The Experience, Dynamics and Artifacts Framework: Towards a Holistic Model for Designing Serious and Entertainment Games

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***Abstract*—Games have been used by educators as a mean for increasing learning retention and providing students with entertainment experiences that go beyond the classroom. However, the process of creating a game for educational purposes (serious game) is segmented into its entertainment structures, which usually are underemployed in a pedagogical application, and in purely educational components, which have been extensively detailed in the literature. This division can hinder the player/learner experience as too much focus in one of these areas can either compromise knowledge acquisition or engagement. To overcome this issue, this work proposes a holistic view of games that includes both learning and entertainment elements, making them indistinguishable in creating either an entertainment or serious game. This notion is further reinforced by reviewing common game design frameworks found in the literature that have an empirical background, and by proposing a unified game design framework that uses elements from the analyzed frameworks and enhances them by including the latest research into game-based learning and serious games guidelines. By proposing a holistic view of games and an accompanying framework, a new way of facing game design is proposed that encourages designers to consider the *postgame* learning experiences and stimulates educators to take the entertainment aspects of their game more deeply.**

***Index Terms*—game design, human-computer interaction, serious games, educational games, game modeling, game-based learning, user experience, games, game development, video game**

I. Introduction

Games have long been studied as a mean for fostering educational outcomes, providing increasing learner engagement and retention [1]–[3]. The practices involving games and education are generally divided into applications of entertainment (i.e. commercial) games into the classroom and into the usage of a special type of games whose purpose is other than mere entertainment, called serious games (SGs) [2].

Generally, a serious game has concerns that differ it from a traditional entertainment game, with frameworks being developed specifically to address these structures, such as the practical methodology proposed in [4], structured as a process flowchart, or the hybrid approach in [5]. However, since games can be viewed as "a problem-solving activity, approached with a playful attitude" [6], one can argue that every game, regardless if it is a serious or entertainment one, has an implicit learning goal: the player has to understand and master rules and its dynamics to solve this problem, with tools provided by the game mechanics. Particularly, good games have inherent properties that make them suitable for educational purposes [7], being even considered as a distributed learning systems [8]. In this perspective, a game design framework or model should consider learning aspects and pedagogical concepts as a natural process within its design, not as an additional component that has to be taken care of only by educators. Most serious game approaches towards a design model fail to grasp this subtlety, and thus create a learning/pedagogical component that exists merely to address commonly associated traditional learning outcomes, rather than integrate learning seamlessly with "entertainment" components. One example of this pitfall is the Design, Play and Experience Framework (DPE) [9], which separates the learning aspects of the game from other components, such as narrative, gameplay, and even user experience, and implies that the learning process is separate from the game experience, not a consequence of these elements interacting with each other [10]. A systematic review of educational game design frameworks in [11] showed that 10 out of 11 evaluated serious games frameworks proposes a pedagogical goal, but only 4 of them were concerned with user experience. Gamer expectations, satisfaction, cognitive development, and learning behavior were not addressed in most of these frameworks [11]. Corroborating with this view, a Delphi interview of academic digital game design experts described in [12] stated that one of the greatest challenges of serious game design is creating motivational challenges, and not explicitly didactic; another study on the development of serious games by teachers working as designers stated that most of them struggled to use basic game elements (such as mechanics) and combining them into useful learning experiences [13]. Even though it is helpful to make the distinction between entertainment and learning aspects of a game, it might give rise to games that have little to no entertainment value as they are overly concerned with educational goals.

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Therefore there is a need to develop a game design framework for the development of both entertainment and serious games, that considers the learning process holistically by either teaching the player about game rules and controls or aiming at learning pedagogical content. While game rules are usually taught intuitively, falling under the field of intuitive design [14], pedagogical content can vary in its approach, either by teaching content explicitly (instructionism view) or indirectly (constructivist view). Regardless of their "intuitiveness", their common goal can be stated as transferring knowledge to the player, whether it is serious or not. Thus game rules and content instruction should be integrated into a single view of learning in games. Since a truly holistic framework must account for various game elements and design considerations, this work proposes a first attempt at developing this unified model by analyzing common game design frameworks found in the literature, combining their elements into a simple design model, and integrating SG's learning mechanics that can be used by game designers and educators.

