Educational Digital Games: A Theoretical Framework About Design Models, Learning Theories and User Experience

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Abstract. This article presents a study on design models for Educational Digital Games, taking into account learning theories, game design models, game elements and user experience. Through a theoretical framework the research seeks to understand the different perspectives involved in these models, considering the interdisciplinary character of the developer teams and their target users. The aim of the research is to identify similarities, differences, and gaps between the models investigated. Thus, a literature review was conducted and four models for analysis were identified. As a method, both a comparative and a qualitative analysis of these models were used, based on a data analysis spiral combined with an analysis protocol. The analysis sought to identify pedagogical approaches, instructional design aspects and other elements involved in the design process. Game elements and user experience were also considered relevant for the analysis. As a result, this research presents a hybrid model which complements the analyzed models, using the investigated framework as a structural basis to assist developers and content specialists when designing educational digital games for teachers and students, according to the learning objectives and the theme addressed in the game. Finally, this article presents a brief analysis of the results obtained and considers how the present study may contribute to future investigations.

Keywords: Educational Digital Games · Game design models · User experience

1 Introduction

The experience of the professionals involved in the design of digital games is an important factor in the design of games, since each professional has a personal perception of their activity. Both the literature and practical observations show that this

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type of product is often developed by interdisciplinary teams composed of professionals with different backgrounds and experiences. This situation becomes even more complex when designing Educational Digital Games (EDG) due to the additional complexity this media presents: the game must be fun and teach specific content.

The development of a successful educational game requires the combination of different types of expertise (e.g. different design models and different instructional design methods). This often causes a lack of structural unification during the design and development processes [1]. It is therefore necessary to identify a model which combines the main aspects used in these processes. In order to do so, this article presents a comparative study between game design models, which despite their qualities still lack the desired structural unification of the different elements of the design process.

According to the literature game design involves two perspectives: the designer's perspective and the player's perspective. This premise represents the basis of the MDA model – Mechanics, Dynamics and Aesthetic [2]. The DPE model – Design, Play, and Experience [1], was proposed as an expanded structure of the MDA model, adding aspects of learning, storytelling, user experience, gameplay and technology. Such an approach allows for new reflections and alternatives to improve the design of educational games, as observed in the DDE model – Design, Dynamics, and Experience [3]. This model offers a more detailed description of the components of the design process. The LDGM model – Learning Games Design Model [4, 10], is also considered. This model focuses on the collaborative design process between game developers and content specialists.

These models were analyzed using a comparative method. The qualitative nature of this method has made it possible to identify similarities, differences, and gaps in these models, taking into account the following aspects: (a) learning theories and instructional design approaches, (b) relevant perspectives, (c) elements of user experience, and (d) game elements. Each model uses their own diagrams to explain their processes. These diagrams were thoroughly analyzed so as to identify their visual components, and a hybrid model combining the main aspects of each model has been proposed.

The hybrid model preserves both the player's (learner) perspective and the designer's perspective, as observed in the models analyzed. However, the hybrid model also takes into account the perspective of the content specialist, since the designer has influence over the design of the game but not over the content. Also, the teacher's perspective was added to the player's (learner) perspective given that the process of designing the user experience involves not only the primary users (learners) but also the secondary ones (teachers). Hence, the hybrid model takes into account both the development team and the different game users, and how they relate to one another. For instance, the teacher influences the choice of the game to be played by the learner and how the elements learned through play, both in and outside the classroom, will be used. Thus, the teacher's perspective is an aspect that must be considered by developers and content specialists in the development of educational games.

In summary, the design of educational games benefits from a hybrid model. Such a model elucidates the relationships between the members of the developing team and their perceptions of the game design process, providing an interdisciplinary

approach to this type of project. Further, this model[1] emphasizes the instructional design and user experience aspects that must be considered in order to enhance the player's experience.

2 The Pedagogical Approach to Educational Digital Games

Games can help players develop self-control and build knowledge and skills related to everyday life situations. Such practice requires attention, intelligence and psychological resistance, all of which must be well managed by the player [7]. These claims are especially related to the pedagogical approach of Educational Digital Games (EDG). Therefore, it should be noted that although game-based learning is not a new concept, much still needs to be investigated about this subject, especially in relation to the design process of educational games.

2.1 Overview of the Learning Theories Directed at EDG

The educational process involves central categories of experiential and spontaneous education, which results in learning. Intentional or purposeful education, on the other hand, corresponds to the determination and organization of learning in specific environments such as school, through specific media. From this context, we have identified theoretical references associated with the construction of these media and which use a pedagogical approach which shows how to best direct learning in EDG.

