Designing and studying educational games: Limitations of current design and research approaches in game-based learning

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The purpose of this chapter is to review the main approaches concerning how to design effective computer games for learning. Given the inconclusive evidence of effectiveness of these attempts, we discuss the assumptions of these approaches in light of key empirical evidence and theories of what a game is or should be. We argue that the educational game field has overlooked the central role of gameplay, and consequently has barely researched it. We believe that the field should either change the manner they understand games. We address this issue by providing a conceptual framework to study the process of "gameplay", that is, how specific designed features might affect individuals' cognition, motivation and emotion in the hope to acquire relevant information to improve the game design process.

Introduction

Over the past 30 years the educational game industry has been designing games for learning purposes. The evidence of its effectiveness have been modest (e.g., Randel et al., 1992; Hays, 2005) and some have ironically referred to these games as either *shavian reversals* (Papert, 1998) or *chocolate-dipped broccoli* (Bruckman, 1999) or, simply, *crap* (Brenda Laural as cited in Fortugno & Zimmerman, 2005). We believe that this worrisome state of affairs has only one way out: either the field think differently of games or think differently of educational content, or maybe both. This chapter focuses on the former alternative, that is, how the field of educational games thinks of games and the consequences for their design and study. The latter, concerning content, although important, has been already discussed by influential scholars (e.g., Gee, 2003).

The first section of this chapter reviews the basic ideas behind current design approaches of educational games and exemplifies them through selected examples from current innovative designs. We can distinguish between designs that emphasize the "endogenous" interaction between fantasy and content of the game and designs that emphasize the narrative aspects of games. The section ends arguing for the need to focus the research efforts in the idea of gameplay[1].

The second section of this chapter summarizes the characteristics of research conducted on educational games. Most studies are quasi-experiments focused on knowledge acquisition. The majority do not explore the process of gameplay as their counterpart do in the area of

[1] Gameplay refers to how the game is in actuality played and emerges from the interaction of a) the game's rules, b) the players' pursuit of the goal of the game, and c) the players' chosen repertoire of strategies and skills (Juul, 2005).

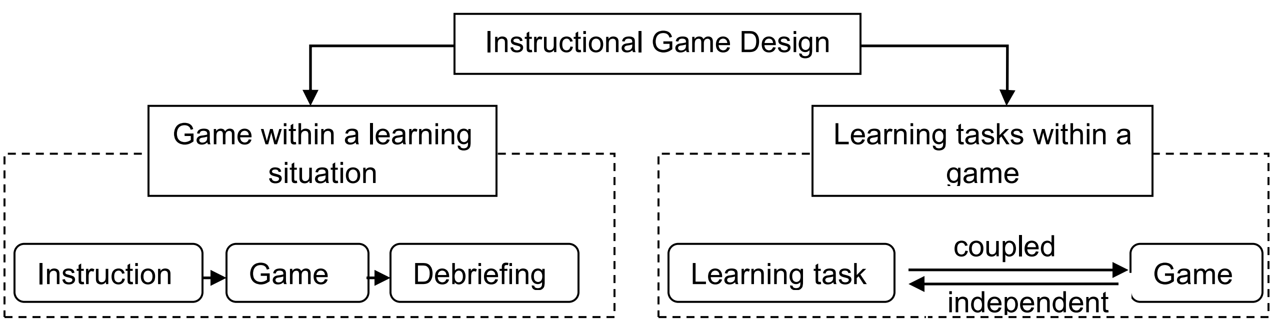
human-computer interaction dedicated to understand game experience or *GX* (e.g., Nacke & Lindley, 2008). Therefore, a closer look at the focus and methods of this research field is described to enrich the research conducted in the educational game field. The section ends with a description of a framework for studying at the same time the attributes of game that contribute to the gameplay as well as individuals' engagement. The framework focuses on the notion of engagement and is defined as a meta-construct entailing different cognitive, behavioral and emotional reactions from individuals as a result of their interaction with specific game attributes.

The chapter finalizes by summarizing the key points discussed on the previous sections and highlighting desirable direction for future research on educational computer games.

Design approaches in educational games

From the instructional design perspective, Kerres, Bormann, & Vervenne (2009) have distinguished two alternatives to harness the potential of games for learning purposes (see Figure 1). In the first one a game is embedded in a particular learn situation as a source of reflection or as a context for practicing the content delivered by instruction. At the end of the experience with the game, a reflection or de-briefing session is suggested to make sure learners acquire the knowledge as expected without misconceptions. Examples of this approach used mainly games for entertainment, but there are also examples using educational games such as River City (Nelson et al., 2005). In the second approach, the focus of this chapter, the gameplay is the reward for having solved different learning tasks. The game and the learning tasks can be more or less independent from each other. The general assumption is that the more dependent they are the better the learning effect of the general game experience.

