gaming experience, learning experience, adaptivity, and usability- characterizing the essential attributes of UX in adaptive serious games.

For describing a UX of serious games, it is important to identify the elements that shape the effective design according to players' motivation. Therefore, the game should be fast, adjustable and provide rich affect-based interactions that enhance the connection between the game context and player input (Yannakakis & Togelius, 2015). To obtain a positive effect on the learning process, the game should consider three design aspects: learning, entertainment, and motivation; by aspects stated in our work.

- Firstly, the learning aspects are based on the learning mechanics. For example, questions and answers, action/task, repetition and reflection, and (self)-assessment.
- Secondly, the entertainment aspect (gaming) should be designed to entertain and amuse players with the game mechanics while learning (goals, rules, and challenges).
- Finally, the motivation aspect includes the elements that take players to play the game, like rewards and feedback.

## 4. Evaluation of The Conceptual Framework as A Design Tool

### 4.1 Application of the Conceptual Framework

To provide an initial assessment of the conceptual model, it is applied in the design and development process of a game for teaching children how to read the clock 'learning Clock game'. The conceptual model can be utilized independently and contribute to the creation of a serious game using any programming language. Consequently, individuals can reuse the conceptual model to develop their serious games. The game developed as a mobile app using Flutter, it could also be implemented as a web application. Figure 3 shows screenshots of the Learning Clock game.



**Figure 3: Learning Clock Game**

To gain a better understanding of how the learning aspect takes place in the game with the conceptual framework models, we identify steps that guide the development team in applying the model for game design. These steps involve moving from a high-level understanding of concepts (concepts of what needs to be done) to the concrete components that implement those concepts.

- The first step is describing the game concepts: the multidisciplinary team development discusses the main aspects of the game and their subjects, such as the general objective of the game, the target group, and the learning aspect of the game. This step helps to highlight the main concepts of the game and allows to observe the game from different and complementary aspects. For our game 'Learning

'Clock Game', is a mini-game designed for children aged 5-10 years to learn how to read and tell the time.

- The second step represents the game sequence: to help in the identification of the game components. The purpose of this step is to establish a reference point that helps uncover how the components of the game are connected throughout the game. The game sequence representation adheres to the UML activity diagrams notation, employing shapes connected by arrows to represent the flow of game aspects. The outcome of this step is a blueprint of the game structure that reflects the essential form of the game components, figure 4 presents the game sequence of the learning clock game.

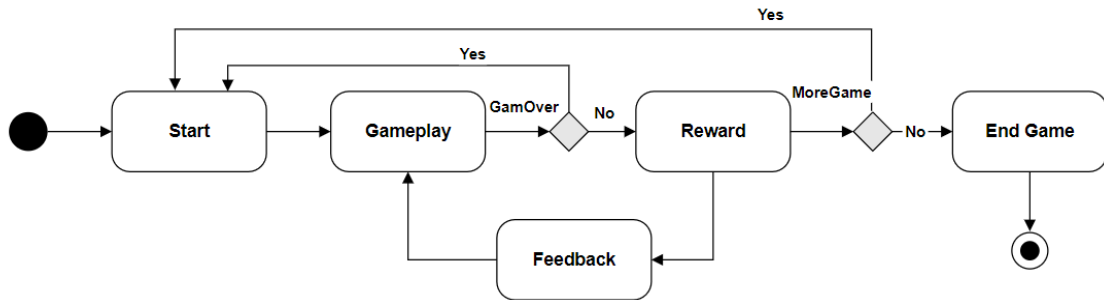


Figure 4: The game sequence of the learning clock game.

- Third step, description of the implementation: this step groups each set of actions and goals that belong to the same type of aspects and are related to the same components of the game sequence. It provides a more detailed description of the implementation of each block or component and explains what occurs at that point in the game, table 3.

