# Proposing a Framework for the analysis of integration in Serious Games

Manzoni, Alex

UNIVERSITÉ DE GENÈVE

FACULTÉ DE PSYCHOLOGIE ET DES SCIENCES DE L'ÉDUCATION

# Proposing a Framework for the analysis of integration in Serious Games

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**Alex Manzoni**

**DIRECTEUR DE MEMOIRE**
Nicolas Szilas - Université de Genève

**JURY**
Nicolas Szilas - Université de Genève

Julien Da Costa - Université de Genève

Denise Sutter Widmer - Université de Genève

Jacob Habgood - Sheffield Hallam University

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**RESUME**

The notion of integration in educational games, namely the way in which the learning content is inserted into a game for efficient learning and increased motivation, remains relatively undefined in the literature (Szilas & Acosta, 2011), and no operational guide to analyse existing educational games has been provided to date.

The goal of this master thesis is to design a tool to objectively classify and quantify educational games based on the type and degree of integration between the game and its learning content.

For this purpose, two questionnaires have been created, the first assessing the primary learning outcome (cognitive, motor, affective, communicative) targeted by the game being analyzed, and the other providing a guide to classify the game's type of integration based on the framework.

The framework's implications for the notion of integration in educational games will be discussed, and propositions for future research on the topic will be provided.

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# *"Proposing a Framework for the analysis of integration in Serious Games"*

Alex Manzoni

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**Master MALTT**

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## Final version

Jury:

Nicolas Szilas - Université de Genève
Julien Da Costa - Université de Genève
Denise Sutter Widmer - Université de Genève
Jacob Habgood - Sheffield Hallam University

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# Summary:

The notion of integration in educational games, namely the way in which the learning content targeted is inserted into a game that is also supposed to be engaging for the player, remains relatively undefined and not clearly understood in the literature. Although attempts have been made by Malone (1981), Habgood (2005), Szilas & Acosta (2011) to offer suggestions for what kind of integration types are more appropriate than others, no attempts to provide an operational guide in order to effectively analyse (and even quantify) this concept on existing educational games have been provided to date.

The goal of this master thesis is to develop a framework to unify all the relevant contributions to this topic advanced in the literature (while at the same time adding new notions to complete them), and to provide a tool to objectively categorise and quantify educational games based on the type and degree of integration between the game and its learning content.

For this purpose, two questionnaires have been created, the first assessing the primary learning outcome (cognitive, motor, affective, communicative) targeted by the game being analysed, and the second one providing a guide to categorise the game's type of integration based on the framework.

The underlying assumption is that certain types of integration are more relevant than others depending on the learning outcomes targeted.

The framework's implications for the notion of integration in educational games will be discussed, and propositions for future research on the topic will be provided.

# Index:

# 1. Introduction:

## 1. 1. The popularity of Videogames today

Video games today are a booming industry, already generating more revenue each year than the music and movies industries. According to the 2016 Entertainment Software Association Report, 48% of U.S. households own a game console and 63% include at least one person who plays video games 3 hours or more per week. According to the same data, the US gamer demographic is progressively getting more diverse in terms of key variables such as gender or age, with the average game player being 35 years old, and women now being 41% of the entire gamer population. Following the 2017 Ipsos "The New Faces of Gaming" report, similar results are found in Europe, with 44% of gamers being female, spending an average of 4.6 hours per week on smartphones and tablet games alone.
Being an incredible source of technological innovation and considering the interest in the activity, video games can be used for a wide variety of goals, including education. Video games with an explicitly educational goal in mind have therefore tried to harness the potential and benefits of the technology, such as the ability to intrinsically motivate (Anyaegbu, Ting & Li, 2012), to generate Flow states in which the user is completely immersed into the experience often losing the sense of self and sense of time (Annetta, 2010), to emotionally stimulate the user to include social activities such as competition (Landers & Callan, 2011).
Among the first attempts at developing video games with educational goals, certain examples can be mentioned such as a 1971 game called "The Oregon Trail" (a game where players experience the life of a group of 19th-century settlers traveling along the Oregon Trail,), or a 1973 game called "Lemonade Stand" for the Apple 2 Computer (a business simulator where the player manages a lemonade stand and has to learn basic business variables such as the costs of the activities, the profits, trying to determine the price of every glass of lemonade, etc).

These first productions, although innovative for their time, were quite limited in terms of graphics, gameplay, and learning experience. Even considering their limitations, they represent an important bedrock and they were responsible for starting a trend that would bring us the more successful pedagogical games we have today.