Outdated approaches such as the behaviorist model are still used in pedagogical practices and in media tools to support learning, despite their noted decline in education research. Thus, in order to identify the main pedagogical approaches which implicitly or explicitly support teaching practices, an overview of the learning theories was consulted and combined with the other authors considered here, in order to identify an approach with a focus on EDG (Fig. 1):

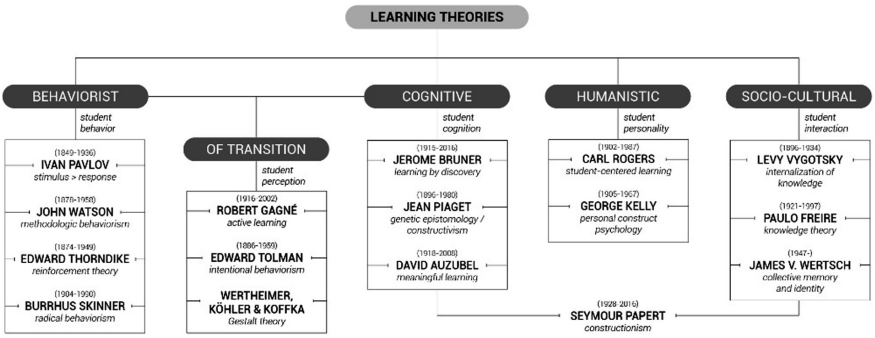

Fig. 1. Learning theories overview

[1] The hybrid model proposed here is part of the first author's doctorate research. It is an exploratory contribution and still needs to be validated. The model aims to be an auxiliary tool to help in the early phases of EDG prototyping.

Five main learning theories were identified. Firstly, the **behaviorist theory**, whose theorists were governed by the individual's behavior conditioning. Secondly, the **theories of transition between classic behaviorism and cognitivism**, whose thinkers were guided by the individual's actions and perceptions. Thirdly, the **cognitive theory** which focused on the individual's cognition and on the acquisition of new meanings. Fourthly, the **humanistic theory** which was based mainly on the personality of the individual. Finally, the **sociocultural theory** which focused on the individual's interactions.

The diagram above (Fig. 1) draws from the constructionist epistemology, which shares genetic epistemology premises and emerges from the Constructivism. It is believed here that the individual can use tools to construct their own knowledge and to facilitate this process [12, 13]. It should be noted that one of the tools used in this approach is the computer.

In order to complete the pedagogical approach presented in this section, it was necessary to understand the types of learning based on a revised version of Bloom's Taxonomy [1, 18], and supported by a structured classification concerned with the definition of some instructional theories connected with instructional design. In this context, three types of learning were alluded to: cognitive, psychomotor, and affective. Thus, the types of learning and their characteristics must be considered when designing an EDG learning situation, and during the planning of the pedagogical content of the game. This will lead to learning derived from a global experience [1].

Game-based learning is also guided by motivational models [19]. Both intrinsic and extrinsic motivation play an important role in learning situations, as they prompt the use of game elements in learning solutions. Thus, the content related in this section aims to assist the analysis of EDG-oriented game design models, as well as the structuring of learning situations proposed in educational projects which make use of instructional design to delimit the strategic conduction of learning during the process.

2.2 Instructional Design as a Strategic Approach to EDG

Instructional design is embedded in the area of educational technology. It encompasses a set of activities, identifying the learning needs to be designed, developed, and evaluated [20]. Therefore, it makes use of learning-oriented strategies, which allow the student to build skills and knowledge. Such strategies must be learned and demonstrated after the interaction with the proposed activity, according to the learning objectives [22]. Hence, it is important to recognize guidelines which help the composition of these objectives, according to the pedagogical approach adopted.

The realization of instructional design at the individual learning level depends on some characteristics desirable to instructional events, most of which are based on cognitive theories of learning. These instructional events define the processes involved in the act of learning which are activated internally by the student. This allows the student to pass from one stage to another and achieve the skill established as a learning objective. Thus, the processes presumed to occur during any learning act use instructional design as a checklist, to verify whether or not the student needs support in learning a task [15] (Table 1):

Table 1. Instructional events and their relation to learning processes [15].

Instructional event	Relation to learning process
1. Gaining attention	Reception of patterns of neural impulses
2. Informing learner of the objective	Activating a process of executive control
3. Stimulating recall of prerequisite learning	Retrieval of prior learning to working memory
4. Presenting the stimulus material	Emphasizing features for selective perception
5. Providing learning guidance	Semantic encoding; cues for retrieval
6. Eliciting the performance	Activating response organization
7. Providing feedback on performance correctness	Establishing reinforcement
8. Assessing the performance	Activating retrieval; making reinforcement possible
9. Enhancing retention and transfer	Providing cues and strategies for retrieval

However, a distinctive characteristic of the strategic management of the instructional design process is the conception and implementation of the proposed educational solutions. This can occur at three different levels: (i) **macro**, to establish a common direction for all learning experiences intended for the project; (ii) **meso**, to structure specific learning programs; and (iii) **micro**, to develop study units from a fine design [21]. In this sense, it is believed that the intended level in this research is related to the macro level, since EDG design seeks to explore learning experiences.

Thus, the instructional design approach has a practical and organizational character. This can be seen in the way it manipulates the information to be received, assimilated, and used by the student from their contact with EDG. The importance of this fact is also noted in the design models consulted, as reported in the next section.

3 The Design of Educational Digital Games

The design process involves managing knowledge which has been acquired, combined, transformed and incorporated. It is an iterative process and encompasses different disciplines. Moreover, the design process goes beyond simple visual results, influencing decision-making [23]. Thus, during the design process, it is important to promote dynamization and facilitate communication between the members of the team [24]. It is essential that the team fully understand the interdisciplinary aspects involved in the design process.

3.1 The Interdisciplinary Character of the Team in the Design of EDG

The different disciplines involved in the development of EDG make use of different areas of expertise in the design process. Thus, the organizational hierarchy of the team has a typical structure, which is usually based on the interactions between producers, content specialists, designers, programmers, and artists [25].

