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Understanding Learning Content Integration in Games

Nicolas Szilas
https://orcid.org/0000-0002-4565-8805
University of Geneva, Switzerland

ABSTRACT

The question of integrating learning content into a serious game is a recurring one, although no clear theoretical framework has yet been provided. It is often argued that integration should occur at the core mechanic level, but this simple statement conceals the complexity of serious game design. The authors therefore propose a theoretical approach to learning content integration that analyzes integration in serious games along several dimensions. A multidimensional game model is proposed, which serves as the basis for a systematic method of analyzing the integration according to each component of the model. To evaluate the proposed analysis method, they present a series of game examples and patterns in which learning content is either fully or partially integrated into each component. They also provide a comprehensive analysis of two serious games.

KEYWORDS

Integration, Intrinsic Integration, Game Analysis

THE ISSUE OF INTRINSIC INTEGRATION

Are games efficient for learning? This is a recurring question in the field (Connolly et al., 2012; Hays, 2005; Ke, 2009), but finally it cannot be answered as such, not only because learning games gather an extreme diversity of artefacts and domains, making any generalization difficult, but also because the context of use of a learning game is a critical factor of efficiency—as it is in fact for any educational technology. Enthusiastic commenters, extrapolating from the motivation present in games, would argue for the huge potential of video games for learning, while more critical commenters would claim that learning games are poorly designed and often fail both as games and as educational media. Meta-analyses tend to answer the above question, showing, globally, some benefit in games, when compared to more traditional methods (Clark et al., 2016), but the size effect is moderate, and the publication bias seems to indicate that benefits are even smaller in practice. One emerging hypothesis explaining relatively poor results regarding game efficiency lies in the design quality of the games themselves, as the negative critics mentioned above suggest. If, generally speaking, learning games are poorly designed, then their effect is limited. The question that finally arises is therefore this: are learning games well designed?

There is a plethora of examples of poorly designed games, even if this affirmation is highly subjective: which criteria are applied for claiming that a learning game is poorly designed compared to another? A criterion that has been often put forward is "learning content integration," that is, the extent to which the learning content is integrated within the game, also termed intrinsic (vs extrinsic) fantasy (Malone, 1981) / integration (Habgood & Ainsworth, 2011) / metaphor (Fabricatore,

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2000), endogenous fantasy (Habgood et al., 2005), or alignment (Kalmpourtzis & Romero, 2020). The underlying hypothesis is that a highly integrated game would be more efficient than a poorly integrated one.

There are two ways to back up the above hypothesis; one is theoretical, the other experimental.

From a theoretical point of view, games are argued to be a good candidate as an educational technology because they engage players in interacting with a system that provides them with an intrinsic motivation to interact. If learning content is not embedded into that system but is added on the side—the non-integrated case—then one cannot expect to obtain an equivalent engagement. At best, the added component does not spoil the gaming experience if it remains light. But if some significant learning content is to be added, the added content on the side distracts from the gaming, and the "gaming effect" may vanish. On the contrary, in the integrated case, if the learning content is within the game—and I will develop what "within" means in that context—then the whole learning game remains a game, and the benefits that are expected from a game can be transferred to the learning experience (intrinsic motivation). Therefore, theoretically, integrated games should be more efficient, all other things being equal.

From an experimental point of view, surprisingly, very few studies have compared an integrated game and a poorly integrated game, despite the fact that the concept of integration dates back more than 40 years (Malone, 1981). In this early experiment, the comparison between a game with an "intrinsic fantasy" and a game with an "extrinsic fantasy" was not conclusive. Research from Habgood managed to demonstrate that the intrinsically integrated variant of a game in math led to better learning results than the corresponding extrinsically integrated variant (Habgood & Ainsworth, 2011). More recently, criticizing the fact that in the Habgood's experiment, the extrinsically integrated version was also less challenging therefore less fun, Nidd designed a study that compared two versions of the same game (a non-digital battleship game to learn complex numbers in math), one intrinsically integrated, the other extrinsically integrated. Results went in the opposite direction: the participant learned less in the intrinsic versions compared to the extrinsic version (Nidd, 2018).

These mitigated experimental results show that the integration hypothesis is more theoretically than empirically supported. More importantly, the type of integration studied in these three experiments varies considerably. As explained by Habgood et al. (2005), Malone's concept of intrinsic fantasy tends to focus integration on the world's (mostly visual) universe, while integration should be thought in terms of the game's structure, its core mechanics, which is the usual accepted meaning of intrinsic integration today (Kiili et al., 2019). But it is interpreted differently between the two last studies mentioned above. In the first one, the non-intrinsic version consists in transferring the learning content outside the fun part of the game while in the second one, in the non-intrinsic version the learning content is still in the same time frame as in the intrinsic version. What is however common in these three studies, and in most literature on the subject, is the fact that they are based on a dichotomic separation between extrinsic and intrinsic versions.

Other works tend to propose a richer structure of the concept. As part of a general model of serious games, the notion of embedding ("how closely the academic content is coupled with the fantasy/story content") is introduced and decomposed in four levels (Gunter et al., 2008). Nevertheless, the levels are loosely defined and difficult to interpret when analyzing a game. In a review focusing on integration in specific math games (rational numbers), games are classified as either intrinsically or extrinsically integrated (Kiili et al., 2019). This remains a dichotomic separation, but when looking in details, the article states that in the extrinsically integrated games, "the rational number content was either totally separated from the gameplay, only superficially attached to the core mechanics of the game, or the implementation of the game was poor (very low fidelity with respect to audio-visual implementation or game mechanics)." This characterization is not only multidimensional but gradual ("superficially attached" vs "totally separated"). This suggests that a finer categorization is needed. In another analysis of the concept, four types of integration were distinguished, systemic learning, winner strategies, obstacles and contextual, the first two corresponding to intrinsic integration and the last two to extrinsic integration (Szilas & Acosta, 2010). It seems that these four categories correspond to points into a larger space that is still to be defined. In a systematic review of integration in learning games (Ke, 2016), three approaches of intrinsic integration were found: conceptual representation (the concept to be learned is represented as a game object), simulation (the game simulates real-world phenomena), and contextualization (relation with the story). Concerning this latter approach, Ke found five strategies for integrating learning in the narrative. In an article discussing the above-mentioned Habgood's experiment, it is suggested that the temporal dimension is also a characteristic to be observed regarding integration (does learning occur at the same time as play?) and that integration is multidimensional and a matter of degree (Szilas & Sutter Widmer, 2009). Even if only a subset of these dimensions is discussed (temporality, fiction, mechanics), this approach already implies that 8 different types of integrations are possible if each dimension can take two values.

At the end, despite some effort to dig deeper into the concept of learning content integration, related research is scarce and disconnected, with limited references between these efforts. We claim in this article that these difficulties are due to the fact that the concept of learning content integration is multi-dimensional and that failing to understand this multidimensionality weakens the analysis of existing learning games and impedes the design of intrinsically integrated games. The aim of this research is therefore to establish a multi-dimensional model of learning content integration that can be used as a tool for analyzing educational games. Games are complex media, therefore the idea of integrating content within this media should reflect that complexity. The result of an analysis should be a set of integration judgement or scores along several dimensions, beyond a single Boolean assessment of integration or even a classification into a set of types. The design of an integrated learning game is out of the scope of this paper, although it will highly benefit from the analysis framework I will propose.