Figure 1: Main Instructional Game Design Approaches

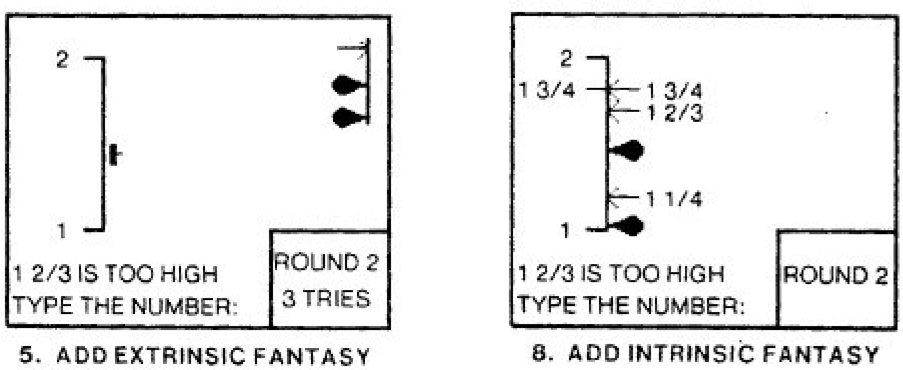


Adapted from Kerres et al., (2009)

This second approach reflects to some extent the broader debate in the game design community concerning the centrality of interaction/interactivity (e.g., Juul, 2001) and storytelling/narrative (Adams, 2001) for the design of games. Consequently, the idea of *coupling* the academic content with the game elements has been addressed from two perspectives: the endogenous fantasy/intrinsic integration approach and the narrative approach. The former emphasizes the mechanics/interactivity side of games, and the latter emphasizes Bruner's idea of Narrative either as a particular structure for organizing knowledge (Bruner, 1996) or as a powerful metaphor (Barab et al., 2007). However, educational game design seems to overlook some key concepts and ideas from the game designers' community and maybe even work under wrong assumptions concerning what is fundamental in a game. We now describe the common approaches to game design and highlight the missing aspects that are key in the game design field.

Endogenous/intrinsic fantasy perspective. Generally speaking, the effective instructional design of games is believed to reside in the manner in which the learning content is organized within a game. One possibility is represented by the highly cited work of Malone (1981). He claimed that intrinsic or endogenous fantasy is a powerful design goal for intrinsically motivated instruction. Malone defined “a fantasy-inducing environment as one that evokes "mental images of things not present to the senses or within the actual experience of the person involved" (American Heritage Dictionary)” (p. 360), and further distinguished between extrinsic and intrinsic fantasy - later called *exogenous/endogenous* with no change in meaning (Malone & Lepper, 1987). The extrinsic fantasy is exemplified in the game *Hangman* in which the player progresses to avoid the fantasy catastrophe of being hung up and it is *extrinsic* because the fantasy “depends on the use of the skills but not vice versa” (p. 360). This means that the skills could be related to algebra, vocabulary and so on and the fantasy will remain the same. On the contrary, in intrinsic fantasies “not only does the fantasy depend on the skill, but the skill also depends on the fantasy”, i.e., the “problems are presented in terms of the elements of the fantasy world, and players receive a natural kind of constructive feedback”. Malone exemplifies his idea with the game *Darts* (see Figure 2) in which players need to estimate distances on a number line on the basis of introducing fractional numbers (i.e., the skill) to determine how distant or near to each other are located a set of balloons on a number line, so that if the players apply the skill correctly they can aim at the balloons with an arrow and destroy them (i.e., the fantasy).

Figure 2: The Extrinsic and Intrinsic Fantasy in *Darts*



Note: Extracted from Malone (1981).