Following the popularity of successful games such as “Brain Training” for Nintendo DS,  the production of what are now called “serious games” (pedagogical games with the explicit intent of teaching the players a specific content) started to expand to include a wide variety of domains, including highly specialised applications such as simulations in the medical field (for Parkinson’s or Alzheimer’s patients for example), using virtual reality, and other innovative game design technologies.

## 1. 2. The current “Serious games” landscape

According to a Report from Markets & Markets, “Serious games” today focus less of broader learning and instead target specific set of skills in various domains (often with the goal of training the users for specific tasks or jobs), such as military, government, education, corporate, healthcare, media & advertising. With an estimated yearly growth for the entire industry of 16% until 2020 and a revenue of 5.2 billion of euros every year, the corporate and educational domains in particular are the ones that are expected to grow the most for the next 3 years.

According to a Report from Sam Adkins (CEO of Metaari, an “ethics-based market research firm that identifies revenue opportunities for learning technology suppliers”) that analysed the Serious Game markets in the US specifically, the trends that are growing the most in this area are games dedicated to young children, and the ones using augmented reality and geolocation.

Furthermore, according to the same data, the general tendency for these products is to follow the mobile trend (which is expected to reach 35% of the revenue from the entire E-learning market until 2020) with many serious games being developed for smartphones and tablets exclusively.

Among the Industry leaders developing Serious games, “Serious Games International” (based in the UK) and “Break Away games” (based in the US) can be mentioned, having created games such as “vHealthcare” (a game for healthcare professionals to better learn how to interact with patients, how to more efficiently perform their tasks, etc.), and “Evo” (a game where biology students learn how certain genetic traits in the Guinea Fish are passed from generation to generation).

With a serious game market so highly diversified, and many products that specifically target institutions’ goals, it is difficult to generally assess the effectiveness of educational games compared to other mediums of learning such as texts, or educational videos. Existent meta analyses however, show promising results such as the ones for serious games in educational contexts (Backlund & Hendrix, 2013; Randel, Morris, Wetzel & Whitehill, 1992), and for the ones evaluating virtual reality (Virvou, Katsionis, & Manos, 2005). More specifically, these studies show that, on top of the better acquisition of the educational material, one of the biggest benefit users get from using a video game format for their learning is motivational, improving the interest in the domain and wanting to continue to learn at a deeper level, compared to standard formats such as text or classroom explanations. Moreover, the types of games that seem to lead to the most efficient acquisition of the learning content are the ones that target specific knowledge or skills.

## 1. 3. The notion of Integration in educational games

Regardless of the type of serious game, its genre, its public targeted, its application, there is an important aspect to always consider when developing educational games: the notion of the articulation between the game itself and the learning content, meaning how the learning content is inserted into the game for efficient learning.
This aspect is central and it is supposed to allow the most effective acquisition of the learning content targeted by the developers while capitalising on what makes games fun and interesting at the same time.

## 1. 4. The first theoretical framework on integration: intrinsic fantasy.

The first contributions in the literature on this topic have been the ones that tried to clearly define this concept and to develop a theoretical framework around it in order to analyse pedagogical games under the lens of the integration between the learning content and the certain features in the game, such as the fictional world the game takes place.
Malone (1981) has developed the notion of “intrinsic” (or “endogenous”) fantasy, where the learning content is linked to the imaginary, fictional world of the game, and “extrinsic” (or “exogenous”) fantasy, where the learning content and the fictional world are not related to each other.
The author makes the example of a game where the players are supposed to understand the concept of fractions, where they have to select the correct point on a line (for example in the middle of a line if it’s a “1/2” fraction), one version with intrinsic fantasy, where the fictional world of the game consisted in a game of darts (fictional world and the learning

content are related) and an extrinsic fantasy version where the fictional world is replaced with generic geometrical figures without any reference to any fantasy context.
The main hypothesis was that games with intrinsic fantasy would be more likely to increase student's motivation and lead to better learning.

Malone has experimentally tested this hypothesis in a study where children played a version of the game about fractions mentioned integrated by intrinsic fantasy (a fictional world with darts) and an extrinsic one (with only geometrical figures), and they measured the duration of gameplay for each version. The results did not confirm the original hypothesis, since there was no difference in duration between the intrinsic version and the extrinsic one.
For male participants, there was no difference in duration, whereas the duration for females was even lower in the intrinsic version of the game (the opposite of what was expected).