II. Methodology

To create a framework that embraces both serious and non-serious aspects of games, it is necessary to couple empirical industry practices with well-known results from academic research about game design for fostering learning and behavioral changes. To this end, this work starts by reviewing current learning theories and practices related to games, revising the definition of a game and proposing a unified view that comprises both aspects, as well as a formal definition for experiences that take place while (*ingame*), and after playing a game (*postgame*). Secondly, this work describes and compares common game design frameworks found in the literature which have a strong empirical background and are generally accepted by both the game industry and academics. This is not an exhaustive comparison, as there are a plethora of frameworks, models, and guidelines that were not considered in this work; the analyzed frameworks were chosen according to their empirical background/context, rather than academic validity. Next, based on the evaluated frameworks, a new model is proposed based on game-based learning approaches and serious game design. This model brings together empirical and research aspects into one integrated view of game design that offers a fresh lens for both designers and educators alike on how to entertain and educate players simultaneously.

III. Learning theories, mechanics and design guidelines

Several pedagogical theories can be associated with serious game design; however, most studies fail to report its underlying learning theory [15]. Works that explicitly address its pedagogical background are most commonly associated with the constructivism approach, followed by humanism and cognitivist theories [15], [16]. Constructivism focuses on the learner as an active information constructor [15], where learning is subjective and related to prior knowledge [17]. A related approach is the socio-constructivist theory proposed by Vygostky [18], which focuses on learning through social structures and interactions, such as family, community, and culture. According to this view, learners can be helped by peers and teachers to achieve a cognitive zone suitable for learning, the Zone of Proximal Development; this process of supporting learning is called scaffolding [18]. Cognitivism considers thinking as an integral part of learning (as opposed to behaviorism, which tackles learning as simple stimulation and reinforcement), and dictates that content must be organized from simple to complex to maximize knowledge acquisition [15]. Humanism states that learning should be personalized, considering not only cognitive aspects but also affective needs and individual values [15].

Each pedagogical theory in turn proposes a different set of learning concepts, such as the use of direct instruction or learning through solving and analyzing problems (problem-based learning) [15], [16]. These concepts can be directly inserted into a game as learning mechanics, which are defined as dynamic operations of learning based on pedagogical principles [19]. Learning mechanics include strategies such as content/task repetition, tutorials, demonstrations, observations, experimentation, guidance, incentives, discussions, instructions, simulations, and assessments [19]. These mechanics can be implemented directly into game elements, such as providing direct instruction/guidance through narrative, task repetitions through game levels, and observations with aesthetic feedback elements (points, sound effects, progress bars). Hence the creation of SGs can be considered as selecting and designing the most appropriate set of learning mechanics, according to some pedagogical theory. Based on this notion, several guidelines and learning mechanics for effective SGs have been proposed in the literature, like the use of goals/challenges (incentive mechanics) [2], [12], [20], clear feedback [2], [12], [20], [21], scaffolding (guidance, instructional mechanics) [12], [21]–[24], and narrative/storytelling (guidance, instruction, observations mechanics) [2], [20], [21], [24].

IV. Games and Player Experiences

The definition of a game and its underlying structures is still a topic of discussion among researchers since there is little consensus about its formal definition. Three views, in particular, are useful for directing game design efforts: (1) the definition of a game as a "system in which players engage in an artificial conflict, defined by rules, that results in a quantifiable outcome" [25]; (2) the view of the game as a combination of rules, quantifiable and variable outcomes that can have different values, player's effort, and investment, and negotiable real-life consequences [26]; and (3) the notion that a game is "a problem-solving activity, approached with a playful attitude" [6].