Before addressing the core issue of integration in learning games, it is useful to bear in mind the following two statements:

- A game that would perfectly integrate learning content is not necessarily a good learning game, because integration does not guarantee a good learning approach. Only in-depth instructional design work can provide a good learning game. In other words, intrinsic integration is not sufficient for good learning.
- In some cases, a poorly integrated game may be relevant. For example, if the learning content is superficial (rote learning); or if the game is integrated into a larger pedagogical sequence that compensates for the game's weakness (in this latter case, the game may just serve as a trigger to an efficient post-game debate).

In order to establish a comprehensive model of learning content integration, my approach consists in proposing a general model of games, that reflects all components that characterize a game and also discusses their relative importance in terms of gaming experience; these are discussed in the second section, titled "The Dimensions of (Learning) Games". An analysis of a given game starts by identifying each component, based on this model. Then, each of these components is systematically analyzed in regards to the way learning content is integrated into that component (detailed in the third section, "The Analysis Method").

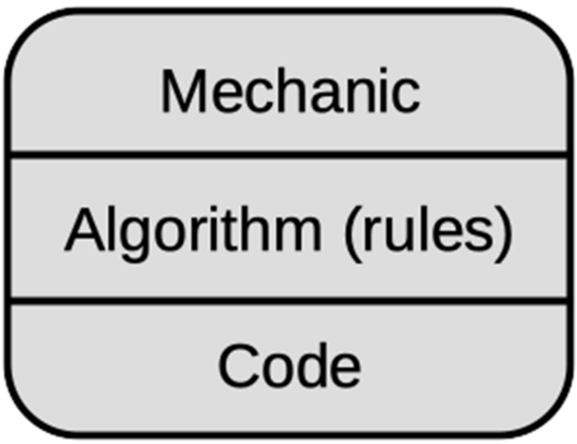
THE DIMENSIONS OF (LEARNING) GAMES

The game framework that will be developed here is based on existing theories on games and video games. It combines various sources to provide an operational model from which integration will be studied in detail.

The Game's Logic

In games, it is common practice to separate the logical part from its surroundings (Hunicke et al., 2004). The latter are detailed in "The Analysis Method." This logic may be described in various ways. For the question at hand, the various parts of this logic need to be separated and ordered, depending on their importance for the gaming experience. As such, the concept of game mechanic is particularly useful. But this is a concept that has been used and defined in many ways (Lo et al., 2021) and an explanation of how it is to be used is needed. The logic of a game can be described at different levels of granularity that are illustrated in Figure 1. Mechanics are therefore different from the rules, that are in fact a form of algorithms that are themselves distinct from code, written in a programming language.

Figure 1. The Three Levels of Game Logic



Within this context, game mechanics have the following properties that need to be put forward:

- A mechanic is essentially an accessible way of describing a certain part of the game's logic (Lundgren & Björk, 2003). It does not need to follow a formal approach and to a certain extent the same game may be described differently, that is with different mechanics, by two different people. It aims to be understandable to a reader, a game fan, a serious game designer, etc. By contrast, an algorithm is a more formal description of the game.
- A mechanic is a higher level of description of a game's behavior, and therefore it may include several rules in order to form a whole. It is centered around a specific interaction (Lundgren & Björk, 2003; Sicart, 2008).
- A mechanic can embed other mechanics, in a hierarchical way (notion of "compound game mechanic" (Sicart, 2008)). Whether a super mechanic or several sub-mechanics are described depends on what an observer wants to describe in the game logic.

Analyzing a game consists in analyzing its underling mechanics. These mechanics do not all have the same importance in a game, some are essential while others could be removed with limited consequences. For the purpose of analyzing the learning content integration, it is central to hierarchize them: integration within a major or peripheral mechanic denotes quite different levels of integration.

Following the usual approach in game analysis that distinguishes the "core game mechanics" from the rest (Järvinen, 2008; Salen & Zimmerman, 2004; Sicart, 2008), I will define three levels of importance for game mechanics:

- *Core mechanics*: They obviously describe the essential part of the game logic. More precisely, I will define them in terms of minimality: if a core mechanic is altered, typically if one of its rules is discarded, then the whole game "collapses," it does not work at all the same way. Take for example *Snake*: if the rule for extending the length of the snake is withdrawn, then the game is still playable but loses all its interest. Note that this definition may differ from other game frameworks, for example my core mechanics cover both core and primary mechanics in Jarvinen's model (Järvinen, 2008).
- *Sustaining mechanics*: The game can be played without them, but they support the gaming experience, and they may largely improve the playability of a game.
- *Accessory mechanics*: These mechanics are added next to the other mechanics but do not interact much with them. They may add some fun but removing them does significantly change the gameplay. Some of them are mostly "decorative." A typical example of such decorative mechanics can be found in *Hearthstone*, a famous turn-based card videogame where beside the cards, elements in the background, although they seem static, can be interacted with, producing small animation effects. These mechanics can be played, for example, when waiting for the other player to play. These behaviors are clearly gimmicks with no value regarding the main gameplay.

Note that the classification of a mechanic into one of these three levels is not entirely rigid and is open to interpretation. For example, deciding whether a mechanic is core or sustaining is not always straightforward.

Finally, within a game, there is the game itself, but also a set of other interactive parts that surround it, for modifying parameters, saving, reading statistics, getting help, etc. One could classify these mechanics into sustaining mechanics, but because they stand next to the game itself, I define another category of mechanics, called the *surrounding mechanics*.

The Game's Wrapping

The game's wrapping concerns all that is not the game's logic. It contains several components that are important to define and distinguish: the diegesis, the narrative (depending on the case, see below), and the media.

Diegesis is a term used in narratology and filmmaking, to denote the fictional world where some events happen in a narrative (Prince, 1987). It replaces the term "fantasy" introduced by Malone (Malone & Lepper, 1987), because fantasy has been used in an ambiguous manner, denoting both the fictional world and the set of events that occur in that world (the story). If any narrative presupposes a diegesis, games do not. Most dice games, for example, do not have any diegesis. In addition, diegesis may exist with no or minimal narrative: for example, as soon as an isometric view of the world is shown to a player, a diegesis is created. Other equivalent terms include fiction (used in narratology and philosophy), theme (Järvinen, 2008), metaphor (Fabricatore, 2000; Marne et al., 2012).

Narrative is a more complex element, related to the temporal unfolding of the events in the diegesis. It includes these diegetic events, in particular actions performed by characters, as well as the way these events are told (showing vs telling, ordering, ellipsis, etc.) (Genette, 1972). As often said and observed, narrative is a powerful way to convey information and knowledge (Bruner, 1991; Sarbin, 1986), hence its relevance in the domain of learning games (Ayramo, 2011; Dickey, 2006; McQuiggan et al., 2008). However, narrative is not a necessary feature in games (Ke, 2016), unless one considers any temporal unfolding of events as a narrative. Narrative in games may appear in three different forms: linear, multi-linear (branching narrative) and unscripted. Linear narrative in games can be analyzed as for traditional media. Multi-linear narrative makes the analysis more tedious, because all branches must be described. In addition, one must also study the conditions of branching, in particular when it depends on choices made by the player. Indeed, what is relevant in games is the narrative experience rather than the resulting story (Aylett & Louchart, 2003). Finally, unscripted narratives, where narrative events depends on complex conditions and are not always predictable by the game designers, or when these events are calculated by a AI-driven engine (Aylett et al., 2006; Riedl et al., 2003; Szilas, 2007), require a more thorough but non-exhaustive analysis of narrative events and their conditions of occurrence.