This study considers the EDG design process as an interdisciplinary process, since it combines different types of knowledge, which interact with each other, transcending the limits of their related areas [26]. During the EDG design process the team must share information, results, and methods, focusing on the continuous learning process based on a collaborative relationship between different but integrated areas of expertise [27].

The Interdisciplinary Team and the Different Perspectives Involved
The composition of the team may vary according to the requirements of the EDG to be developed. The ideal team, however, would consist of the following professionals [10, 24, 25]:

- Production manager: focuses on process management to ensure the filing of the documents developed and that deadlines are met.
- Instructional designer: focuses on management and quality of the instructional content; acts as project leader and makes final decisions.
- Content specialist: focuses on content and learning objectives. This professional knows the content in depth and has enough experience to teach it.
- Educator: focuses on the learning. This professional has classroom experience and fully understands the needs of the teacher and the student.
- Developers: focus on the game according to their areas of expertise. Similarly to artists, programmers, designers, writers and producers, developers give shape to the game.
- Assessor: focuses on the overall quality of the game; identifies problems, measures results, and refines the product.

Hence, each member of the team plays a distinct role during the design process and each contributes to the process according to their area of expertise. However, regardless of their expertise, every member of the team is involved in the following stages of the process [4, 10]:

- Refinement of the learning objectives according to the skills and knowledge that the student must present during the game, as well as understanding of how the student can demonstrate the required knowledge or behavior change.
- Ensuring that the content is appropriate to the game environment.
- Conducting of formative tests to ensure the educational usability and effectiveness of the game.
- Development of ideas and supplementary learning materials during the game development.

Such an approach ensures that the educational objectives of the EDG are achieved, and that the interdisciplinary nature of the team fulfills its function, by sharing information and results throughout the process. It also promotes collaborative work, integrating the different perspectives and disciplines involved.

3.2 Games and UX Elements of EDG

Game Elements

The term "game" refers not only to a specific activity, but to all images, symbols and tools necessary to the activity [7]. All these elements are specific components to be communicated between the development team members during the design process. Thus, these elements are grouped according to their respective characteristics as follows [19, 28]:

- Dynamic: combines elements that give consistency and regular patterns to the player experience. It is implicit in the game and supports both rules and conceptual elements such as constrictions, emotions, storytelling, progression and system relationship.
- Mechanic: corresponds to mechanisms that configure the actions in play – e.g. "verbs" – and that change the game such as challenges, luck, cooperation and competition, feedback, resources acquired, rewards, negotiations, turns, and winning states.
- Components: correspond to the specific ways which qualify and execute the dynamics and mechanics represented conceptually in the game, such as achievements, badges, avatars, collections, combat, "boss fights", unlocked contents, donation, score, levels, points, research and exploration, social graphs and virtual properties.
- Storytelling: corresponds to the sequence of events which take place during the game and can occur in a linear, branching or emergent way. It includes all the narrative elements of the game (e.g. the game's premise, characters' stories, environment), and it is based on a main concept, prompting the game experience.
- Technology: corresponds to the tools, media and interactions that make the game possible, such as software, game engine or another technological apparatus. It is essential for the development of the other elements in the game.

The game elements help define the experience to be experienced by the player during the game [19]. Thus, the planning of these elements must be carried out together, according to the game experience proposed.

User Experience Elements for Games

The user experience (UX) corresponds to the general effect created by the interactions and to the individual's perceptions when using a product. It refers not only to what the individual actually does but also to the impact caused by the interaction through an interface [6, 16]. Thus, in design practice, the UX must ensure that every aspect of this experience has been planned and is intentional, because all possibilities for each action and expectation must be predicted in the composition of the experience [16].

Specially in the practice of game design, the UX is based on two main elements [17]: (a) **graphic interface**, visibly available to the user on the device screen and its peripherals, and composed of common controls (buttons and menus) and Heads-Up Displays (HUD[2]); and (b) **interaction**, experienced by the player via the interface.

[2] HUD is one of the graphic elements available on the screen which can transmit information to the user, such as energy bars, scores, maps, etc. [17].

The interaction depends largely on the graphic interface, which should be carefully planned so that it can be fully explored by the player, offering them a positive experience during the game [17].

Game interaction also depends on other elements of the player's experience [29]. Thus, taking into account elements of user experience[3] non-game and their experience during the game, the interaction can be planned based on the following elements of the player's experience (Fig. 2):

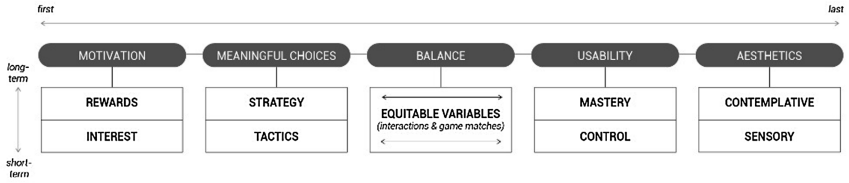

Fig. 2. The elements of player experience [29]: authors' adapted model

The initial layer of the player experience (Fig. 2) is **motivation**, which corresponds to the reasons for the player to start a game and to play it until the end. The main elements of motivation are (a) interest, which is generated in the short-term by the user's initial attraction for the product and gives them pleasure during the interaction; and (b) rewards, whose intrinsic characteristics sustain the player's interest in the long-term experience and can affect their involvement in the game.