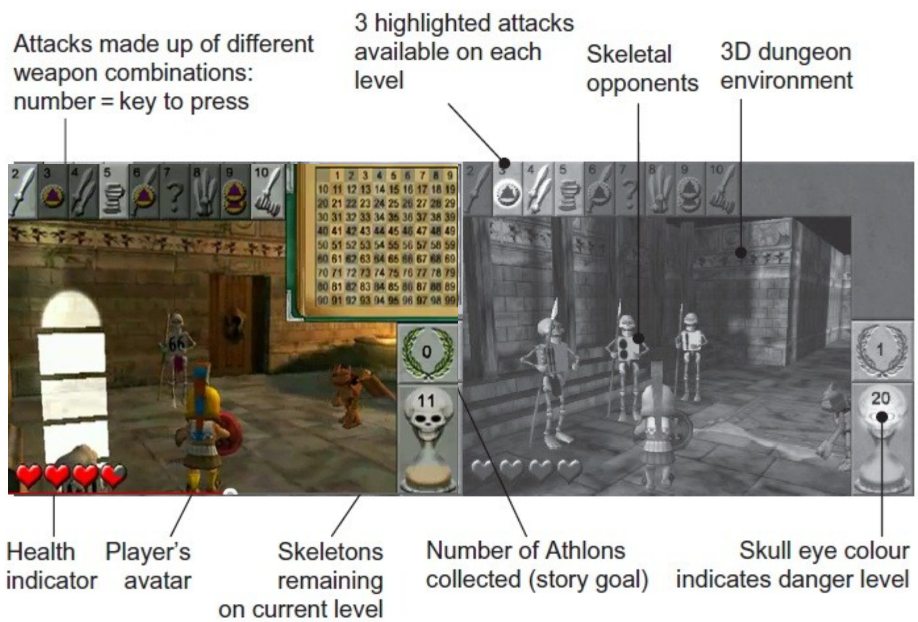
Among the few scholars that raised a critique to Malone’s initial conceptualization of intrinsic fantasy are Habgood & Ainsworth (2005). They concluded that the concept of intrinsic/extrinsic fantasy was conceptually misleading and proposed to focus on the games’ *core mechanics* and its assumed relation with flow experience to design effective instructional games. Specifically, the authors’ basic design guidelines for the integration of learning in digital games were (p. 494):

1. Deliver learning material through the parts of the game that are the most fun to play, riding

on the back of the flow experience produced by the game and not interrupting or diminishing its impact.
2. Embody the learning material within the structure of the gaming world and the player's interaction with it, providing an external representation of the learning content that is explored through the core mechanics of the gameplay.

Under these guidelines they developed a math game for children called *Zombie Division*[2] from which they created and compared two versions: an intrinsically and extrinsically integrated version (see Figure 2). In general terms the authors presented the game as a 3D action-adventure game based on sword fighting; where the player destroys skeletons by dividing them according to the number the skeletons have in their chest.

Figure 3: Intrinsic and Extrinsic Versions of Zombie Division



Note: The extrinsic version has skeletons without numbers and a final test is embedded at the end of the game. Extracted from Habgood & Ainsworth (2011).

The authors described the core mechanics as "defeating enemies in combat by attacking each enemy with a divisor that divides its dividend into whole parts". They continued by identifying other mechanics for the purpose of learning math as well as *secondary* mechanics. Among the formers we find:

- Each game level contains 20 zombie skeletons (enemies)
- An appropriate attack is the one that matches the weapon-divisor used by the player and the dividend carried on the skeletons' chest
- Three different weapon-divisors are available to players
- Skeletons divided by an appropriate attack turn into equally-sized small ghosts

[2] See http://www.gamelearning.net/

(depending on the divisor used by the player) showing the quotient.

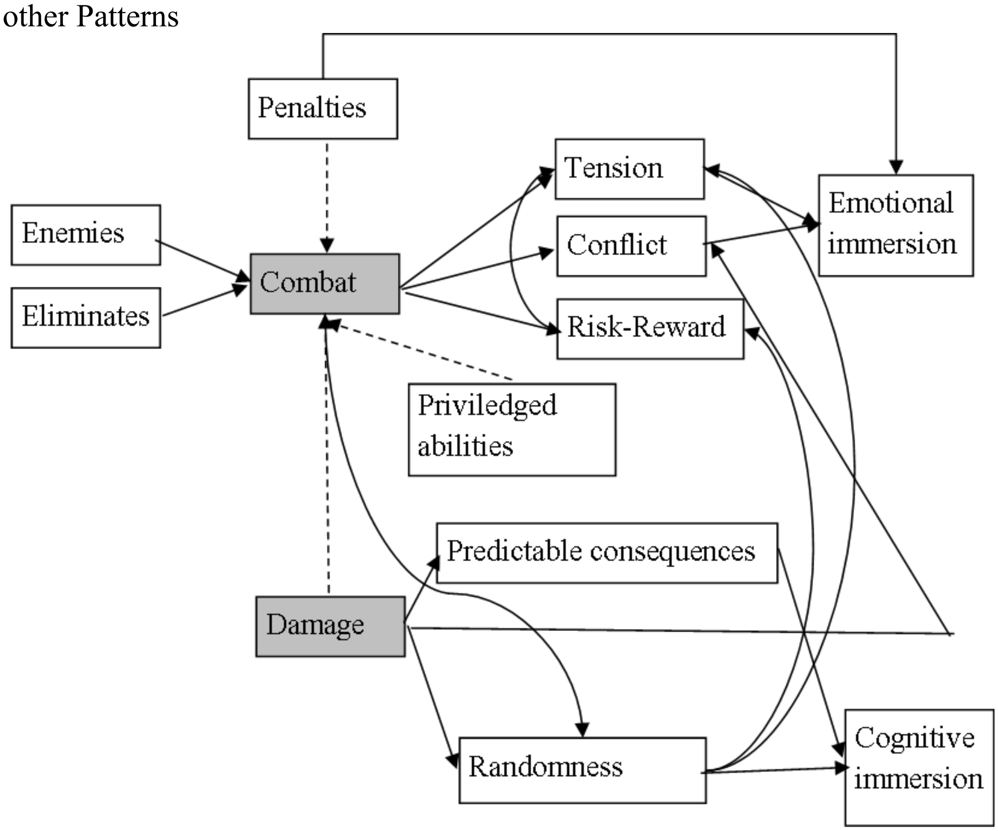
- Skeletons fight back if attacked using an inappropriate attack, diminishing player's health
- When Health is equal to zero, the player has to start the level again
- Skeletons gain weapons to parry the players' attacks
- Giant skeletons turn into small ones if attacked by weapon-divisors resulting in quotient greater than 10.
- Skeletons gain more ferocity as levels increase going from passive standing and blocking areas to overt pursue of the players. The skeletons' hostility is shown in their eyes' colors (from green to glowing red).