Another study (Habgood, Ainsworth, Benford, 2005) showed that children, if put in a condition where they had to imagine and create prototypes of games themselves, had a much greater tendency to develop games with extrinsic fantasy, which underlines the difficulty in conceiving and developing intrinsically integrated games. Furthermore, they seemed to positively evaluate games primarily based on other elements than their fictional world (such as the graphics, whether the game was "fun", whether it was difficult), which seriously put into question the primacy of the fictional world as the central criterion to determine the effective integration of an educational game.

### 1. 5. A different theoretical framework for integration: the integration by game mechanics

These studies pushed their authors to reject the idea that the fictional world was the central aspect when determining the degree of integration in a pedagogical game.
Malone himself proposed to focus on other elements, such as the mechanics of the game itself, namely the rules that determine the interactions allowed by the the game.
This approach has not been developed by Malone himself, but has allowed other authors to elaborate a much more complete theoretical framework to analyse the integration of educational games.
Habgood and colleagues (Habgood, Ainsworth, 2005), inspired by Malone's conclusion, proposed therefore a theoretical framework around the notion of efficient games being integrated around the game mechanics and not around the fictional world. They define "core

mechanics" as "the mechanism through which players make meaningful choices and arrive at a meaningful play experience".
Without necessarily forgetting that the fictional world of the game has its importance in order to motivationally engage the players into completing the tasks required in the game, the "core game mechanics" are a much more central element that will determine the success of any game (what makes the game "Super Mario" fun is the fact that jumping from platform to platform, avoiding enemies and interacting with the world is fun, regardless of its fictional world, which could be set in ancient Greece or the Moon, without necessarily losing most of its appeal).
Habgood (2007) adopts therefore the notion of intrinsic and extrinsic integration similar to that of Malone, but this time that refers to the mechanics as opposed to the fictional world. As the authors themselves have explained, it is easier to define this notion as a negative, by taking the example of many limited educational games, that clearly show an extrinsic type of integration. For example platforming games with context information that is supposed to convey the learning content that appears between levels, or quizzes at certain points in the game.
Intrinsically integrated games should make sure that the player learns the mechanics themselves, and to insert the learning elements into the more "fun" elements of the game, avoiding a tension between the "fun" parts of the game, and the learning parts of a game.

## 1. 6. An experimental test of the efficiency of games integrated by the game mechanics.

Habgood (2007) has tested the notion that the game mechanics (rather than the fictional world) represent a much more useful criterion to determine whether a game has an efficiently integrated learning content. In order to do this, he developed an educational game called "Zombie Division".
Zombie Division is a game about teaching its players to perform mathematical operations (more specifically, divisions) on the basis of certain divisors (such as 2, 5, or 10). In the study, the goal is to compare two different versions of the game, an intrinsically integrated one, and an extrinsically integrated one.
In the intrinsic version, the player impersonates a knight that has to fight skeleton enemies, who have number attached to their chest, and the player has to choose the correct weapon among the available ones to defeat them (each weapon represents a different divider, such as 2, 5 or 10). The goal is to divide the number on the skeleton's chest until it is no longer

divisible, using the different divisors. The player advances after each level, has a fixed number of life points, and after each error (choosing the wrong weapon for a skeleton that wears a certain number), the player loses 1 life point, and once the life points reach 0 the player has to restart from the beginning of the level. In the extrinsic version the player fights the skeletons with standard “action” mechanics without any reference to mathematics, and performs divisions only at the end of every level, in a standard quiz format. Finally, there is an additional control version of the game without any reference to mathematics whatsoever. It is important to note that in “Zombie Division” the fictional world is set in ancient Greece with fantasy elements such as living skeletons (the “zombies”), and the authors have created these three versions of the game based of an articulation around the game mechanics regardless of the fictional world. The fictional world could have been modified without necessarily having a big impact on the game mechanics.

In the study, three versions of Zombie Division were evaluated, utilising measures of learning (in order to evaluate whether a version of the game allowed better learning compared to the others), and of motivation (the duration of gameplay with the version when the participants had the choice to switch to different version whenever they wanted) and interviews that showed what participants thought about the different versions of the game. The results showed that the intrinsic version was chosen more often compared to the other versions of the game and this version lead to better short-term learning of the content (tested with a post-test right after the gameplay sessions) and a long-term learning as well (tested with a delayed test two weeks after the first gameplay session).