The second layer presents **meaningful choices**. These define how the structure and the rules of the game allow the player to make decisions, and as such influence the results of the game. Here two factors are considered: (a) **tactics**, which are short-term tactical decision-making, and (b) **strategy**, which requires from the player the ability to anticipate future moves in each turn.

Balance measures how the game elements have been combined to create a challenging, fair and balanced system. It covers short-term aspects and the most basic game interactions whose effects are perceived more quickly. It also covers long-term aspects, such as the player's participation in turns that unfold throughout the games and whose effects are constructed according to the player's progress.

The **usability** layer is responsible for the planning of all interface elements and considers specific elements of the game experience. In this sense, usability should facilitate the player's perception of their own actions and of the goals to be achieved. This situation should give the player a sense of control over their short-term experience and allow them to master the game over time.

[3] Specific UX model designed for the web by Garrett [16] consisting of five layers divided between the product functionalities and its information.

Finally, the last layer relates to the **aesthetic**[4] aspects of the game, which are the interface elements which are visible to the player. The game aesthetic is guided by the following two factors: (a) sensorial factor, which in the short-term corresponds to the user's direct sensory experience with the game, from images, characters, and game controllers, for example; and (b) contemplative factor, which in the long-term corresponds to the narrative of the game and the way it unfolds during the game.

It is important to mention that although the pleasure factor (UX) and the fun factor (game UX) emerge from this model (Fig. 2), they cannot be directly projected. Thus, these factors may contribute to the game experience if the layers of the player experience are adequately addressed [29]. Another important point to consider is the player experience in EDG. This, however, still needs to be further explored in future studies, according to the learning theories adopted by the content specialists during the design process.

3.3 Design Models for Educational Digital Games

Game design must be guided by a brief description of the player's intended experience during the gameplay. In general, this process relies on design documents which guide the project from start to finish. Such documents direct the professionals involved in the different stages of the game development [24]. Thus, from the several models identified in the literature, this study has selected the following ones for the design of digital games: MDA (Mechanics, Dynamics, and Aesthetic) [2], DPE (Design, Play, and Experience) [1], DDE (Design, Dynamics, and Experience) [3] and LGDM (Learning Game Design Model) [4, 10].

This context was delimited so as to identify the relationships between developers, content specialists and other stakeholders in each model. This strategy has led to a consensus with regard to the perspectives involved and all the relevant aspects of the product development (EDG). The relationship between these models and theories offers an analytical and complementary framework that aims to become a more robust model for EDG design.

Mechanic, Dynamics, and Aesthetic: The MDA Framework [2]
The MDA framework offers a formal approach, and thus contributes to the understanding of the games and bridges the gap between developers and players. This framework makes use of game techniques to clarify and strengthen the iterative design process, whose goal is to set aesthetic objectives, the design of the dynamics, and the mechanics established to achieve these objectives.

MDA's first layer corresponds to the **Mechanics** (M). This layer contains a description of the specific components of the game as actions, behaviors and control mechanisms. From the designer's perspective, the mechanics create the dynamic behavior of the game system and, consequently, the aesthetic experiences of the player. The second layer is the **Dynamics** (D), which comprises a description of the system behavior in relation to the mechanics and the results during the gameplay. The dynamics

[4] The term "aesthetic" is used here according to Ferrara [29], but its adequacy is discussed throughout this article since it relates to the game appearance design.

create aesthetic experiences that are determined by the player's average progression time during the game. The third and final layer of the MDA framework is the **Aesthetic** (A). Here the emotional responses to be evoked in the player during the game are described. From the player's perspective, the aesthetic layer defines the tone of the game (originated in the game dynamics) and, eventually, the operable mechanics.

According to this framework, the designer creates the game for the player to play, and thus considers the player's perspective during the design process (Fig. 3):

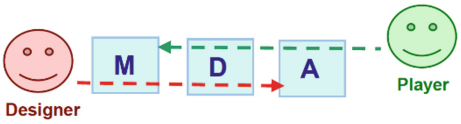

Fig. 3. The MDA framework [2].

Each category is directly related to the designer's and player's perspectives. Thus, when designing for the player, the designer is in a better position to propose a directed experience. Any small change made in any of these categories can result in a progressive effect, as one category can affect the other.

This framework has been widely used and criticized in the game design field. According to the DDE framework [3], for example, MDA neglects many aspects of game design. It also incorrectly uses the term "aesthetic". Nevertheless, MDA is a useful approach for this study, as it is a relevant model in the game design area.

Design, Play, and Experience: The DPE Framework [1]

The DPE model was proposed as an expansion of the MDA framework [2]. Its application would assist in the development of EDG, as well as guide the discussion on some semantic barriers identified among the development team in particular. This framework presents objective language to be used when discussing design, methodology and EDG (Fig. 4):

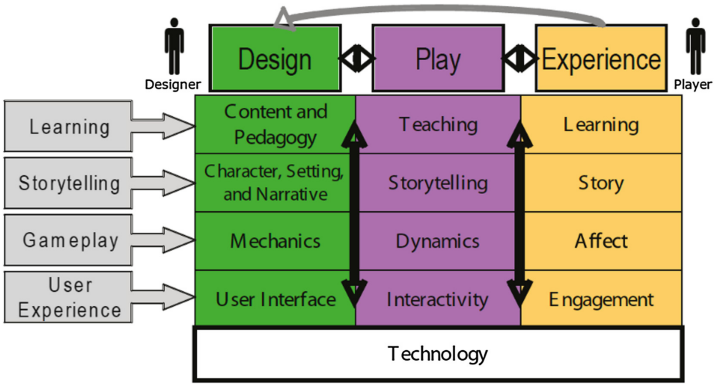

Fig. 4. The DPE framework [1].