Concerning the secondary mechanics (i.e., the fantasy), the authors described them as related to exploration of a dungeon and collecting keys. The fantasy is rooted in the ancient Greece and the Olympic Games. The winners were Heroes that received *magical Athlons* which gave them strength to keep piece among people. However, a king wanting to have all the Athlons for himself mistakenly cursed the Athletes who disappeared. Since then people are hoping for a hero to bring back the Athletes. The hero is the player's avatar Matrices and the cursed athletes are the Skeletons. The curse will be dispelled if skeletons' numbers are divided with the magical attacks. In each level all the dividable skeletons should be defeated using the weapons available. The authors explicitly stated that this was an arbitrary fantasy to give the above mechanics a context and that "this fantasy…could very easily be replaced with an entirely different fantasy context…without changing the intrinsic relationship of the learning content with the game's core mechanic." (p. 178).

However, as Juul (2005) argued in his book *Half-real*, the relationship between *rules* or mechanics and *fictions* or fantasy is more complex and interdependent than the design of Zombie Division suggests. According to Juul, "rules and fiction interact, compete and complement each other" (p. 163). In video games, the rules of the game are inferred from the fictional world. The players have expectations about how the fictional world works and while playing the game they discover which of these expectations have been in actuality programmed and embedded into the rules of the game. This may turn into disappointments in particular in educational games given their limited implementation of the fictional world into the rules of the game. For example, in Zombie Division one could assume that the dungeon may contain hidden rooms or halls, torture chambers and so on as depicted in gothic fictions. Or if one has played *Dungeons Keeper* one could expect to be able to build a prison and have enemies who will turn into skeletons, ghosts or vampires depending on specific players' actions.

From a game design pattern perspective (Björk & Halopainen, 2004), a game is an activity in which the players encounter reoccurring designed parts of a game that relate to gameplay. These parts are called *patterns* and each of them has particular consequences on gameplay. The authors distinguished more than 200 patterns, so we will discuss just a few concerning directly Zombie Division. In Zombie division, the design belongs basically to the action genre in which the motor skills are important to succeed in the game – usually a fight. When we look for the pattern that might govern these fights we found the *Combat* pattern. Additionally, Zombie Division reduces the players' health if skeletons have the opportunity of fighting back, which occurs when players choose the wrong weapon-divisor to attack skeletons. This can be identified as the *Damage* pattern. From a design pattern perspective the relationships between Combat and Damage and the consequences they might have on gameplay are much more complex and rich that the description provided by Zombie Division. Combat as a pattern in games refers to actions aim at killing or overcoming opponents. On the other hand, Damage refers to actions that can lead to negative consequences. This seems straightforward concerning Zombie Division: players choose the right weapon-divisor and divide (defeat) the skeletons, otherwise skeletons fight back and diminish the players' health. However, a deeper exploration of the pattern shows how these two patterns interact with other elements to give gameplay tension and emotion. It is unknown how Zombie Division can achieve such a gameplay if does not address the other patterns as well (see Figure 2).