The main contribution of Habgood’s study is that it shows for the first time that an intrinsically integrate game (by its mechanics) can effectively lead to increased motivation (such as Flow states) and learning compared to an extrinsically integrated one.

Regarding the hypothesis of better learning for the intrinsically integrated version, although no differences were observed for short-term learning, the authors also showed that the benefits of the intrinsically integrated version concerning learning were primarily long term ones, as measured by the post-test questionnaire several weeks after the gameplay sessions.

## 1. 7. Secondary aspects: the "production values" and competition

The study also showed that other aspects of the game not necessarily related to the mechanics were considered determinant by the participants, as observed by the interviews with them. The players mentioned that elements such as the graphics and the 3D world played a key role into the appreciation of the game by the participants.
These are usually referred to as the "production values".
Social elements of comparison and competition (the participants often compared their scores to those of their peers and were motivated to do better) were also mentioned several times in the interviews, and were shown to increase motivation and the game's appeal through sharing strategies and solutions for the tasks in the game.

These studies confirm the potential of pedagogical games that consider that an integration by the mechanics is the more appropriate way of inserting the learning content into an educational game, but also remind us that other factors such as the "production values", competition, social comparison, or the fictional world (as seen in the "intrinsic fantasy" approach by Malone) have their importance as well.

## 1. 8. An attempt to classify games integrated by their mechanics

Following the mentioned attempts at assessing the motivational and educational benefits of pedagogical games, others studies have tried to lay out the groundwork for a classification of types of articulation between the game mechanics and its learning content, in order to allow for a systematic analysis and development of these type of games.

Szilas & Acosta (2011) have proposed to distinguish between mechanics based on "Systemic learning", "Winning strategies", "Obstacles", and "Contextual learning". The authors cite a few examples of games for each type of integration and justify their choices with detailed explanations.

The first type of articulation between the game mechanics and the learning content is called "systemic learning" and in this type of games the player effectively learns the mechanics themselves, the system of rules with which he interacts with for the duration of the gaming

experience. The player constantly interacts with the system and he adjusts his actions based on the reactions from the system itself.
The example that the authors cite is that of “Energyville”, a game where the player needs to learn the game mechanics that govern the energy resources of a city where he is the major. Certain actions (such as deciding to reduce CO2 emissions) will have certain undesired or unforeseen consequences. What the player learns is the mechanics themselves, meaning the basic interactions between element in the game (what is the effect of environmental policies on the economy etc), without necessarily having to learn exactly what kind of actual policies a government can introduce.

The second type of articulation between the game mechanics and the learning content is an integration by “winning strategies”. The idea with these types of games is that the player needs to reach a specific goal set by the game and he has different available strategies to achieve it. By freely exploring the world and the mechanics, what he will learn is a specific strategy among the available ones to achieve the goal set by the game. The game gives the player feedback (which can be in a binary “right/wrong” format, or a more natural in-game type of feedback that avoids judgement).
The example the authors give for such type of integration is the game “Dimenxian”. In this game the player will have to utilise game interfaces in order to practice and learn mathematical notions. For example, in order to find a meteorological station the player has to reach to advance to the next level, the player has to learn to use a coordinates interface. The player has different strategies available to orient himself using this interface and find the station. In this type of articulation, the learning content itself is not the mechanics of the game but the correct strategy the player will have to use (and that the game has to reinforce thanks to appropriate feedback that will hopefully guide the player to the correct strategy choice).

The third type of integration identified by the authors is called interaction by “obstacles”. In this case, the learning content is inserted at certain moments in the game when the player will be in front of an “obstacles” in order to continue in the game. The obstacle will be comprised of a choice between different options (for example a multiple choice question). The authors cite as an example of this type of articulation the game “Trivial Pursuit”, a Trivia game where the player has to answer multiple choice questions in various domains such as History or Literature and receives points every time he answers correctly.

Although “Trivial Pursuit” can be classified as a game and includes motivational elements to keep the player engaged, it is not that different from standard multiple choice tests found in any school. Clearly this game does not utilise the potential of educational games for improved learning experience and motivation.

This type of articulation is often used in many pedagogical games in what are usually referred to as “edutainment” games, among the first attempts at educational games, where the learning content is added as an inconvenient addition to a stand-alone game, where the game is visibly divided between the “fun” phase and the learning phase, creating an unwelcomed tension and the risk of being labeled as “chocolate-covered broccoli” (Habgood, 2007).
However, this type of articulation, if efficiently implemented, allows for many different types of learning content to be conveniently put into a game format and for certain types of learning content it might be the only solution available.