This model preserves the perspectives of the designer and the player, both presented in the MDA framework [2]. However, the DPE framework adopts the graphic representation of an iterative design process between the Design (D), Play (P), and Experience (E) layers, and each one of these layers can be influenced by the other (Fig. 4). This structure is supported by technology and the game design process depends on the available technology.

The Learning layer allows the designer to plan how the pedagogical content should be taught in-game and how this content should direct the learning derived from a global experience. The second layer contains the Storytelling, which presents two contexts: (1) the designer's story, constructed for the game and used to promote engagement and convey content; and (2) the player's story, which corresponds to the experience resulting from the projected narrative, the player's interaction and their choices. The design decisions related to the narrative are influenced by the intended results.

The Gameplay expanded layer differs from the original MDA model [2] and replaces the Aesthetic category with the affect idea. This layer defines the actions of the player and their consequences, and is divided into three parts: mechanics, dynamics and affect. It is up to the designer to define what affects to induce in the player. To do so, the designer must consider every fun aspect of the game and understand the particular aspects that derive from the fun experience on the part of the player. Experience is the deepest layer of this structure, from the player's perspective. This layer aims to create means to achieve the desired learning outcomes. In this sense, the designer develops a game whose environment can involve the player and promote a significant immersion in the game experience. The Technology available is at the base of this framework. This layer influences the design process since the beginning, as it can either facilitate or hinder the project. Some design choices depend more on technology than others. For example, the user experience is most influenced by the technology, as the player experience depends heavily on technology.

The DPE framework is based on the idea that games are more effective for engaging students, giving them a more active role in the learning process. This framework considers three perspectives of the EDG[5] development process: (1) academic, which focuses on the theories related to education, pedagogy, communication theories, etc.; (2) content specialist, which focuses on a specific content; and (3) game designer, which focuses on creating involvement and entertainment during the game. However, only the designer's and the player's perspectives are graphically represented in the model's structure (Fig. 4).

Design, Dynamics, and Experience: The DDE Framework [3]

The DDE framework is based on other models such as the Elemental Tetrad – MTDA + N (Mechanics, Technology, Dynamics, Aesthetics and Narratives) Framework[6] [28], the DPE framework [1], and other models in the gamification area which take into account the gaps and incongruities of the MDA framework [2]. Accordingly,

[5] It is important to clarify that in the DPE framework [1] Educational Digital Games (EDG) are considered serious games.

[6] This model was proposed by Paul Ralph and Kafui Monu, and it combines the MDA framework and the Elemental Tetrad [3].

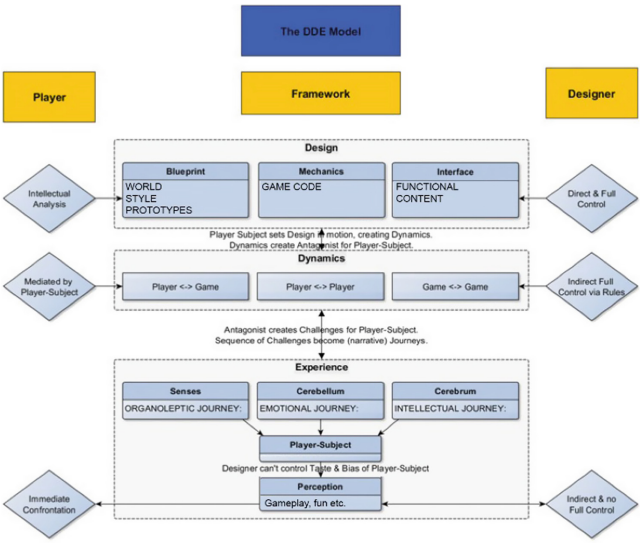

Fig. 5. The DDE framework synthesis [3].

the DDE model covers the entire development process, including the elements of the actual game production and the eventual journey of the player. As a result, this approach has a rather extensive structure, whose synthesis based on keywords is presented in Fig. 5.

The DDE framework offers Design, Dynamic and Experience as the main categories of the model. These are however, presented as separate layers and preserve both the designer's and the player's perspectives. The Mechanics layer – reminiscent from the MDA model [2] – is more specific in this model and delimits the entire architecture of the game, the technology and other elements of the game's operational system. However, in the DDE model the mechanics layer has been incorporated into the Design category, along with the subcategory Blueprint, which conceptually defines the game world, and the subcategory Interface, which defines the elements of the system which interact with the player.