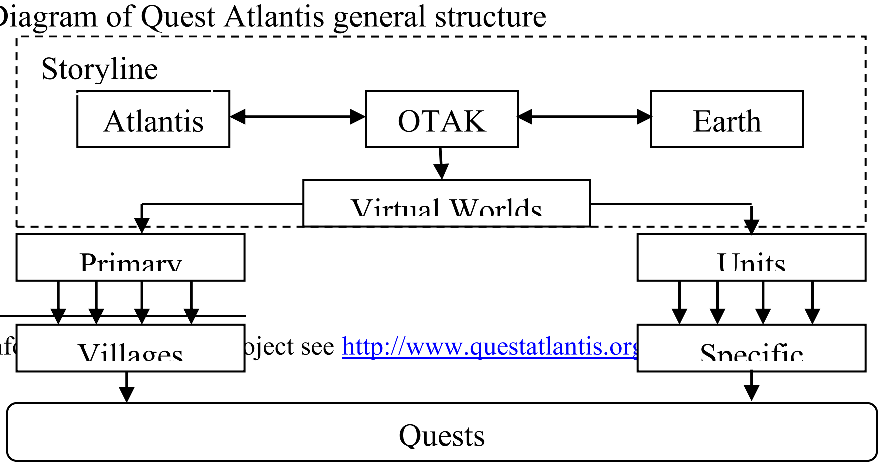
Figure 4: Diagram of Combat and Damage Game Design Patterns and their Relationships to other Patterns



The figure summarizes the main patterns identified in Zombie Division and their theoretical interaction. The solid arrows mean that the pattern *instantiates* or cause the other pattern in the direction of the arrow. *Enemies*, for example, instantiates Combat. That is, if one designs the existence of Enemies (i.e., avatars or units that try to avoid the players' completion of some goal) this will provoke a Combat situation between them. Similarly, Damage instantiates *Randomness* (i.e., events that cannot be exactly predicted), which in turn instantiates *Tension* (i.e., feeling of lack of control of the outcomes of actions or events in a game) and *Cognitive immersion* (i.e., focused attention upon problem-solving aspects of a game). On the other hand, segmented arrows indicate that one pattern *modulates* the other not causing it, but fine tuning its expression. In this theoretical model as applied to Zombie Division, it is important to note that emotional and cognitive immersions are opposing ends. This means that designers need to think of ways of making cognitive immersion more likely: which patterns instantiate this type of immersion? We have, among others, *puzzle solving* and *budgeted actions points* (not represented in the diagram). The first one refers to actions solvable using inductive/deductive reasoning. In Zombie Division this could have been achieved by having some skeletons leaving *cues* or *traces* concerning either the king that first produced the cursing and that is being protected by the skeletons so that killing the king is another goal of the game. Or adding other creatures or game spaces in which the player needs to *Negotiate* or *Bluff* with the creatures in order to exchange game elements necessary for moving forward. For instance, in the dungeons the player may discover a torture room with different instruments that may serve as weapons or other elements that can support the player's journey in the dungeons. Another pattern relationship interesting to explore is *Risk-Reward* and *Tension*. Risk-Reward refer to the extent that the chance of receiving a *Reward* is linked to some risk of receiving a *Penalty* if the player fails to acquire the Reward. This pattern requires the non-existence of *Predictable consequences.* In the context of the fight between the player and the skeletons, it is not clear what the reward in Zombie Division is in terms of advancing the player chances of success in the game or giving some *Extra-Game Consequences*. Similarly, given that the player either chooses the right weapon defeating the skeleton or fail to do so diminishing her health, there is a predictable situation. With a predictable situation and no clear Reward, the *Risk-Reward* pattern is unlikely to emerge and therefore the *Tension* in gameplay could turn out to be weak.

The narrative perspective. The second broad design guideline is narrative (e.g., Barab et al., 2007). The core argument is that a curriculum would help students better in understanding the meaning and value of the underlying principles of an academic topic, such as Erosion, if the academic content is embodied within an interactive narrative, so that the person and the story are *coupled* together. In a game this interaction should be designed as to push back player's understanding of academic concepts, thus becoming games a type of *transactive curricula* that afford the interplay between player and the story line. Under these premises the authors develop Quest Atlantis (QA) a multiuser learning environment which was inspired by role-playing games such *Everquest,* in which a metagame provides context, coherence and meaning to the different Quests individuals are invited to solve (see Figure 3). QA's metagame consists of an online adventure to save Atlantis - a mythical world - from its complete disaster, a set of online 3D worlds, rewards systems and a homepage for each individual. Through the figure of an avatar, individuals respond to the Quests so as to help people of Atlantis to restore its wisdom. By responding to the Quests, individuals gain points (i.e., *Cols* and *Lumins*) that can be used to increase Atlantis wisdom and the player's status within the game. The points can be exchanged, for example, for trading items (e.g., pins and stickers), renting land to build buildings or in time they can open new privileges in the world (e.g., flying).[3]