The last type of integration identified by Szilas & Acosta (2011) is what is called a “contextual coupling”, where the mechanics of the game can be completely unrelated to the learning content, where what the player is supposed to learn is disseminated in the context of the game, it can be found in the story, in pop-ups that the player can open (often times these pop-ups being optional).
The example the authors mention to illustrate the limits of this type of integration is the game “Versailles”, a “point and click” educational game where the player has the option to click on certain objects in order to reveal information about the context the game (the learning content, which consists in a french history lesson).

This type of integration is clearly the weakest, since it doesn’t make sure that the content is actually absorbed by the player, and it creates an even bigger tension between the learning content and the “fun” portion of the game.
Clearly, although the role of the fictional world the game is set in cannot be underestimated (as said before, secondary elements such as the “production values” can be surprisingly important in determining the appeal of an educational game), this type of articulation should be avoided, in favor of “systemic learning”, “winning strategies” or at the very least “obstacles”.

Szilas & Sutter Widmer (2009) mentioned the notion of “temporality”, namely the idea that the contact with the learning content should happen at the same time than the more “fun” elements in the game.

## 1. 9. Learning outcomes:

The literature on integration in pedagogical games has always tried to evaluate this notion in games with the idea that certain game design choices are to be preferred when it comes to develop an efficiently integrated game. However, it is also clear that the effectiveness of integration and the type of integration that should be sought also depends on the type of game that is being evaluated.
For example, the same standards should not be used to evaluate a game about learning math and a game about practicing the movement of certain limbs for patients affected by Parkinson’s disease.
Evaluations and considerations about the type of integration in a game should therefore take into account what is usually referred to as “Learning outcomes”, meaning the type of learning content that is targeted by the game.

The first attempt at classifying learning outcomes can be retraced to Bloom & Gagné (1978) and these were identified as being of cognitive nature, outlining the different components of such learning outcomes, such as the “content of the task” (basic knowledge the learner has to acquire in order to perform the relevant operations) and the intellectual “operations” to perform on such content. Bloom & Gagné further divide such content in “facts”, “concepts” (categories of objects), principles (indicating the relationship between different objects) and procedures (motor procedures).
The intellectual operations that can be performed once learned are of different types, such as retelling the information by heart (“Memorisation”), paraphrasing the information (“Summarisation”), the information can be used to anticipate certain outcomes (“Prediction”) or used in a certain way in order to produced a specific result (“Application”).

This learning outcomes’ taxonomy of Bloom’s & Gagné (1987) was subsequently modified by Krathwohl (2002), who added an affective dimension to the framework. He defines this emotional type of learning outcome as follows:

*“Affective learning is demonstrated by behaviors indicating attitudes of awareness, interest, attention, concern, and responsibility, ability to listen and respond in interactions with others, and ability to demonstrate those attitudinal characteristics or values which are appropriate to the test situation and the field of study”*

In order to further refine the taxonomy of learning outcomes in the literature, Baker & Mayer (1999) added a new social dimension, mentioning that in certain contexts, “communication skills”, “self-regulation” and “teamwork” are essential outcomes of the learning experience.

All of these approaches that focused on specifics types of learning outcomes (cognitive, affective, social) were summarized by Wouters, van der Spek, & van Oostendorp (2009) who proposed a unifying framework that classifies learning outcomes in the domain of pedagogical games into 4 main categories, “cognitive”, “motor”, “affective”, and “communicative”.

Each learning outcome category can be further divided in different sub-categories. For example, regarding the cognitive learning outcome, this outcome can be divided in declarative knowledge that is either textual (such as an explanation of how an atom works) or non-textual (such as a 3D image of an atom), and skills such as problem solving, decision making, and situational awareness.

Motor outcomes can be divided in acquisition or motor skills (for example acquiring the motor skills required to throw a basketball into the hoop) and compilation of such motor skills (integrating different skills, the old ones being integrated in the new ones)

Affective outcomes can be divided in attitude (for example a game that is supposed to change the player’s attitude regarding a topic) and motivation (increasing the motivation for a specific domain targeted by the game).

Communicative outcomes can be divided in communicative skills, cooperation skills (learning to better cooperate in a board game for example) and negotiation.