In relation to the MDA model [2], the Dynamic category has undergone less intervention in the DDE model, and focuses on defining what occurs in the game according to the mechanics established by the design. It considers the unpredictability of the dynamics due to the different behaviors involved between the different types of players. The Experience category, on the other hand, was designed to suppress the controversy caused by the inaccurate use of the term "Aesthetic" (emphasis added by the authors [3]) in the MDA framework. The Experience category was discussed at length and presented through the player's configuration as player-subject. This term is used by Sicart [30] to define the act of playing, since it is not exactly the player who acts in the game, but a subset of himself through a character and the projection of its senses, emotions (cerebellum), and its mental journey (cerebrum), all of which rule the player's experience in play.

Also in relation to the MDA model [2], the DDE framework has added new sub-categories and replaced others. This model deeply examines the player's perspective. The authors of the DDE model admit that the model is still under development and may undergo changes in the future. Nevertheless, the present study considers that the DDE model as it stands is visually confusing and does not provide valid arguments for the criticisms it makes to the MDA [2] and DPE [1] frameworks. In addition, although the DDE model briefly addresses some aspects related to learning in the EDG design, this is not its focus, and the way learning issues are discussed may not be appropriate, particularly in its critique of the DPE model [1]. Yet, its contribution to the Experience category is relevant to the research reported here.

Learning Games Design Model: The LGDM Framework [4, 10]

This model was designed according to a specific approach to EDG which was developed by instructional designers from the Learning Games Lab[7] for the collaborative development of educational multimedia. This specific approach to the creation of EDG was intended to promote collaborative work between the members of the development team from the beginning of the design process. In this approach, everyone was responsible for both the game design and the intentioned educational outcomes. This joint action aimed at understanding the content, refining the educational objectives, and adjusting these objectives to the game mechanics. Based on these premises, the Learning Games Design Model (LGDM) has been proposed. The model considers the implications of such an approach for a more effective EDG development, and demonstrates its application through a case study (Fig. 6):

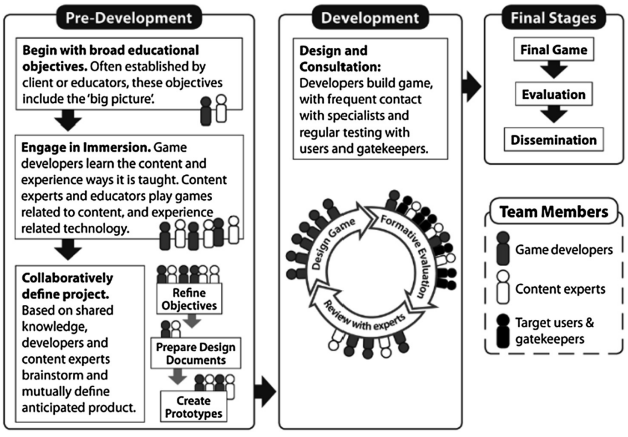

Fig. 6. The LGDM framework [4, 10].

The LGDM model integrates content specialists, learning experts, stakeholders (teachers and students) and the creative team. This design process has a cohesive team and is divided into three stages [4, 10]:

[7] The Learning Games Lab at New Mexico State University (NMSU) in Las Cruces, NM focuses on the study and development of educational multimedia [4, 10].

1. Pre-Development: team building and sharing of overall educational goals. At this phase the entire team is immersed in the educational content, traditional educational approaches used for teaching content, and any games considered relevant.
2. Development: active creation of the game by the team through an intense collaborative process. Formative tests should be conducted so as to preserve every aspect of the game design.
3. Final stage: summative evaluations should be conducted before the game is distributed and publicized.

The design process adopted by the team follows more closely with this model, when compared to previous ones. However, the LGDM visually demonstrates that all those involved in the process have actively participated since its inception. However, this situation does not always occur in the practice, since the participation of the content specialists and the stakeholders is minimal in many real teams [33]. Nevertheless, the LGDM model is relevant to this research, since it provides notes that can significantly assist the objectives defined herein, despite the identified limitations.

3.4 Design Model Analysis Directed at the EDG Design

The comparative-qualitative analysis conducted here was developed during the reading of the materials, according to the research problem and the characteristics identified in this reading. The analysis was a cyclical process in which it was often necessary to redo readings, revisit theories, and re-evaluate decisions made during the formation of the categories of analysis. As a result, the research has generated an analytical table, the narrative of the research, and the hybrid model based on the analyzed material.

Analysis Protocol

The spiral model of data analysis [31] has been adapted to the theme and research specifics, so as to support the analysis protocol, as shown in Fig. 7.

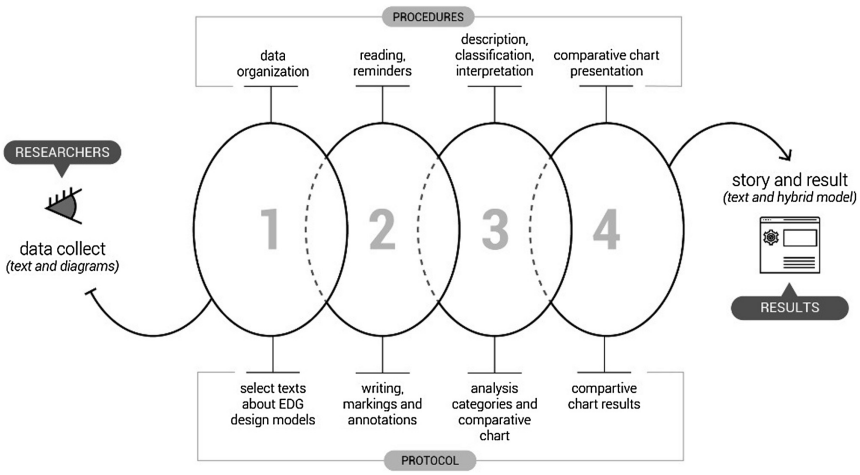

Fig. 7. Spiral of the data analysis and the analysis protocol.