Table 3: The Learning Clock Game Components

Components	Description
Mechanics	Rules: Multi choices
Challenge	The player should select the correct answer.
Level	Task: Gameplay screen
Feedback	Check the player's answer and provide information about their answer whether it is correct or not.
Reward Manager	To Calculate and update the player score after every corrected answer, and also update the game state
Object and Characters	To represent the objects within the game.
UI Manager	View: Levels and tasks (scene), display the feedback
Activity (action)	Interaction: Mouse, Keyboard Control: select the answer, button

Figure 5 demonstrates a screenshot of this game as a mobile app, a) represents the gameplay screen (Level), and b) shows the feedback that is given to the player when he chooses the correct answer.



Figure 5: The Gameplay and Feedback of the Learning Clock Game

Combining these steps offers a comprehensive view of the structure of the game, from its high-level purposes and general characteristics to its concrete implementation. Furthermore, they provide insights into the level of integration between gaming and learning components, thus highlighting possible weak points in the design.

## 4.2 The Conceptual Framework Evaluation

We performed an evaluation study in which investigating the users' perception of the framework's usability and usefulness. In this study, participants used the framework model and its design approach to design the "Senior PM Game", a simple simulation game aimed at teaching project management to university students. Using an online survey tool with a proper set of questions, the experience of the participant in using the framework to develop the serious game is thoroughly evaluated and reported.

### 4.2.1 Participants

Participants of this evaluation totaled 17, aged 23-36 years ( $M = 28.76$ ,  $SD = 4.024$ ). The participants are master students of software engineering at the University of Babylon, Iraq. The participants are asked to use the conceptual framework model to design the 'Senior PM Game' and based on their practical experience, they evaluate the framework by answering the questionnaire. Participants first received an explanation of the framework, and then asked to apply the framework to design the game, using either templates or paper. After completing the game design, they are asked if the conceptual framework contributes to improving their perception of the game and if they have any suggestions to enhance the framework. They were also asked whether the framework was easy to apply and understand, and if it provided them with a better understanding of the game characteristics.

Furthermore, they were asked about their experience with the framework using an adapted version of the System Usability Scale (SUS) questionnaire (Brooke 1996). SUS is a simple, ten-item Likert scale that provides a global view of subjective assessments of usability, which yields a single usability score on a scale of 0-100 (100 is the best achievable score).

### 4.2.2 Qualitative Data Processing

In addition to the usability scores, we also collected qualitative data on the participant's experiences with the framework through open-ended questions on how the model affected their perception of the game if it was easy to apply and understand, and if it gave a better understanding of the game characteristics. To process the comments of participants, we coded answers to identify general statements about the framework. Each answer could contain one or more general statements. These general statements were grouped, and the results were presented subsequently.

### 4.2.3 Results

In general, participants considered that using the framework helped them better understand the characteristics of the game. It was positively evaluated by a large number of participants: among the 17 participants, 16 (94%) mentioned that the framework was helpful for them. It was considered simpler and easy to apply by ten participants, four of them non-gamers. The framework perception noted in qualitative data in the SUS usability scores was apparent. For the non-gamers group ( $N = 10$ ), the average usability score was 71.25, and for the gamers group ( $N = 7$ ), it was 68.93. While the average usability score for both groups of participants ( $N=17$ ) was 70.29.

## 5. Conclusion

A conceptual framework is presented to facilitate the design and development of serious games for learning in a flexible and easy-to-use way. It identifies the main components for learning that could be incorporated into the game to aid the design process of an effective serious game. It links the mechanics that serve as learning mechanisms and those solely associated with gameplay to maintain the game's entertainment value. This linking provides the development team with a "dictionary" for adjusting the game mechanics to the learning objectives of the game. Additionally, the conceptual framework is easily understood and used because it employs vocabulary derived from the serious game domain itself, hence supporting the collaborative work among multidisciplinary development teams. Since it is possible to reuse design components of its model, it can serve as a guide throughout the development process, potentially reducing the time and effort required to complete the development compared to designing and developing serious games from scratch.

Finally, we demonstrated the feasibility and applicability of the conceptual framework by developing a serious game as a web application according to our proposed models. While this confirms the contributions of our conceptual framework, further evaluations are needed to demonstrate its utility in terms of productivity improvement. This could involve developing design methods and tools based on the model that can be compared with other design approaches. Additionally, further research could explore the conceptual model to identify any missing core components of serious games for learning.

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