There is an intrinsic parallel between these definitions and the activities taken from an educational perspective: all learning activities can be taken as having real-life consequences, and are negotiable in the sense that the learner can decide what he/she will retain. Learning processes are also defined by a set of rules (how to engage with content), have quantifiable and

variable outcomes (learner's performance and progress), and depend on player's (learner's) effort and cognitive-affective investment. Pure entertainment games can also have learning outcomes, related to player's affordances [14]: game rules, goals, environment, rules, culture/lore.

Based on this synergy, this work changes the notion of game to a *system focused on affective (i.e. emotional) outcomes in which players engage in a learning challenge designed to overcome a problem, with a playful attitude.* This particular way of defining games, which values both entertainment and learning aspects, leads to the design and balancing of two types of player experiences: (1) *postgame* experiences consisting of any impressions, thoughts, behaviors, and knowledge originating from the interaction with the game, but stored permanently by the player and taken outside the game experience; and (2) *ingame* experiences, related to all player's interactions and outcomes during the activity of playing the game.

V. Review of game design frameworks

The Mechanics, Dynamics, and Aesthetics (MDA) is one of the first and most known frameworks for game design, accepted both by academia and practitioners [10]. It formalizes the experience of a game into three components (fun, system, and rules), and propose their corresponding parts from the design perspective: (1) Mechanics, which describes components of a game, its data representation, and algorithms; (2) Dynamics, the game behavior after mechanics interactions and interactions with the player; and (3) Aesthetics, the desirable emotional responses evoked in the player [27]. Even though this is a very straightforward interpretation of the game experience, it has been criticized due to some possible misinterpretations and ambiguous definitions. For instance, Mechanics comprises both code, technology, and game mechanics, which can be confusing to designers while establishing a standard nomenclature for game design. Aesthetics is also problematic, because the term itself has multiple meanings from different backgrounds (design, art, psychology), and yet it refers only to player emotions; this definition makes the game user interface (UI), art style, and overall looks of the game be a part of Mechanics, even though they technically refer to the aesthetics of a game in a broader sense [10]. According to the MDA, the player experiences the game first by its Aesthetics, then by Dynamics, and lastly by its Mechanics; this is somehow strange, since buttons, controls, interactions, and game UI all belong to the Mechanics component, thus being the first ones the player has contact with.

Another conceptualization of game elements is the Elemental Tetrad, which divides game components into Aesthetics, Mechanics, Technology, and Story [6], [28]. According to this view, Aesthetics corresponds to the look and feel of the game; Mechanics refers to the game goal's, rules, and procedures; Technology corresponds to any materials and interactions that make the game possible; Story in this context is the sequence of events that unfolds in the game [6]. The Tetrad is further subdivided into various elements, which can sometimes provide an inconsistent definition [28].

The Design, Play, and Experience Framework (DPE) is an expansion of MDA that aims to address the learning aspects of serious game design [9]. The elements of this framework correspond directly to MDA. However, the DPE adds a feedback loop from the Experience to the Design component. This loop emphasizes the influence of experience goals on the design and reinforces the concept of design iteration. It further expands the original MDA components into five layers: (1) Learning, which accounts for the learning outcomes desired for the game experience; (2) Storytelling, comprising both the designer intended story and what the player makes of it through its own experiences; (3) Gameplay, defining what the player does in the game, including its mechanics, dynamics and resulting experiences (affect); (4) User Experience, which corresponds to the most visible aspects from the player's perspective; and (5) Technology, reflecting the capabilities and limitations of technical aspects utilized in the design. These layers represent cross-sections in all three DPE components, and that they all influence each other, meaning a change in one aspect of the layer can influence all others, regardless of their position in the three main components [9].