Importantly, in the current description, narrative has been placed as the wrapping of the game's logic. However, this is not always the case: in some games, typically adventure games, the player's action consists in making choices regarding what will happen next in the story (typically, taking the role of a character). In this case, one cannot disconnect the logic from the narrative, and the latter is part of the core game mechanics. Typically, the above-mentioned unscripted narrative approach considers the narrative evolution as a core mechanic.

The media denote the way by which the game elements are conveyed to the player. Two sensory modalities are mainly used, visual and audio, via several types of external representations (text, image, animation, film, sound, etc.), as largely documented in multimedia research (Caelen, 1996). The media convey both the diegesis and other elements. Regarding the diegesis (and the narrative that unfolds within it), there are various ways to represent its elements, via more or less realistic graphics, 2D or 3D, with or without sound, etc. Regarding other elements in the game's description, analyzing the media goes back to analyzing the user interface from the graphic and sound design perspective.

Although usually not part of the core of the game, the diegesis, the narrative and the media are three elements that play a key role in games regarding contextual framing, engagement, and emotional response.

Temporality and Granularity

When analyzing the whole set of mechanics at work in a complex game, it appears that they are not all active at the same time. More precisely, at a given instant during the game execution,

a mechanic or an individual rule may be:

- active, meaning the code corresponding to the mechanic is currently running and produces an effect (either perceptible or not);
- activable, where the code corresponding to the mechanic may be executed if some actions are triggered by the player; or
- inactive, in which case the game is in a state where the mechanic cannot be activated.

The same could apply for other components: a game may contain two separate stories, or two separate graphic styles, not active at the same time. Therefore, many complex games cannot be analyzed uniformly, and, at a macro level, one needs to consider the time dimension.

A first consequence of this observation is that the importance of a mechanic is also related to the frequency of activation of this mechanic (proportion of time when the mechanic was active). For example, a classical definition of the concept of core mechanic is "the essential play activity players perform again and again in a game" (Salen & Zimmerman, 2004, p. 316). The key feature of this definition is the high frequency of the mechanic's active state. More generally, I identify frequency as one of the characteristics of a game mechanic. It is difficult to estimate because it depends on the player's behavior.

The fact that at some point in time, a mechanic cannot be activated (inactive state) shows that games are also structured in macro-units in which some mechanics are activable (together with corresponding wrapping elements) and some are not. Take, for example, The Sims 2. The interface for creating a virtual character is extremely developed (compared to The Sims) and constitutes such a macro-unit, along with another macro-unit: the simulation of these characters in a virtual house. We term these macro-units *game phases*. Relative frequency of these game phases is also an important feature of a game.

A specific and very important type of game phases are *levels*. Levels are the successive reproductions of a given game phase in which some elements are changed between levels, in order to provide a changing and often more challenging experience. Levels are therefore often ordered, and elements that can change between the game's levels are numerous: the organization of its objects (the map), the media, the parameters (especially regarding difficulty), the mechanics. The progression between levels is an essential feature of games, and the game design must make sure that the player follows a smooth learning curve (Sykes, 2006).

Another typical case of game phases, which is highly represented in serious games, is the case of minigames. A specific case is that of "games within games" (Björk & Holopainen, 2005), as for example in the *Shenmue* adventure game where the player character can enter an arcade room and play some retro games there.

Strategies

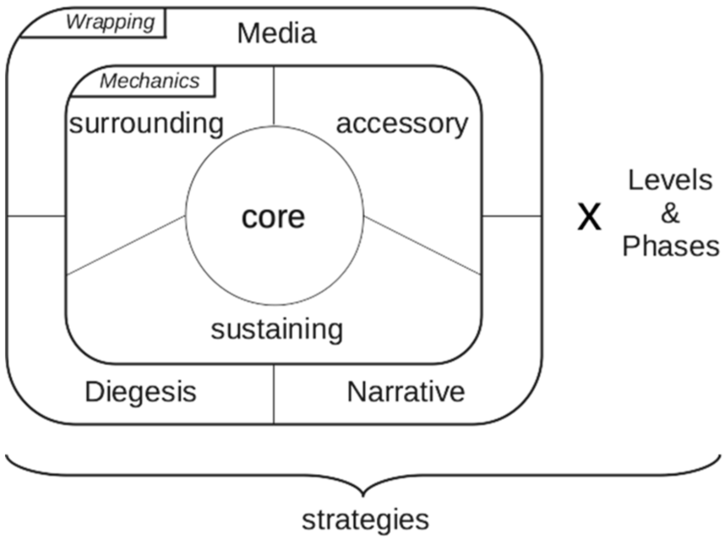
I define a strategy as a method that a player may use to progress in the game. Strategies, even if they are sometimes called "rule of thumb," are distinct from the rules of the games that constitute game mechanics (Salen & Zimmerman, 2004). Except for the case when some strategic advice is given to the player by the game itself, the strategies lie outside of the game's description. They are, however, induced by the game mechanics: they emerge *en creux* from the game's mechanics. For example, in chess, a well-known strategy is to try to keep control of the center of the board. There is no rule indicating this pattern, but it becomes apparent with experience or when players are taught how to play.

Strategies are an essential part of gameplay. Discovering them, applying them, evaluating them is a central activity of the player. Therefore, I decided to include them in the analysis framework, as one of the dimensions of a game. Some strategies may be logically inferred from the game rules, but most of the time, they are experienced during play.

Synthesis

A number of dimensions for analyzing games have been established in the previous sections. These dimensions are represented in Figure 2.

Figure 2. A Multidimensional Game Model



This approach may be seen as yet another framework for analyzing games. Compared to other frameworks, it has the advantages of being concise and accessible, as summarized in Fig. 2, while avoiding overly general categories such as the MDA model (Hunicke et al., 2004), or the "fantasy/story" category (Gunter et al., 2008). The model is concise also because it is incomplete, discarding many relevant aspects in game such as game's quality criteria, emotional impact, playing context, cultural context, social play, etc. The proposed framework is first and foremost an operational model to develop a method for analyzing learning content integration.

THE ANALYSIS METHOD

Global Procedure

From the above-described general model of game, I propose a method for analyzing learning content integration in learning games in three steps:

Step 1: Preparation

First, it needs to be established if the product being analyzed is effectively a game. This may seem absurd since I am proposing a method for analyzing learning games. However, many learning/serious games are not really games (Fabricatore, 2000); they are called games for communication or commercial purpose but are merely quizzes, or simulations with points. For those "pseudo-games" the proposed analysis is not relevant, because it could be concluded that the learning content is well integrated into the pseudo-game, which is straightforward if the pseudo-game is a pedagogical product that does not satisfy the constraint of being ludic. However, it must be pointed out that when analyzing an interactive product, the decision to classify it as a game or not can only be made a posteriori (Henriot, 1969; Huizinga, 1951), after having observed that users entering the game effectively adopt a play attitude. Therefore, this first check is not straightforward and requires having the game tested.