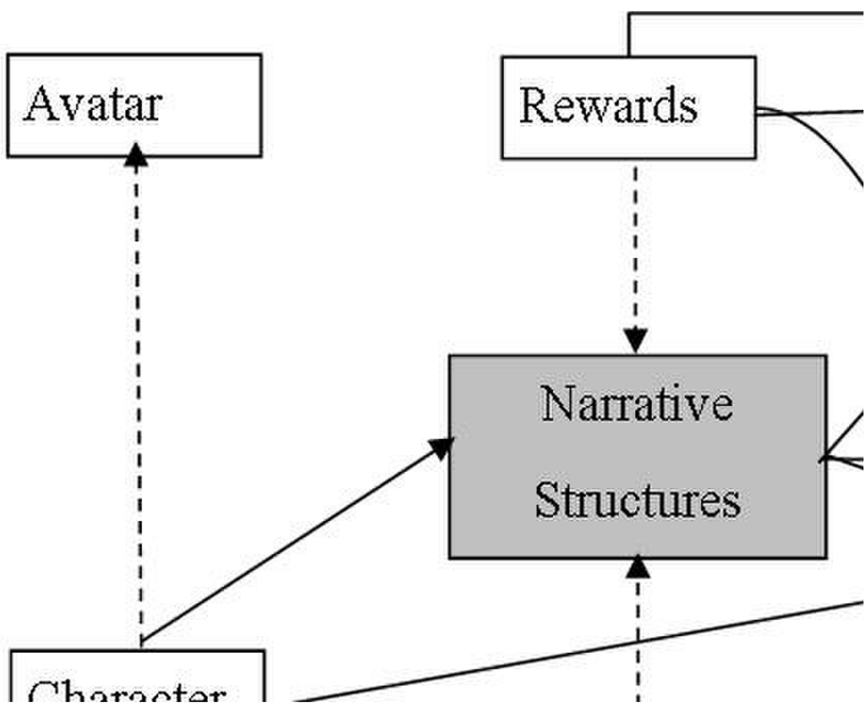
Figure 5: Diagram of Quest Atlantis general structure



[3] For more inf… oject see http://www.questatlantis.org

According to the story, the OTAK represent the virtual world through which the Council of Atlantis communicates with the Earth (i.e., individual players). The OTAK is made of several primary worlds and villages reflecting social commitments (e.g., Unity world) and subject-matter units (e.g., Taiga unit[4]). In each case individuals explore the virtual world and the main gameplay consists of clicking on Non-Player Characters (NPCs) to gain information needed to complete a Quest. Through their avatars, individuals take the role of field investigators, mathematicians, etc., using the academic content embedded in the game so as to make inform decisions that change the environment.

Figure 6: Diagram of Narrative Structures and Trans-Game Information their relationships to other patterns



The main patterns appropriate to discuss QA's gameplay are depicted in Figure 4. As with the description of Zombie Division, solid arrows represent instantiations relations and segmented arrows represent modulation relations among the patterns. The main point here is the limited connection between the higher level components of QA's meta-game (i.e., the story) and the lower level components such as a particular Quests within a specific world (e.g., Taiga unit).

[4] See http://www.questatlantis.org/#42

Narrative structures (i.e., the stories' structures unfolding while playing the game) motivate individuals to pursue certain goals and rewards them by "weaving the consequences of players' actions into an unfolding story" (Björk & Holopainen, 2004, p. 216). This pattern is instantiated by, among others, *Characters* (i.e., a representation of persons in a game), which together with Narrative Structures instantiate key patterns such as *Immersion* (i.e., immersion in the activity of play or deeply focused in the game interaction) and *Emotional Immersion* (i.e., being affected by the events of the game). In addition, the character of this immersion is modulated by, for example, *Rewards* (i.e., receiving something perceived as positive for completing goals in the game) and *Trans-Game Information* (i.e., Information passed from one game session to another). As a case in point, after completing a Quest, individuals in QA are given either *Cols* (i.e., QA's currency) to trade items and rent spaces in the world to build or individuals get *Lumins,* which, according to QA's story, may help Atlantis get its wisdom back. In both cases we are dealing with Trans-Game Information, that is, information concerning the degree of completion of the Quests. This information, in turn, may instantiate a particular *Social Status* (i.e., the degree of admiration, approval or esteem a player enjoy within the game) and bring about *Extra-Game Consequences* (i.e., consequences that do not affect the game state or how it is perceived). In QA, individual can buy pins and stickers, use badges and rent land to build houses and similar buildings. This situation, on the other hand, can lead individuals to feel they can affect the game, that is, experience the consequences of *Empowerment* (i.e., Players feel that they can affect the events and outcome of a game).