The Artifacts, Players, and Experience framework (APE) was proposed as a unified model for digital games based on the MDA and the Elemental Tetrad [28]. It considers the Player as an explicit component of the game process, consisting of aesthetics (emotions evoked by the game) and interpreted narrative (player's mental representation of game narrative); the Player component relates to player typology, game genres, and style, describing elements that are available only in the mind of the player instead of the game itself [28]. Interestingly, the Player aspect refers to both human and nonhuman agents. The Experience relates to events and behaviors that originate from player-artifact interaction; it is composed of dynamics (the emergent behavior from player-game interactions) and emergent narratives (a meaningful sequence of events that emerges from player-game interactions). Finally, the Artifact component refers to artificial objects and systems used to structure play [29]; it comprises game mechanics (elements used by game developers to create and manipulate challenges), narrative mechanics (elements used by game developers to advance the plot of the game), technology (tangible and intangible elements used to deliver the game), and embedded narrative (stories told by the designer using game and narrative mechanics).

The Design, Dynamics, Experience (DDE) framework is also based on the MDA and the Elemental Tetrad but is more focused on the production process [10]. The Mechanics from MDA was reframed into the Design component, consisting of blueprint (the game world in concept, its culture, narrative design, art style, sound design, and overall planning and documentation), mechanics (everything related to code and technical aspects of the game, including technology), and interface (everything that is used to communicate the world to the player, from art to sound assets). The Dynamics component is similar to the one with the same name in MDA, but DDE specifies it further by dividing a game's dynamics into

TABLE I
COMPARISON OF GAME DESIGN FRAMEWORKS

Characteristics	Description	Frameworks			
		MDA	***DPE***	***APE***	***DDE***
Theoretical background	The underlying model utilized	-	MDA	MDA; Elemental Tetrad	MDA; Elemental Tetrad
Player Model	Whether or not framework explicitly accounts for a player model	Implicit	Implicit	Explicit	Explicit
Hedonic Aspects	Interface design, emotions, player experience, scenario, and graphics	Aesthetics (player experience); Mechanics (UI and style)	Experience (Gameplay layer); Design (User Interface)	Player; Artifacts (Mechanics)	Experience
Player-Game Interactions	Dynamics arising between player and game	Dynamics	Play (Gameplay and User Experience layers)	Experience (Dynamics)	Dynamics; Experience (Player-Subject)
Game-Game Interactions	Dynamics arising from interaction between game components	Dynamics	Play (Dynamics)	Experience (Dynamics)	Dynamics
Game Components	Game constituent parts (rules, mechanics, narrative, etc)	Mechanics	Design (Mechanics)	Artifacts (Mechanics, Narrative)	Design
Experience Design	How the player iterates through the development process	Linear	Nonlinear	Nonlinear	Nonlinear
Experience Development	How the designer experiences the framework components	Linear	Linear	Not viewed as a design process	Not viewed as a design process

game-game interactions, player-game interactions, and player-player interactions. One fundamental change from the MDA component is that Dynamics in DDE is explicitly stated as being in control of the designer, but indirectly, implying its emergent nature and the iteration needed between designer, game, and player to fine-tune its dynamics. The Aesthetics component from MDA was reframed into the Experience component, which in DDE consists of a player-subject (a form of mental persona, a small subset of the player that allows exploring challenging situations from a safe place) and an antagonist (representing the conflict and player opposition from a narrative perspective). The Experience stimulates the player-subject in multiple levels (sensorial, emotional, intellectual), loosely associated with physiological parts of the brain: senses, cerebellum, cerebrum [10].

A. Comparison

The frameworks here analyzed come from an empirical background, being closely related to industry practices and standards. However, several of them, like the MDA, APE, and DPE, were created to analyze and compare games from an industry point of view [4]. They provide some guidelines for game development. According to the MDA, when designing a game it is beneficial to look at both designer and player perspectives [27]. Based on the MDA, the designer determines the aesthetics aspects of the game, attempts to control them by providing appropriate mechanics, and adjusts the whole experience through *playtesting* and game balancing [9]. The DPE states that the target audience must be taken into account while designing a game and that the goals of the game (and the resulting player experience) should inform design decisions [9]. DDE, on the other hand, explicitly states that its components should not be interpreted as a development process, and describes the player (and designer) experience as an iterative simultaneous experience of all components [10].