Second, before starting the analysis itself, it is necessary to identify the learning goal/content underlying the game. If it is well documented, the learning goals should be available, because it is the basis of any instructional design method. Otherwise, one needs to infer them from the game itself. At this level, it is advisable to focus on the specific learning content of the game, not on some general impact that the game could have, such as improving digital skills, improving spatial abilities, etc.

Third, a full analysis of the game should be undertaken, based on the general game model described above. It does not need to be detailed, but each component must be considered: mechanics, wrapping (diegesis, narrative, media), strategies, as well as the possible organization into distinct phases.

Step 2: Systematic Analysis

The general principle of this analysis is to cross the learning content, and the game elements described in the full analysis of the game. That is, one needs to check for each of the elements, if it embeds some parts of the learning content. This approach considers, as an a priori statement, that a learning game is a game and must be analyzed as such. It departs from other approaches that distinguish game mechanics and "learning mechanics" (Arnab et al., 2015). We consider that making this distinction may bias the analysis towards an accepted separation between learning and playing. On the contrary, in the proposed method, if such separation exists, it will emerge from the analysis, with the underlying idea that for an ideal learning game, such a separation cannot be found.

In practice, it is convenient to use a two-column table, where the first column contains the game components, and the right column discusses whether some learning content is effectively part of this game component. A matrixial approach could also be considered, with several columns for distinct learning objectives.

Step 3. Synthesis

From the multidimensional analysis performed in Step 2, one tries to answer the question: "Is the game well integrated?" The answer will be positive if the learning content is visible at several levels, and particularly in at least one of the core game mechanics. However, it is anticipated that the response will not be a simple "yes" or "no," and that further discussion will be required. Understanding a game from the perspective of integration consists precisely in identifying and qualifying game elements that embed some learning content, while detecting other game elements that could also have embedded this content.

A scoring mechanism could be added at that level, weighing each assessment on individual element, but this would inevitably suffer from the problem of reducing to a single score a complex situation.

These three steps allow for a thorough analysis of the learning content integration in a learning game. Nevertheless, even with this framework in mind, the analysis is not straightforward, and more guidance is needed to put these three steps into practice. In addition, some recurring patterns—whether good or bad—occur in the game design of serious games, and I would like to highlight them, in order to bring the proposed method to life. Therefore, in the following, I will tackle integration for each of the game's components, discuss methodological issues that are raised, and provide typical games and patterns that illustrate the integration or non-integration of learning content in this component.

Integration in Mechanics

As already claimed in previous work (Habgood et al., 2005; Isbister et al., 2010; Szilas & Acosta, 2010), the key assessment regarding integration concerns the degree of integration of the learning content into the game's mechanics. In particular, the content should be integrated within the core game mechanics. In this section, I will discuss to what extent serious games achieve such an integration, which will lead me to analyze categories of games in more detail.

Learning Content as Simulation

Games centered around a simulation do integrate learning content within the core game mechanic, if the simulation effectively covers the learning content. For example, in the game called

Launchball that teaches various physics phenomena, the player has to bring a ball to a certain location by moving specific physical blocks (a battery, an electromagnet, a fan, a generator, a simple conductive block, etc.) and then launching the corresponding simulation. As the player is either modifying simulation elements or running the simulation, the core mechanic includes the simulation of physical laws, these laws being the content to be learned. Note that in such "simulation games," it is important to verify, as mentioned in the above Step 1, that we are effectively dealing with a game. Other examples of games whose content lies in the simulation's rules include Stop disasters, Cellcraft, etc.

These simulation-based learning games do not have to be realistic; indeed, they may be simplified to focus the learner's attention on the learning content and enhance the learning process, despite the realism argument often put forward in commercial simulations (Burkhardt et al., 2003; Richards & Szilas, 2012; Vadcard, 2017). The trend towards non-realism is stronger in games than in simulations, leading to games that only remotely, or metaphorically match the real situation. For example, the game "Guts and bolts" covers the human anatomy by allowing the player to manipulate various cartoon-like pipes that represent anatomical elements (vessels, digestive system, etc.). In the game entitled "La Chasse aux Trésors" (The Treasure Hunt) (*La Chasse Aux Trésors*, n.d.), the player controls the direction and power of the engine according to the direction of the current, which amounts to adding vectors. In these two examples, there is effectively a simulation of the content to be learned, but gaming constraints, such as amusement (first example) or immersion (second example) have pushed the designers to move away from a classical simulation.

To summarize, there is a continuum because what is often called "simulation games" focusing on realistic simulations of the phenomenon to be learned, and more metaphorical games that largely deviate from the realistic situation to only retain some core parameters. Despite the variety within this continuum, all these games share the same feature: learning content is inserted into the game as simulation rules that act as the game's core mechanic.

Cases of Secondary Integration

In many educational games, content is embedded in secondary or accessory mechanics. For example, in a game teaching history, such as *Versailles*, historical documentation is accessible outside of the central gameplay, as a facultative reading activity, for the curious player. The reading activity occurs at distinct times, outside of the main playing activity (that involves interacting with characters), so it typically corresponds to a non-integrated case (Habgood et al., 2005). Note that in the particular case of the game Versailles, content is also integrated in the main narrative mechanics, therefore the analysis of this game is mitigated.

In other cases, it is slightly less obvious to identify poorly integrated content. Several math games for example use a shooting mechanic as a way to convey mathematical content: the player has to shoot the correct answer to progress in the game. At first sight, one might claim that these game's mechanic embeds learning content, since the math content is intervening constantly when the player is interacting with the game, through its core mechanics. However, the main mechanic consists in aiming and shooting, which has nothing to do with adding numbers. The addition mechanic is only an exercise that the player must solve to know what to shoot. As a result, such games are simply poorly integrated. Conversely, in the math game called "L'Attrape-Nombres," the player learns addition by filing some trucks with boxes of different sizes. In this case, the main game mechanics, filling trucks, mirrors the learning content, as it embeds a spatial representation of numbers (the length of the truck and the boxes it may contain).

The Case of Quizzes

A large portion of serious games are quizzes, that is a series of questions related to the learning content, inserted within a reward mechanism. This the case for example of educational games developed within generic games: questions are inserted within another game such as the game of the goose (Sauvé & Samson, 2004). While some learning games are indistinguishable from quizzes, many others add some ludic elements to "make them fun." Regardless of their learning intention, quiz games are a popular type of games, as exemplified, in the non-digital domain by the Trivial Pursuit board game.

Serious games in the form of quizzes can be considered in two ways. On the one hand, they are a well-established form of games, and the content, the questions themselves, represents the core mechanics of these games. Therefore, they seem to be a good example of well-integrated serious games. On the other hand, quiz games are often considered as poor serious games, lacking immersion and situatedness, that do not promote active and thorough learning.