However, if the main gameplay in QA consists of clicking on different NPCs within specific worlds (see above Figure 3) such as Taiga, how in actuality the patterns described are connected, if at all, within the metagame of QA is not obvious. For example, an individual in Taiga drafts a summary of the indicators (e.g., Nitrates) that may account for the erosion of rivers and gets teacher feedback plus, say, 5 Cols and 7 Lumins. How is this connected with the general storyline of QA? There is nothing in the gameplay of these specific worlds that indicates how these patterns might be connected and how they can generate the highly valued immersion and empowerment. For example, Narrative Structures need a degree of *Limited Foresight* (i.e., little knowledge of the next events in a game). In QA the overarching goal of helping Atlantis is very predictable, that is, one must solve Quests, accumulate points (e.g., Lumins) so as to illuminate Atlantis lost wisdom. The links between these events is direct and clear for the individuals playing the game. Similarly, the lack of Enemies and *Boss Monsters* (i.e., powerful enemy the players have to overcome to reach certain goals in the game), diminish the probability of experiencing dramatic points and challenges and, therefore, Tension. On the other hand, Social Status is accompanied with Rewards, which in QA are basically Cols and Lumins and are associated with trading, renting and performing special actions. An interesting variant could be that groups of individuals might be able to agree upon types of Rewards. Similarly, an individual could ask for permission to distribute these Rewards from a successful Quest. Another interesting pattern to explore is *Character Development* (i.e., improvement of skill and knowledge). Two alternatives to achieve this development are through either being more likely to succeed with actions in the game or make actions previously absent possible. The central point is that individuals should be able to perceive they can influence the game state with their current *Privileged Abilities* (i.e., players perform actions that are not readily available to other players) or *New Abilities* (i.e., gain new abilities during gameplay). Even though in theory individuals in QA can fly if they get enough points, this new ability does not have a perceivable change in the game state, that is, no matter how high or skillful one can fly, the level of wisdom of Atlantis remains unaltered. By changing QA's story, individuals could gain the ability to hire some secret agent or a group of mercenaries to find out, for example, who might be behind the decay of Atlantis.

This brief description of two different approaches to the design of educational game reflects the misunderstanding of the relationship between rules and fiction. In the first case, the notion that the fantasy/narrative side of the game can be interchanged by any other without altering the core mechanics of the game risks the development of simple games that are neither abstract games nor adventure-type of games. The second case reflects an overemphasis on the narrative side of games, but with virtually no rules that connect the narrative as a context with the actions executed during the game. In particular for QA the idea of conflict, key to games, is in actuality non-existent. The whole metagame is about *helping* another society in danger, while the game Everquest (and other similar) is based mainly in combat, enemies, conspiracy and deception. Finally, the focus of weaving content such as Algebra or Water Quality with a game has made researchers and designers to put gameplay as a secondary design goal. The general point of this analysis is to show how richer could be the discussion on educational computer games if more attention is paid to the game design patterns approach and how useful could be for improving existing designs so that the field could advance toward more sophisticated educational games not in terms of features such as 3D or graphics, but in terms of interesting choices and high quality of gameplay.

Educational game research: A conceptual framework for future research

The empirical evidence concerning the effectiveness of educational games for promoting learning and motivation is inconclusive (e.g., Hays, 2005; Randel, Morris, Wetzel, & Whitehill, 1992; Tobias & Fletcher, 2011) and the highly touted relationship between motivation and learning has barely been able to be replicated (cf. Kebritchi, Hirumi, & Bai, 2010 and Lepper & Cordova, 1996). Research on educational games seldom develops a theory of action about how the designed instructional game will reach a particular learning goal (Honey & Hilton, 2011), or how specific game design patterns contribute to a particular learning goal. Most studies only postulate mechanisms and processes, but seldom measure them. For example, Habgood (2005), when studying Zombie Division, although a detailed description of the design was provided, the hypothesized mechanism of flow for explaining the effectiveness of his game was presented without data to explore how flow led to learning. Later Habgood & Ainsworth (2011) acknowledged "…most of the research on flow does not describe how flow enhances learning (…) all we can do is postulate some possible mechanisms…" (p. 197). Similarly, research on QA has shown positive impact on understanding and achievement, but the mechanism that led to those results has been left out. In addition, QA's research has not formally studied how Cols and Lumins, that is, Rewards, Score and Extra-Game Consequences might have affected the positive impact on achievement. What is needed then is a more *process-oriented* approach that considers the design of the game and how it impacts the quality of individuals' experience of the game. Some attempts have been made to study game "attributes". For example, Pavlas, Bedwell, Wooten, Heyne, & Salas (2009) mapped particular game attributes with different learning outcomes through experimental manipulation of the attributes selected. Similarly, Kickmeier-Rust, Hilleman, & Abert (2011) through eye movement analysis showed that good learners scanned visual field evenly with longer saccades, attending to relevant areas of the screen more frequently. Although promising, these types of studies tend to consider games as objects with different features that can be removed at will in order to explore their effect on learning. However, we contend that games are a unitary system in which gameplay is central and we do not know the effect that the removal of some features might have on the game and, hence, the experience of playing the game. Therefore, we believe that educational game research should focus on games as unit in order to explore individuals' gaming experience.