The data collection (cycle 1) occurred during the reading of relevant papers and publications in the area, and the material collected was organized according to the following selection criteria (Table 2): (a) recognized in the game area and the academic environment; (b) presenting relevance and possible adherence to EDG development; (c) presenting a visual synthesis which allows the visualization of the model; and (d) presenting the different perspectives involved in the design process.

Table 2. Data organization and selection criteria.

Data collection		Criteria			
Model	Source	(a)	(b)	(c)	(d)
MDA [2]	Literature review	●	◉	●	◉
DPE [1]	Literature review	●	●	●	◉
DDE [3]	Literature review	◉	◉	◉	◉
LGDM [4]	Systematic literature review[a]	◉	●	●	●

● = yes | ◯ = no | ◉ = partially

[a] The first three models originated from the literature review conducted throughout this study. The last model was identified during a more systematic literature review, conducted by the first author of this paper during her doctoral research.

Cycle 2 was the most extensive period of the analysis. It was during this cycle that the analytical reading of the texts which made up the theoretical framework of the research and of each model was conducted. This procedure was accompanied by notations, flagged whenever some strong and relevant information was identified.

Cycle 3 was dedicated to answering the research question and consisted of the following: (a) description, which included a report on each model through a synthesis text; (b) classification, which implied the breakdown of the elements of analysis according to the research question; and (c) interpretation, which included the organization of the data in a comparative table.

Finally, cycle 4 was dedicated to the presentation of the comparative table created during cycle 3 and whose protocol provided the discussion of the results, as reported in the next section.

Comparative Table Elements

The comparative table was designed according to the research question and draws on the theoretical framework on which the interpretation and analysis of the models described here are based, taking into account the following aspects (Table 3):

In order to analyze the **learning theories (LT)** and **the instructional design (ID)** involved in the models, a theoretical framework (Sect. 2) was used to identify how these items were dealt with in the EDG design models. Regarding the **perspectives involved**, we sought to identify how the perspectives beyond those of the designer and the player were treated, based on the framework presented in Sect. 3.1. Thus, this study considered the following perspectives as the main ones for the analysis: developer,

Table 3. Comparative table of the game design models.

Model	LT and ID	Perspectives	UX elements	Game elements
MDA [2]	○	D + P	●	●
DPE [1]	●	D + P	●	●
DDE [3]	○	P + D	●	●
LGDM [4]	◉	D + CS + P + T	●	◉

● = yes | ○ = no | ◉ = partially | D = designer | P = player | CS = content specialist | T = teacher

player, content specialist and teacher. It also sought to analyze the **elements of the user experience (UX)** presented in the models, considering the factors involved in the game interface (Sect. 3.3).

The analysis of the **game elements** investigated how and when each model handled the configuration of these elements during the design process. This was the most general aspect of the analysis and it was included to help identify possible differences or innovations in the way the game design is conducted. The theoretical framework of this aspect of the analysis is described in Sect. 3.2.

Discussion

Learning theories (LT) and instructional design (ID) approaches were identified only in the DPE [1] and the LGDM models [4, 10]. The DPE learning planning relied on the transition theories (Bloom's Taxonomy) and on humanistic theories (active learning), and the direction of the instructional design in this model was guided by the events of instruction. The LDGM, on the other hand, focused on collaborative instructional design, and did not explain the learning theories involved. However, this model contemplated learning aspects at all stages of the design process, since the educational objectives were its priority [4].

As regards the **perspectives involved**, only the LGDM model [4, 10] presented the perspectives sought in the present study. In the DPE model [1], for example, the framework itself did not describe the perspective of the content specialist nor the teacher's. The content specialist was briefly mentioned in some of the readings, and in interviews conducted in the GEL Lab[8], it was identified that these professionals would be considered in the process as needed as part of the design team, and were usually consulted when their expertise was required.

When analyzing the **elements of UX**, the MDA framework [2] considered this aspect from the player's experience point of view. This model's approach was supported by the formal decisions about the gameplay impacts on the player experience. The DPE framework [1], on the other hand, considered the elements of UX a category between the designer and the player perspectives, as in the MDA framework. Thus, according to the DPE model the design of the experience should optimize the learning outcomes and the fun-related factors, according to the layers established in this model [1].

[8] These interviews were conducted by this paper's first author with the resources provided by CAPES – "Foundation within the Ministry of Education of Brazil (…) to coordinate efforts to improve the quality of Brazil's faculties and staff in higher education through grant programs" [11].

The analysis of the UX elements in the DDE framework [3] was quite extensive. The model critically discussed the terminologies used in the MDA [2] and brought the term "player-subject" to the fore. In the LGDM [4, 10] model, the analysis of these elements during the course of the development stage was somewhat implicit. "Design and consultation" sections were planned, in which all perspectives involved took part in an iterative cycle to plan the game design, formative assessments and expert's reviews.