In order to properly assess quiz games, one needs to distinguish two kinds of gameplay, that is two ways of making a quiz game fun. Either the content itself is fun, the questions are mind challenging and/or humoristic puzzles, with an element of surprise in the solution that provides a form of satisfaction for the player; or the quiz mechanics go far beyond a mere score and add some complex mechanics, like thresholds, different types of questions, not to mention social interaction between players (competition, collaboration, etc.). This is typically the case in the Trivial Pursuit game. These two cases will be analyzed separately.

In the first case, if the content in itself may be made fun, which is clearly recommendable, then it is not the game which is fun, but the content itself! We are not anymore in a game design situation, but in the design of good questions/puzzles from a given educational content. In the second case, when a sophisticated reward mechanism is added to the questions, the question to raise is: is the learning content embedded within this additional mechanic? The answer is usually negative, the content is in the questions themselves, not in the scoring mechanic that surrounds the questions. Therefore, in such games, the content is not integrated in the core mechanics.

To summarize, quiz games are popular, and easy to build, but do not properly integrate content in their game elements. Beside the "question part," which I do not consider as ludic in itself, the "game part" has no specific pedagogical value and at best slightly enhances motivation, at worst distracts the learner. Reflector[1] is a noticeable game in this respect: while its learning goal is to teach/train mathematical operations, in order to answer a quiz, the player needs to orient a number of small mirrors to direct the light to the correct answer. The game teaches mathematics while the core mechanic is about optics!

Narrative Games

As mentioned above, some games use interactive narrative as their core game mechanic. For example, Syrian Journey (*Syrian Journey: Choose Your Own Escape Route*, 2015) puts the player in the position of a Syrian refugee escaping his/her country in the mid 2010's. The player has difficult choices to make that will impact the success or failure of the journey. In this example, the learning content is particularly well integrated into the game mechanic because the learning content (raising awareness about the difficulties encountered by Syrian refugees) is integrated at two levels:

- the story, where it matches the learning content—the journey—and also illustrates several political and social issues in countries travelled through; and
- the nature of choices, which puts the player in dilemma situations, mirrors difficulties encountered during the journey.

Other examples of such interactive stories include Sauve une vie (save a life) (*Sauve Une Vie*, n.d.) on first-aid techniques, Be Washington (*Be Washington*, n.d.) on the United States early history, covering very various areas but in which the learning content is congruent with both the story and the associated choices.

In other games where interactive narrative is the core mechanics, it is less the story itself (the series of narrative events) that matches the learning content but its underlying meaning, in terms of characters in the story, their interrelations, and the story's values or norms. This is the case for games that deal with social skills, often termed soft skills or non-technical skills, such as Start the Talk (and many other games from the company that developed the game, Kognito), on youth drinking prevention, as well as more research-oriented games (interactive drama) such as FearNot! on the issue of bullying in schools (Aylett et al., 2005) and Nothing For Dinner (Habonneau et al., 2012; *Nothing For Dinner*, 2014), on family relations with a loved one with traumatic brain injury.

However, just because a serious game uses narrative as a core mechanic does not necessarily mean that its pedagogical content is perfectly integrated. In games such as GHD games (Molnar et al., 2012) or Cristal island (Mott & Lester, 2006), both putting the player in the shoes of an investigator searching for the cause of an infection, learning content (microbiology) is integrated in the dialogs as well as in the main quest in the story. However, the story itself, even if it plays a key role in motivation, is distinct from the learning content: the learning objective is not to become health workers or investigators, but to learn biology. In addition, the inter-relations between characters are disconnected from the learning content, contrary to the games cited above that deal with social skills.

To summarize, in narrative games, learning content may be integrated into the story, the dialogs, the choices, the story's values, the inter-character relationship, creating various degrees of integration (see also Ke, 2016).

Other Experiential Games

Games that manage to integrate learning content within the core game mechanic are not limited to the two above categories (learning content as simulation and narrative games). In particular, a wide range of games, including serious games, convey what could be termed "experiential content," that is a perceptive message that is experienced when interacting with the game mechanics. For example, two games that aim at teaching the player what it means to suffer from Alzheimer's disease use this approach, Forgotten (Autoscopia Interactive, n.d.) and Before I forget (3-Fold Games, n.d.). In the former, the player experiences non-consistent situations, such as quickly switching from a scene where the main character is alone, to a family dinner, expressing and/or enabling the player to experience the strong cognitive disorder that the main character is suffering from. In the latter, in the main character's house, the same door may lead to another place, expressing the stressful disorientation of the character. In these two examples, the classical navigation mechanic is distorted, conveying a surprising and expressive message.

Integration in Game's Wrapping

Diegetic Integration

As explained above, a game's wrapping contains the diegesis, the narrative (when not in the core mechanic), and the media. Learning content integration should be analyzed at each of these levels separately.

Integration at the level of the diegesis means that the elements of the diegesis, that is the temporal context, the places, the objects, and the living inhabitants are related to the content to be learned. In games where learning content is integrated via a simulation (see "Learning Content as Simulation," above), the integration into the game mechanics implies an integration into the diegesis. For example, in the game Stop Disasters!, the player is understanding disaster prevention by making decisions regarding land use planning; learning content lies both in the mechanics (how some decision prevent or not the consequences of the upcoming disaster) and the diegesis (the particular geographical elements that are handled by the simulation).

Nevertheless, these two types of integrations (diegesis-based and mechanic-based) are decorrelated. First, as argued by other researchers, integration into the fantasy, as defined by Malone, is distinct from integration into the mechanics. The game taken as example by Malone, a dart game for teaching fractions in mathematics, where target positions correspond to various answers to a fraction's recognition problem, is typically a game where content is integrated in the diegesis, not the mechanic. It is in fact similar to the Flash game called TreeFrog, except that this latter game contains a larger diegesis with a jumping frog, making the whole experience more ludic. In these two games, the game's core mechanic is an aiming mechanic that requires no mathematical skill, but the spatial distribution of the answers is related to the concept of fractions. Second, conversely, some games may be integrated at the mechanic level, without being integrated at the diegetic level. For example, in the game QuarkCocktail, that teaches the components of quarks within elementary particles, the player places incoming quarks into a 3 per 3 grid; when three quarks forming specific particles are aligned, they merge into this particle; at each level, the player must create a set of particles and avoid creating another set. The content, that is the decomposition of particles into three quarks, is integrated into the game mechanic of properly aligning these quarks in the grid. But the diegesis itself, a grid in which position of quarks makes them merge into a particle is purely abstract and does not match with learning content.

Narrative Integration

In this section, I analyze integration into the narrative, in cases where the narrative is not at the core of the interaction (see "Narrative Games," above, for the opposite case). In these games, learning phases, based on other (non-narrative) game mechanics, are part of a larger narrative context.

Beyond the integration of learning content into the learning phases and into the overarching story, a key question is: how the activity involved in the learning phases impacts the narrative that is displayed outside these phases? The integration will be considered as more effective if this activity is strongly related to the external narrative content. To properly analyze the narrative integration, one must embrace the richness of the concept of narrative. In the field of narrative studies, there is no consensual definition of narrative. For my purpose, I will retain the following main characteristics of narrative:

- narrative is a matter of events occurring in time (Prince, 1987);
- these events are causally related (Adam, 1994; Prince, 1987); and
- narratives contain characters (Adam, 1994; Ryan, 2004) that perform actions (a type of events [Herman, 2002]).