In terms of player interaction and experience, they also diverge in some fundamental ways: while the MDA views the player experience as a linear process (from Aesthetics/Experience to Mechanics), DPE, APE, and DDE consider it as nonlinear. DPE, in particular, provides a feedback loop from Experience to Design, representing iterations needed to adjust the game. The DDE is highly based on narrative structures, where the experience arises from conflicts between the player-subject and the antagonist. The DDE and APE are the only frameworks evaluated that explicitly considers the player as the main component (Player from APE) or a subcomponent (player-subject of component Experience in DDE).

As for hedonic aspects (UI, art style and elements, sound effects, music background), MDA, DPE, and APE divide these into design components (assets used by the designer to create the look and feel of the game) and into the player experience. Thus, these elements can be found in multiple components in each framework. All of these frameworks consider that the full game experience arises not only from the player-mechanics interaction but from their inherent dynamics and the dynamics between game components; these interactions are clearly stated as Dynamics either as the main component or as a part of one. DDE and APE frameworks treat the origin of these dynamics differently from the others: the APE proposes that the Dynamics arise from Player-Artifact

interactions, while DDE's Dynamics are created by the player-subject and take form as a narrative antagonist, that opposes the player's actions and creates conflict. A full comparison of the frameworks can be seen in Table I.

It is important to notice that all frameworks evaluated refer directly or indirectly to MDA. Even though MDA has some shortcomings related to its linear approach of player's interactions and the definition of the Aesthetics component, it is still useful for the analysis of existing games [30]. However, it has low relevance for the game design process when compared to its analytical properties [30], since MDA does not provide a clear set of guidelines or directions on how changes in the Mechanics will affect the subsequent Dynamics and Aesthetics. To increase their relevance, all MDA-based frameworks could be complemented with additional guidelines and properties to enhance their usefulness for game design purposes. These additions could involve theory-based models that provide a strong foundation for creating and evaluating games or empirical processes with additional guidelines and theories coming from various complementary fields, such as psychology and pedagogy.

To solve this gap of enhancing the design usefulness of MDA-based frameworks, this work proposes a new framework related to MDA, complemented with learning theories and guidelines for serious games design. The proposed framework is a first attempt at addressing this gap and bridging concepts of learning in entertainment and serious games, providing a holistic foundation to create high-quality games.

VI. Proposal of a new framework

Based on the reviewed frameworks, a new model is proposed aimed at integrating practices for designing both entertainment and SGs. Similar to the frameworks presented before, this model describes player outcomes/experiences, game and player interactions/dynamics, and game components. These components are summarized as: (1) Artifacts, which refers to the APE definition, comprising any artificial objects and systems used to structure the game experience; (2) Dynamics, related to the emergent events and behavior coming from player-artifact and artifact-artifact interactions; and (3) Experience, consisting of player's affordances, mental representations, interpretations and appraisal of the game's intended and emergent dynamics as viewed by their players.

These components are related to each other through the concept of game loop, which is a relatively new element in the game design vocabulary [31]. The game loop can be viewed as a "composite of game mechanics, computing operations, and feedback mechanisms that are repeated until a break condition are reached, either in the game mechanics or in the computing operations" [31]; using this abstraction a game can be considered a collection of loops and their interactions [31], making the game loop a key element in game design [25]. The iterative nature of the game loop can also be replicated to the game designer activities: to design a game, it is necessary to create an initial version of it, test it with potential players (*playtesting*), get feedback, and improve the game's balance based on it.

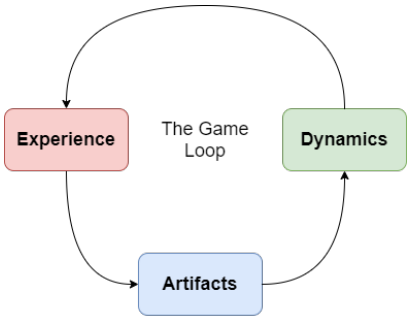

Fig. 1. The Experience, Dynamics and Artifacts (EDA) framework and its interactions through the game loop. The player experience loop and design experience loop are depicted as a single, iterative process .