One alternative is represented by the field of games for entertainment which has adapted methods for capturing the players experience (GX) and the playability of the game design by studying games as a whole and not as pieces (e.g., Nacke & Lindley, 2008; Nacke, Drachen, & Goebel, 2010).Their focus is to find how particular design attributes of games affect users' experiences by employing different game metrics (e.g., physiological and eye tracking measures together with self-reports and interviews). With an important focus on interface design and individuals' enjoyment, this research community has investigated the process of gameplay or playability far more than the educational game community. For example, Nacke & Lindley (2008) tested three modes of play based on boredom, flow and immersion, using as dependent variables physiological measures (e.g., facial electromyography) and self-reports of individuals games experiences. Regarding the physiological measures, the authors found that the measures were sensitive to the different game modes. Interestingly, despite having different sources of data to analyze, the authors displayed measures separately and no correlation among the questionnaires and physiological data was reported. Although a promising line of research, to our knowledge there is no systematic study that captures the GX and relate it to identified game design patterns as described in the previous section. To this end we describe our proposal to study, in particular, how design patterns affect engagement and, ultimately, learning in an educational computer game.

The problem we are after is to determine whether individuals who perform better and show higher learning outcomes in an educational computer game also engage differently during gameplay and if so whether these difference can be accounted for the features of gameplay- that is, specific game design patterns (Björk & Holopainen, 2004).

Table 1: A Conceptual Framework for Studying Relations among Game Design Patterns and Individuals' Engagement

		Engagement		
Game Design Patterns	Game Usability	Cognitive	Emotional	Behavioral
GDP1… …GDPn	Self-reports, Observations & Interviews	Self-reports, Interviews: Amount of invested mental effort Workload Strategies and reasoning employed	Self-reports, Sampling Experiential Method, Interviews, physiological measures: Flow, Enjoyment, Frustration, etc.	Eye tracking: Visual attention Focused versus scanning behavior Depth of reading Scanpath analysis

Note: Here Interview includes open ended, focused and think-a-loud (concurrent and retrospective) alternatives. GDP: Game Design Pattern.

Table 1 presents a summary of the key experience we need to understand deeply individuals' engagement. For this engagement to be relevant for educational purposes, we borrow the conceptual framework based on motivation and self-regulation literature. This framework portraits engagement as a multidimensional construct composed of different behaviors, emotions and cognitions: behavioral engagement refers to active participation and includes effort and concentration; emotional engagement refers to the extent the individual experiences positive and negative reactions such as interest, enjoyment, and enthusiasm; cognitive engagement is defined as investment in learning and includes self-regulation, thoughtfulness, and willingness to go beyond the basic requirements to master difficult skills (Fredricks et al., 2004). Therefore, an individual showing a high engagement is characterized by high attention, interest and enjoyment, and effort to master new skills. Meanwhile, a low engaged individual is characterized by boredom, inattentiveness, and passivity (Bohnert, Fredricks & Randall, 2010). This framework is to be used mainly under experimental designs in laboratory settings. However, the framework can be easily adapted by incorporating different strategies to collect information about engagement. These strategies may entail, among others, discourse and interaction analysis and data mining (e.g., sequence analysis) of log-files.

Conclusions

Researchers and designers of educational games have worked in a narrow version of what a game is (e.g., Salen & Zimmerman, 2004; Juul, 2005) and consequently used what we call a "black box" research design where the process of gameplay have been left out of the agenda and only pre and post questionnaires are the main sources of data to inform design practices. We argue that in order to improve the design of games we need to move from these broad design guidelines to discrete and concrete instantiations of design patterns of instructional games, to the extent that they can show a possible trend of effectiveness across individuals. To achieve this, we need to bring together both games and educational games research methods and instrumentation so that the weaknesses of each can be overcome. In doing so, we may start the development of an *instructional game design patterns repository* for effective instructional game design, similar to the principles already identified in other learning environments.

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