These characteristics do not constitute a definition of narrative but are sufficient to analyze narrative integration in the scope of this article. We note that both games and narrative share the concept of action, therefore the relation between actions in the learning activities and actions (and events) in the narrative that embed them is of particular interest. The above question can now be specified as follows: "how the activity involved in the learning phases impacts the narrative's events?" We found the following three levels of integration:

- Juxtaposition: what players do within the learning game mechanics has nothing to do with the narrative. For example, in the Desert Oasis game (*Desert Oasis*, n.d.), the player learns that a village in the desert suffers from a drought and could be saved by a djinn who is imprisoned for 1000 years and that a sorcerer has put clues in the village that need to be deciphered. The player then navigates into the village and finds messages to decipher; there is no explanation as to why solving cryptographic puzzles is necessary to progress in the story.
- Arbitrary relation: the narrator or a character explains why solving a given problem is necessary to progress in the story, but the causal link between the outcome of the activity and the story is mediated by an arbitrary character or process. It can be a magician needing some information, a secret code to open a door (Algebra Mystery, part I [*Algebra Mystery*, n.d.]), etc.
- Causal relation: what the player achieves when solving a problem in the learning phase logically advances the story. More precisely, the story is designed so that the problem-solving activity makes sense within that story. For example, in the second part of Algebra Mystery (*Algebra Mystery*, n.d.), some paintings have been stolen from a museum, and the player needs to identify

them based on the proportions of the packages containing the frames as seen in a surveillance camera and the total length of the wrapping strings discovered nearby—which amounts to solving an algebraic equation. Another example is the Geniventure game that teaches the basics of genetics. Various exercises are built around genetics, resulting in the creation of dragons with various features (with or without wings, for example). These features are motivated according to some narrative elements, such as defending against attacking enemies, pleasing toddlers with flying pets, etc.

Note that the boundaries between these three categories are not strict, because it remains subjective and not necessarily clear-cut whether a relation is not motivated, arbitrary or causal.

Another dimension of narrative is worth considering, the narrative theme, and how it is linked to the learning content. Indeed, regardless of the degree of causality discussed above, the story that encompasses the learning activities may contain thematic elements that evoke the learning content. For example, in the Cipher Island game (*Cipher Island*, n.d.), the follow up of the above mention Desert Oasis game, the game mechanic is once again causally disconnected from the unfolding of the story, but instead of taking place in a desert, the story involves a paranoiac community, living in a culture of secrecy on an island isolated form the rest of the world. This setting, which evokes some backstory events, makes sense regarding the learning content, cryptography.

Integration with Strategies

As explained above (in "Integration in Game's Wrapping"), strategies stem from the game mechanics but cannot be reduced to it. In a wide range of learning games, the learning content is integrated within these strategies. A typical case is the flight simulator: even if, when playing those games, the player acquires some notions of aerodynamics (which corresponds to learning content as simulation), the main learning content is the decisions that a pilot must take to fly an airplane.

From a learning perspective, what is key is that only pedagogically valid strategies make it possible to win the game, pedagogically valid strategies corresponding to the skills that the player must acquire. In other words, if the game allows a strategy that offers no educational value to be a winning one, then it is a failure from an integration perspective. (Szilas & Acosta, 2010). Nevertheless, this quality criterion is a matter of degree. If a winning wrong strategy is not easy to find, the game can still be regarded as (pedagogically) successful, compared to a game in which the winning wrong strategy is obvious and frequently used by the player. At that level, the evaluation is naturally difficult, as it requires either to estimate the "obviousness" of these strategies, or to test the game with real players.

Integration and Temporalities

Many serious games are structured into phases (see "Temporality and Granularity"), and it is therefore necessary to perform several analyses based on the method described so far, one analysis per phase. Considering the game at the global level, the more frequent phases featuring a strong integration, the better the serious game, in terms of integration.

In the following, I will discuss three typical patterns of distributions of these phases in the domain of serious games.

Levels and Progression

As it involves an acquisition of skills and knowledge, learning is inherently temporal at a macro scale—the micro scale corresponding to the temporality of the game mechanics. In the domain of games, this corresponds to what is called the progression (cf "Temporality and Granularity"). From the perspective of integration, it should be analyzed whether the game progression matches the progressive increase of difficulty in the learning domain (Manzoni, 2017). Ideally, this should be the case. For example, in the game called Ice Flows (*Ice Flows*, n.d.), the first level lets the player modify the temperature variable and observe its effect on the ice sheet thickness. In a further level, a second variable is introduced, the strength of the snowfall, making both the game more challenging (game progression) and the learning more efficient (progressive increase of difficulty).

Another interesting aspect of game progression is the way successive game mechanics, or game mechanics' elements are added in the game. In some cases, the more advanced levels introduce new mechanics while keeping the previous ones, so that the player is still practicing the content of the previous levels. We may call this situation the "nested mechanics." This is the case for the above-mentioned Ice Flows game. However, this is not always the case (Manzoni, 2017).

The Case of Minigames

A typical pattern in the domain of educational and serious games consists of a global fictional world in which the players navigate and select a specific minigame, covering a certain learning topic. Games in that category include classical Edutainment products (e.g. Adibou) as well as more recent games such as PowerZ or "Une journée au fil de l'eau." This approach is, per se, not problematic in terms of integration, but most of the time, minigames themselves are poorly integrated, as they are mere quizzes with points and other rewarding mechanisms (see "The Case of Quizzes"). When analyzing such games, what must be first and foremost analyzed is the integration of learning content within the mechanics of each minigame. Then the global game must be analyzed, in terms of progression as discussed above (in "Levels and Progression"), but also in terms of narrative integration, and finally in terms of mechanic, in case it would embed some learning content.

Alternance Between Gaming and Non-Gaming Phases

It is common that a gaming phase follows or is followed by a non-gaming phase, focused on the learning content. If the gaming phases do not properly integrate the learning content, then, obviously, the whole game is poorly integrated. As Fabricatore put it more than 20 years ago, it is like "going to the groceries store around the corner with a Ferrari," meaning that the potential of games is poorly exploited. Conversely, one must analyze the role of non-gaming phases related to the gaming phases in order to determine if it is pedagogically relevant.

For example, following the classical structure of learning simulations (Gredler, 2004), the non-gaming phase may play the role of briefing and debriefing. Typically, they would present the learning content in an expository form, either before the gaming phase to introduce or recall critical concepts, or after it, in order to consolidate the content inserted into the preceding gaming phase. Another approach consists of including static learning data within the game's diegesis, typically as a notebook, so that the player can frequently consult this data without leaving the game world, which may be necessary for some complex learning content. All these approaches may be valid, but they run the risk of disrupting the playing experience (Sutter Widmer & Szilas, 2011). They are typically a breach of the ideal of intrinsic integration, but they may be justified. The analysis of such cases requires evaluating to which extent the chosen compromise is effective or not.