In the proposed Experience, Dynamics and Artifacts (EDA) game loop, the player interacts with the Artifacts (controls, mechanics, UI), which triggers an emergent behavior in Dynamics; the Dynamics are then interpreted by the player in an Experience. From the player's perspective, these interactions happen iteratively during gameplay, in a cycle that can bring forward multiple experiences and different dynamics at every moment; the player can interact with the same Artifacts, but over time and through the game loop a new experience or dynamics can emerge. This framework is called EDA (Experience, Dynamics, Artifacts). A view of this model can be seen in Fig. 1.

From the designer's perspective, to create a game it is necessary to consider the player's Experience first, then the underlying Artifacts one should use to evoke that experience properly; lastly, the designer has to fine-tune the Dynamics structures through *playtesting* iterations. Thus the game design loop is this cycle of looking into player experience, choosing the right Artifacts, and fine-tuning their Dynamics. EDA can be further broken down into smaller subcomponents that create the gameplay. The following sections describe each component and its parts in detail.

A. Experience

The EDA's Experience refers to both impressions from the player during the gameplay (*ingame* experiences) and after it (*postgame* experiences). For simplicity, all *postgame* experiences are mapped into a Perception component, summarizing all "permanently stored" cognitive-affective and behavioral impressions after playing a game. Both *ingame* and *postgame* experiences are dependent on the player's beliefs, preferences, prior knowledge and metacognitive skills [32], [33]. These player-related processes are integrated into a single Persona component. In line with player typology and psychological traits/personality studies [34]–[36], EDA's Persona also includes the player's personality traits and *ingame* behavioral tendencies. This Persona is similar to the player-subject from DDE, highlighting the fact that the player is only a subset

of cognitive-affective functions of the real person who is interacting with the game.

The Persona is the one who takes the place of the player in EDA and interacts with the Artifacts; it is also responsible for evaluating all outcome Dynamics through a cognitive-affective filter, deciding what will be permanently stored as a Perception. To evaluate and decide this long-term knowledge acquisition, the Persona must create an appraisal of every event and outcome resulting from interactions with the game (Dynamics). An appraisal can be defined as a person's subjective evaluation and the resulting outcomes from unconscious strategies devised for coping with a particular situation [37]. In the EDA context, an appraisal is defined as all interpretations and results from the game interactions, consisting of (1) interpreted narrative as stated in the APE model; (2) player engagement, consisting of cognition, behavior, and sociocultural elements [38]; and (3) affect, the emotional reactions and outcomes arising from interacting with the game. Even though affect can be considered as a part of engagement [38], [39], it was isolated in EDA due to its importance for both learning and entertainment.

The sociocultural elements of player engagement describe both the influence of other players in the appraisal process, as well as the cultural context the Persona is immersed in. This view integrates both learning and entertainment outcomes as an iterative process of appraising a game's Dynamics, filtering the outcomes through the Persona and deciding whether it will be stored permanently as a Perception. Note that in the context of entertainment games, learning refers to the understanding of the game's commands, lore, rules, challenges, and the resulting emotions of playing it. A detailed view of the Experience component and its underlying structures is shown in Fig. 2.

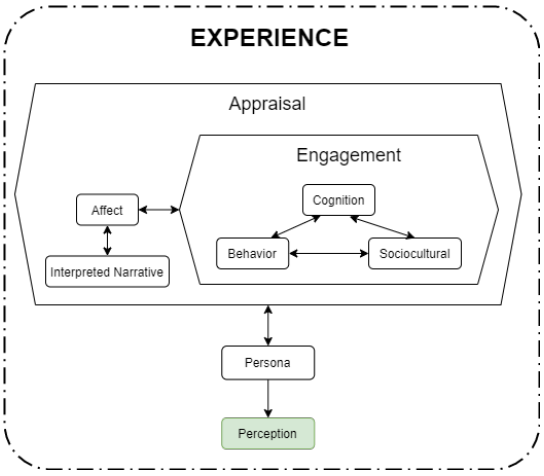

Fig. 2. Detailed view of the Experience component. Elements in green corresponds to those that exist beyond the gameplay, remaining with the player.