As for the **game elements**, the MDA framework [2] focused on delimiting these elements according to the gameplay, although these elements were not visually presented in the diagram. The DPE [1] diagram, on the other hand, visually represented these elements, focusing on storytelling and gameplay, similar to the DDE [3], which implicitly related these elements to its three categories. The LGDM [4] diagram did not specify at which point in time the game elements were delimited, but it made reference to the preparation of the design documents in the pre-development stage, and thus referred to their design.

These analyses showed that all the models, to a greater or lesser degree, used the perspectives involved, the elements of UX and the game elements, considering that the pedagogical and instructional approaches were not limiting factors. However, only the LGDM model [4, 10] took into account all the perspectives considered relevant in this study to the development of EDG. LGDM was also the only model to clearly present in its diagram the design process stages. The other models, although they also referred to iterative design processes for game development, did not clearly present them in their diagrams. The analysis presented here showed that there are more similarities between these models than differences and, therefore, it was concluded that the models can be complementary to each other, justifying the hybrid model proposition.

3.5 Proposed Hybrid Model for the EDG Design

Based on the results of the analysis a hybrid model is proposed (Fig. 8):

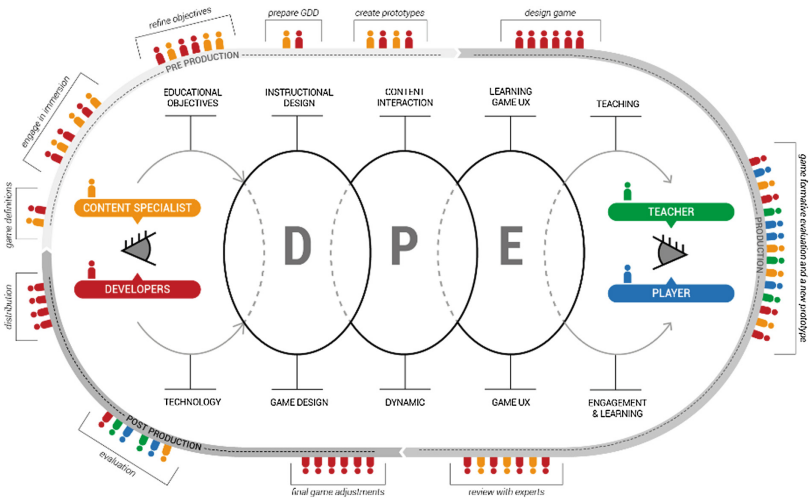

Fig. 8. Hybrid model of the EDG design.

Relevant aspects to EDG development were considered when creating this model. We have chosen to maintain the categories Design, Play and Experience of the DPE framework [1]. However, the DPE layers have been redistributed between these categories and the perspectives involved. Following the DDE framework [3], we considered the dynamic as part of the Play category. Following the MDA framework [2], we preserved the designer's and the player's perspectives, also presented in the DPE and DDE models. The stages of the design process were then inserted into the hybrid model based on the LGDM [4, 10] structure, signaling the performance of each perspective involved in this process.

The proposed model suggests a number of modifications based on the theoretical framework and on the objectives of this study. First, the content specialist's perspective is to be considered, along with the developer's perspective – which includes not only the designer but the development game team – while the teacher's perspective is to be added to that of the player. A further recommendation was inspired by the DPE [1] and the LGDM [4, 10] models and refers to the perspectives involved. The hybrid model visually relates the content specialist to the educational goals, and the developers to the technology aspects of the game. The teacher is related to teaching, and the player to the engagement and the learning through the EDG.

As for the iterative feature of the design process emphasized by all models, the hybrid model presents it as a cycle involving the three main categories, the relevant perspectives, and other related factors. Although based on the LGDM [4, 10] model, the resulting model differs from it in that it refers to its design process stages as: pre-production, production, and post-production [24, 25, 33]. Although the terminology has changed, the procedures adopted by the LGDM stage process are maintained.

Base on the research objectives, in what relates to the pedagogical approach and the learning theories involved, the hybrid model predicts its definition by the content specialists in the pre-production stage, although the model does not show these aspects in the diagram. As for the game elements, this model also predicts their definition during the pre-production stage, relating them to the game design subcategory, inserted in the Design category. The development of these elements is divided into categories and are constantly reviewed during the design process. Finally, the model associates fun aspects with engagement as an element predicted from the player perspective.

It should be highlighted that this model is the result of a research that sought to identify the fundamental aspects of EDG development. The model is a work in progress and requires amendments to be carried out in further research. The model will also be validated by representatives of all perspectives involved in the EDG design process.

4 Final Considerations

The framework reported here has led to the proposition of a hybrid model that is still under development. We believed that the framework between the analyzed models and the resulting model can be replicated and tested through an experiment in further research. With this, we hope to obtain results that allow the interpretation of collaborative situations among the team, both in the formation of concepts and in the

negotiation of meanings. Such results would make a valuable contribution to the EDG design process.

Despite their limitations, the results of the analysis have provided relevant observations for the development of EDG. The results obtained during the comparative analysis and demonstrated in the proposition of the resulting hybrid model, also proved to be satisfactory with regards to the research focus and objectives. Yet, it must be noted that this study is part of an ongoing doctoral research. The final results will be presented later according to the schedule provided by the author.

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