EVALUATION

The proposed model has been illustrated with several serious game examples, in order to stress its applicability. Nevertheless, a more systematic evaluation is needed in order to provide insights regarding the strengths and weaknesses of the approach. First, the analysis method will be applied on two serious games not mentioned so far. Second, in an educational context, analysis produced by students based on the model will be analyzed and discussed

Application of the Model to two Serious Games

Application to Viruscape[2]

Step 1. Viruscape is an independent game that covers the topics of Covid-19 with two identifiable learning objectives: 1) The rules that must be followed in order to prevent the spread of the virus; 2) Provide a testimony of the Covid-19 period.

Viruscape is effectively a game: the player is challenged to avoid being contaminated during 14 consecutive days, by interacting with the game objects; the game cannot be reduced to a set of pedagogical documents and quizzes.

The analysis of the game according to the model is synthetized in Table 1.

Table 1. Analysis of the Viruscape Game According to the Proposed Model

Dimension		Description	Integration?
Logic (mechanics)	Core	1. Move: The player can move his/her character in four directions via arrows (top view), the view changing via horizontal and vertical scrolling. The movement speed is lower in some areas. There are two maps: inside the house and outside.	N
		2. Actions: Upon reaching specific locations, the Player Character (PC) initiates an action that results in a change to one of the four gauges (satiety, rest, hygiene, asepsis) or one of the five resources (money, food, soap, masks, gel), or time. One action is always available by pressing the space bar. The list of actions, their effect, and their availability conditions are not detailed here for reasons of space.	Y
		3. Spontaneous evolution: The variables also change autonomously with time. When some thresholds are reached, the PC is contaminated, which ends the game.	Y
		4. Character Interaction: Outside are circulating numerous Non-Player Characters (NPCs). When the PC gets close to one of them, a message reminds them of the importance of keeping distance. In some cases, it leads to contamination and the end of the game.	Y
	Sustaining	1. Newspaper: Inside, a newspaper containing several daily news is available. It may also give hints of what is specific in the current level mechanics (see Temporality).	Y
		2. Reading: The specific action of reading, inside the house, moves time forward by an hour.	Y
		3. Navigation aid: Some arrows indicate out-of-field places.	N
		4. Hints: When a gauge is low, a message alerts the user.	Y
	Accessory	None.	
	Surrounding	Pause: At any moment, the player can pause the game.	N
Wrapping	Diegesis	A house and its surroundings in a small town.	N
	Narrative	This is a story of someone dealing with the KOF-KOF virus that has contaminated the town and the world. It spans over 14 days.	Y
	Media	Top view, retro design, Pokémon style.	N
Temporality		The game is divided into 14 levels (one level per day). Each level has a new journal and variations (constraints) in the core mechanics (movement restrictions, shortage of resources, etc., not detailed here for reasons of space).	Y
Strategies		1. Buy in advance: For example, buy food and masks in the first days to avoid issues during lockdown days.	Y
		2. Save resources: Use only the necessary number of resources, no need to have all gauges full.	Y
		3. Stay home: Go outside only when necessary and optimize trajectories when outside.	Y
		4. Avoidance: When outside, anticipate NPC movements in order to avoid collisions.	N

Note. See also Figure 2 and assessment of the learning content integration for each component (last column).

Step 2. For each component of the above analysis, it should be assessed whether it embeds the rules preventing virus propagation or refers to the Covid-19 period. For that purpose, a column has been added in Table 1, indicating Yes (Y) when this is the case, No (N) otherwise.

Note that the analysis can be refined for each learning objective. For example, the first strategy, buying in advance, does not correspond to a rule to be learned (it would mean guessing the future), but corresponds to the history of the period (second learning goal).

Step 3. The game integrates quite well the learning contents because, as we can see from Table 1, most components of the game embed the learning content, and particularly three out of the four core game mechanics. Effectively, the mechanic of move does not embed any learning content, contrary to the three others that follow the pattern of simulation. Learning content is also nicely integrated at the level of most secondary mechanics and strategies.

Application to Math Ascension3

Step 1. Math Ascension is a game designed to teach primary school pupils their multiplication tables and practice mental calculation (complex multiplications, additions, and subtractions). As previously, Math Ascension is an authentic game, with its original universe, characters, and gameplay. The analysis of the game is synthetized in Table 2. The table shows that the game contains many different game mechanics, but that the core game mechanics are much simpler than the previous game.

Table 2. Analysis of the Math Ascension Game According to the Proposed Model and Assessment of the Learning Content Integration for Each Component.

<table>
<tr><th colspan="3">1</th><th>2</th></tr>
<tr><td rowspan="17">Logic (mechanics)</td><td>Core</td><td>The player is required to provide the result of the multiplication of two numbers, represented by a block made of square tiles (1x1). The width and height of blocks correspond to these two numbers. If the answer is correct, the block piles up to build a high tower. If the answer is incorrect, exceeding unit tiles fly away, or the block collapses, destroying the last row of the tower. This is repeated until the end of the level.
A non-player character (NPC) also builds his/her own tower. The level ends with success if the player reaches the top before the opponent NPC.</td><td>Y</td></tr>
<tr><td rowspan="8">Sustaining</td><td>1. Powers: The player can activate a special power by pressing the space bar. These powers either ease the ascension or hinder the opponent. Only one is active at a given moment, automatically chosen among the three selected by the player before the start of the level. There are dozens of powers that will not be detailed here.</td><td>N</td></tr>
<tr><td>2. Dynamic of powers: Powers are progressively made available during the game's progression. In addition, after a certain number of uses, they evolve to stage 2.</td><td>N</td></tr>
<tr><td>3. Auras: They are specific advantages the player chooses before starting the ascension. Auras are placed within a grid of seven slots, each of auras taking one to three slots. Available auras vary according to levels, and must be bought with money.</td><td>N</td></tr>
<tr><td>4. Challenges: Players can select a number of challenges that, if successfully completed will earn them money.</td><td>Y</td></tr>
<tr><td>5. Daily quest: a challenge that must be met 10 times.</td><td>N</td></tr>
<tr><td>6. Money: the player character (PC) earns money by finishing the ascension and succeeds in reaching challenges and quests. S/he may use the money to have more objects, buy auras, and increase the number of slots for auras.</td><td>Y&N</td></tr>
<tr><td>7. Scores: At the end of each ascension, statistics are given, according to each multiplication.</td><td>Y</td></tr>
<tr><td>8. Management of multiple: the player can choose which multiple s/he wants to practice (1-12). According to results, the player progresses for each multiple (three levels).</td><td>Y</td></tr>
<tr><td>Accessory</td><td>Skins: The player can change the skin of the PC, with objects in the inventory. Some objects must be bought.</td><td>N</td></tr>
<tr><td rowspan="5">Surrounding</td><td>1. Saving is automatic</td><td>N</td></tr>
<tr><td>2. The player can choose the language</td><td>N</td></tr>
<tr><td>3. Pause: the player can pause the game; during the pause, it is possible to change options.</td><td>N</td></tr>
<tr><td>4. Options: customization of volume and audio effects.</td><td>N</td></tr>
<tr><td>5. Time screen: After a certain gaming duration, the player is invited to resume playing.</td><td>N</td></tr>
</table>

continued on following page

Table 2. Continued

1			2
Wrapping	Diegesis	Imaginary world inspired by the antic roman period.	Y
	Narrative	The hero, Mathilda, needs to restore light to the archipelago, and for that to reach the top of the Maths Tower. To achieve this, she must engage in a series of calculating duels against various opposing gladiators. At the end of the game, she restores the light.	N
	Media	• Colorful, light, cartoon-style 2D graphics. • Epic music.	N N
Temporality		The game is structured into successive levels (ascensions), with an increasing complexity, according to the player's successes.	Y
Strategies		1. Good student: answer correctly to mathematical questions	Y
		2. Powers: use powers according to the context	N
		3. Win tine: by triggering a power, or by pausing the game, the player has more time to think.	N