B. Dynamics

The Dynamics represent all emergent behavior from player-artifact and artifact-artifact interactions. It contains all the changing elements that arise from the interactions between Persona and Artifacts, thus being procedural by definition. Due to its emergent behavior, EDA's Dynamics is a suitable candidate to include all learning mechanics, which are also dynamic. Based on the guidelines and learning mechanics described in Section III, EDA's Dynamics are composed of challenges, scaffolding, and narrative. The narrative element corresponds specifically to an emergent narrative, similar to the one defined in the APE model. The feedback learning mechanics is represented in EDA by the game loop itself, connecting Artifacts, Dynamics, and Experience. It is important to highlight that, in line with the frameworks evaluated, the designer has indirect control over the Dynamics component: he can decide the challenge levels, scaffolding processes, and interactions within the narrative; however, these will only prove effective after the player's feedback, through *playtesting* iterations. Fig. 3 shows the detailed Dynamics component.

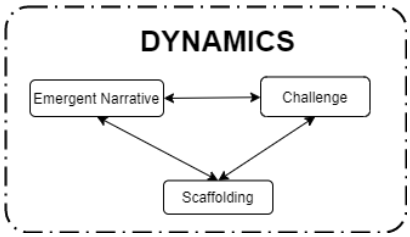

Fig. 3. Detailed view of the Dynamics component. Drawing from pedagogical perspectives, it includes the concept of scaffolding and its potential interactions with the game's challenges and emergent narrative.

C. Artifacts

The Artifacts are all objects and systems used to build and structure the game; it brings together elements from the APE's Artifacts and the DDE's Design component. This combination includes interface elements (UI, sound), narrative elements (world-building, theme, characters, plot), technology elements, and game elements (rules, randomness, levels, and so on). Based on this integration, EDA's Artifacts is subdivided into three categories: (1) medium, referring to technological structures of the game (digital vs analog, game engine, programming language), being similar to the technology aspect from APE and the Elemental Tetrad; (2) mechanics, referring to the game building blocks, rules and procedures as described by the Elemental Tetrad; and (3) embedded narrative, defined similarly as the corresponding block in the APE framework; this component refers to the order and sequence of events and narrative mechanics utilized that gives rise to the story as intended by the designer.

Since mechanics is such a large concept from Artifacts, it can further be divided into game elements (elements used to evoke challenges and experiences that are mostly found in games, following definitions from [28], [29]), narrative mechanics (as defined by the APE model), and aesthetics. The definition of aesthetics proposed here is based on the Elemental Tetrad definition, which is very different from the MDA-based frameworks. Thus aesthetics refers simply

to elements that are used to compose the game's look and feel; it includes UI, sounds, and game genres (action, horror, adventure). Even though the aesthetics contain elements that can evoke emotional responses (being closely related to the "A" component in MDA-based frameworks), the actual emotional response is taken part at the Experience level, by the Persona. The designer can use aesthetics elements to foster different emotional responses, but they will only be validated after player interaction. This means that to evoke a particular emotional response, the designer has to select appropriate aesthetics elements and validate them through *playtesting*, reinforcing the idea that game design is an iterative process that must take the player's impressions into account. The interactions between these elements are shown in Fig. 4.

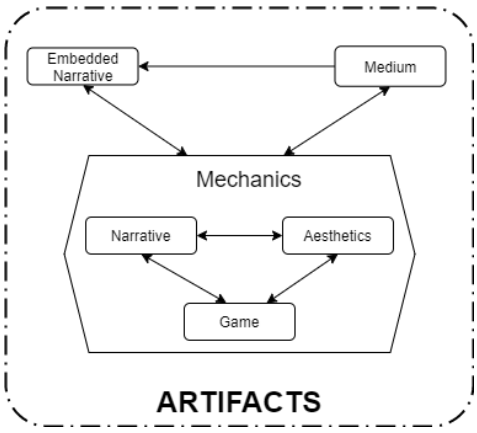

Fig. 4. Detailed view of the Artifacts component. It consists of the chosen medium (i.e. technology), mechanics and embedded narrative (designed sequence of events to tell a particular story).