Step 2: Table 2 states that the learning content is integrated within the core mechanic. This assessment is based on the fact that the core mechanic involves building a tower with blocks, and that the learning content is directly related to these blocks. When answering a series of multiplication questions, the player is visualizing what these multiplications means from a spatial point of view. This is what differentiates Math Ascension from the numerous educational games that just ask questions and give a reward when the answer is correct.

Step 3: Math Ascension can be considered well-integrated, since the learning content forms part of the core game mechanic. However, many other games' components do not embed the learning content. In that regard, it is possible to suggest that the game could be improved, not by removing secondary mechanics (they have been added for a reason, to enhance playability), but by rethinking some of them in terms of the learning objectives. It must be noted that the negative answer concerning integration of the powers is an average: if most powers, effectively, do not relate the math, a few of them do. More of such powers should be included.

Discussion

These two cases show how the model and the corresponding analysis method can be used in practice to analyze learning content integration in serious games. The two games analyzed are quite complex and I did not enter into the details of each mechanic (rules of evolution of each parameter). The analysis is subject to variability, particularly with regard to the level of detail that each evaluator wishes to provide. This has an impact on the resulting integration assessment. For example, in the Math Ascension game, the analysis of integration regarding the "powers" used by the PC would require detailing each of these powers individually.

Future work could involve several experts analyzing the same game to assess the variability of the analysis and potentially reduce it by adding more constraints.

Use of the Model in an Educational Context

Within a yearly bachelor course on Educational Technology, one activity consists in analyzing an existing serious game. The task is particularly complex, especially for undergraduate students. To make the task more manageable and provide strong guidance, the proposed model is presented to the students, and an evaluation matrix is provided, similar to the one in Table 1. Student work is assessed using a peer grading method. Each piece of work receives four or five marks (0 to 4) from its peers, based on an evaluation grid and the teacher's answer key.

Within this context, I want to evaluate whether the model and the associated analysis matrix enabled students to properly assess the integration of learning content in the game. The game analyzed for the 2023–24 academic year was the previously discussed Viruscape game. Specifically for that game, two criteria are used to evaluate the correctness of the analysis: 1) Most game mechanics integrate learning content, but not all of them—n particular, diegesis and media do not—and 2) The move mechanic is properly analyzed, either by considering that it does not integrate the content because moving is not part of what needs to be learned, or by claiming that is does integrate the content if the *character interaction* mechanic (see Table 1) is considered.

From the 188 analyses with marks, I sampled 10 analyses as follows: 5 randomly chosen among the first quartile and 5 randomly chosen among the fourth quartile. I re-evaluated these 10 samples regarding the learning content integration, using the two criteria above. Results are displayed in Table 3.

Table 3. Evaluation of a Sample of 10 Students' Analysis, with Marks Ranging Between 0 and 4

ID	Peers' mark	Criteria 1	Criteria 2	Comments
1	4	Yes	No	Wrong justification regarding the moving mechanic.
2	4	Yes	Yes	Link between moving mechanic and social distancing.
3	4	Yes	Yes	Link between moving mechanic and social distancing.
4	3.88	Yes	Yes	Moving in general considered as non-related to the learning content.
5	3.88	No	No	All components, including graphics, are considered to integrate the learning content.
6	3.38	Yes	Yes	Link between moving mechanic and social distancing. Diegesis mistakenly taken as integrating learning content.
7	3.38	Yes	Yes	Link between moving mechanic and social distancing.
8	3.25	Yes	Yes	Link between moving mechanic and social distancing.
9	3.13	Yes	No	Wrong justification regarding the moving mechanic. Diegesis mistakenly taken as integrating learning content.
10	2.63	Yes	Yes	Link between moving mechanic and social distancing. Diegesis mistakenly taken as integrating learning content.

The results tend to show that the analysis grid allowed students to provide the right analysis for six of the ten samples. In addition, all analyses concluded that the game was globally well design regarding learning content integration, which is correct. Only one analysis can be considered as incorrect, since it considered learning content integrated everywhere.

Interestingly, in Table 3, results at the top of the table are not better than the one at the bottom. It seems to show that the benefits of the analysis grid are distributed equally among all students, regardless of the marks they receive from their peers.

However, the presented evaluation of the analysis framework remains preliminary. A larger sample should be analyzed with more criteria and measures of inter-expert agreement. In addition, a control group would allow to better identify the benefit of the model in a teaching context.

CONCLUSION

The importance of a proper integration of the learning content within learning games has been stressed for many years. Yet, this notion of integration lacks conceptualization, and is often reduced to a single-criteria assessment, initially as an integration within the fantasy in the early work of Malone (1981), or later withing the game mechanic itself (Habgood & Ainsworth, 2011). The main contribution of this article is a multi-criteria framework for analyzing integration, paving the way for much richer analyses of learning games. Within this framework, I am able not only to detect poorly integrated games but also to assess more subtle situations where learning content is only partially integrated within the game, providing more nuanced analyses. Beyond stereotypical situations, analyzing a learning game remains a tricky endeavor that reflects the complexity of designing quality learning games.

Following the pilot experiment described in this article, a more systematic evaluation of the benefit of the approach should be undertaken. One option would be to recruit experts in the field and ask them to compare analyses using the framework with analyses written without using it. Another option would be to have these experts analyze games using the framework, and then evaluate their appreciation of the framework and the consistency of the analyses.

Beyond analysis, the proposed model is also suitable for the design of learning games. The model suggests that not only learning content should be embedded in the core game mechanics, but that the content should also be reflected in other parts in the game. Nevertheless, I believe that there is no universal scheme for integrated games, as it depends on the learning domain.

COMPETING INTERESTS

The author of this publication declares there are no competing interests.

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ENDNOTES

[1] https://www.jeuxmaths.fr/jeuxhtml5/reflector/jeu/
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[3] https://math-ascension.com/

Nicolas Szilas earned a doctorate in cognitive science at the University of Grenoble, France, and has conducted research at the crossroads of computer science, gaming, narratology, and human learning. At the University of Geneva, he supervised several research projects on interactive drama, with the aim of training people in formal or informal care situations. He has developed computational models of narrative that formally describe narrative components such as dramatic situations, narrative acts, and emotional reception. He chaired the 8th International Workshop on Computational Models of Narrative (CMN'25). Nicolas Szilas has also developed expertise in intrinsically integrated learning games, from both analytical and design perspectives.