D. Discussion

The proposed EDA framework is an attempt to unify concepts related to entertainment games and serious games. It brings forward a fundamental element of every game, the game loop, to integrate Experience, Artifacts, and Dynamics into an iterative cycle that represents the interactions between player and game, as well as their temporal relations. The EDA was also detailed in a second level, following common structures found in empirical frameworks, such as narrative elements, aesthetics elements, and game mechanics. It brings together common structures found in APE and DDE models but distinguishes itself from the reviewed frameworks by (1) including learning mechanics and learning in general as an integral part of game experiences, (2) including player's psychological structures based on appraisal theory [37], (3) explicitly acknowledging the role of sociocultural elements as an important part of the player experience.

From an educational perspective, EDA's foundations are influenced by constructivism, since the Experience component assumes that players have an active role in knowledge acquisition and long-term retention. Furthermore, Vygotsky's socio-constructivist approach is also present by acknowledging the role of social context in learning. Although constructivism is part of its foundations, other learning theories can be utilized for designing games with EDA. For instance, creating a behaviorist game by utilizing specific game mechanics, such as *cutscenes*, for providing direct instruction. While EDA's Experience is more closely related to pedagogical theories, its Dynamics relate to specific learning mechanics described in Section III. Hence EDA gives insights on how to creating quality learning experiences within a game: by designing challenges, providing proper scaffolds, telling a meaningful story, and creating constant feedback between these learning mechanics and the player. EDA also brings forth behavioral and cognitive elements associated with game-based learning practices, like meta-cognition, prior knowledge, and personality traits [33].

From a design perspective, EDA considers the game creation as an iterative process, related to user-centered design techniques [40] where game elements must be fine-tuned through *playtesting*. The designer has only indirect control over the player's outcomes and experiences, and must continuously improve the game experience by testing its game loop. EDA gives insights into how designers can create meaningful experiences: by designing appropriate challenges, taking into account the player's sociocultural context, and thinking about not only the *ingame* experience but also what will stick in the player's mind after the game (*postgame* experiences). Unlike all MDA-based frameworks analyzed, EDA shifts the designer focus from purely thinking about aesthetics to consider the overall emotional outcomes and player's impressions.

VII. Limitations

This work has some limitations at this moment. The game design frameworks analyzed represent a small portion of all models, guidelines, and frameworks proposed for designing games, which could impact EDA's validity and overall generalization. Since the EDA foundations are based on a very particular view of the game design process, that is, heavily inspired by MDA-based frameworks. Thus it should be considered as the first step toward a truly holistic approach to game design. It is also important to highlight that, although the proposed framework is aimed at analyzing existing games and helping game designers, it is still missing key aspects of the design process and "second-order" processes, such as risk analysis, project management practices, and production pipelines.

VIII. Conclusions and Future Work

This article proposes a first step towards a holistic framework for analyzing and designing games with or without explicit learning goals (serious or entertainment games, respectively). This was achieved by reviewing learning theories and serious game mechanics, proposing a reinterpretation of games that includes learning, and analyzing empirical game design models found in the literature. Based on this analysis, a common structure for the process of game design was proposed, integrating empirical practices with academic research on games as a learning tool. The resulting "Experience,

Dynamics and Artifacts" (EDA) framework brings forward general game design elements and terminology that can be used to foster learning activities or improve engagement during gameplay. EDA takes into account player's cognitive-affective and sociocultural aspects, and describes learning holistically that can either represent formal educational goals or player affordances. Future work could include EDA's integration with second-order production processes, as well as new guidelines aimed at serious game design. Additional research is also required to measure and evaluate its empirical validity and usefulness from a game design perspective.

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