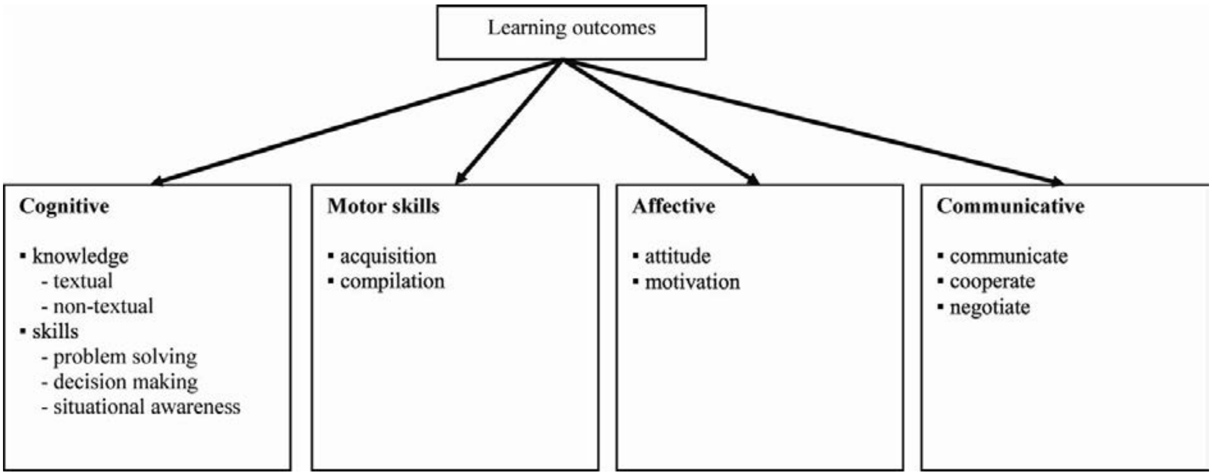


Figure 1: Learning outcomes according to Wouters, van der Spek, & van Oostendorp (2009).

Thus far, no attempt to include the notion of learning outcomes in an evaluation of the integration in pedagogical games has been observed in the literature.

# 2. Proposing a unifying Framework:

## 2. 1. Unifying the contributions in the literature

As we have seen in the previous chapter, there have been efforts in the literature to clarify the notion of integration is pedagogical games, proposing classifications that each adopt different underlying assumptions (such as the fact that game mechanics are a more central aspect of games than the fictional world where they take place).
Despite the progress, there are no actual specific frameworks that try to unify these claims and approaches into an operational guide.
Students attempting to learn about the notion of integration in pedagogical games are confronted with a limited body of literature that is often times too complex and highly theoretical, which makes it hard for them to effectively absorb the material.
Although the relevant papers have cited several existing serious games to anchor the discussion to concrete real life examples (Habgood 2007, Malone, 1981; Szila & Acosta,

2011; Szilas & Sutter Widmer, 2009), no practical tool to categorize or systematically analyse games exists today.

An effort must therefore be made in order to unify these approaches and theoretical frameworks, in order to design a standardised tool (such as a questionnaire or an application) that is able to be used as an operational guide to analyse the integration in serious games in the most straightforward manner possible.

## 2. 2. The benefits of the framework.

The benefits of using such a framework should be two-fold. First of all, although some knowledge on basic concepts (such as game mechanics) will probably be required in order to use the tool, the tool should be able to be used by students who haven't reached expertise on the topic yet.
Secondly, on top of being an operational guide, the tool will be an instrument which clarifies doubts on certain concepts that are perhaps too difficult to fully grasp by simply reading about them in the relevant papers. For example, a student might have read the literature on the difference between “obstacles” and “systemic learning”, but only by classifying a game answering to specific questions will he be able to fully comprehend these concepts that he had only vaguely theoretically understood up until that point.

The framework will try to unify existing concepts, theories, approaches, will be grounded in the current literature, but will also try to introduce novel concepts and ideas on how to think about integration in serious games.

Users who will benefit from the use of this framework will be of two kinds. Firstly, the framework will be useful for students who want to be able to analyse games and to categorise them, such as university students or any subject being interested in the subject related to serious games.
Secondly, the framework will be useful for developers who are actually creating serious games. Both during the design and realisation phases, the developers will be able to use the framework as a guide to create games that are more integrated, allowing their product to be more appealing and useful.

# 3. The Elements of the framework

The logic of the framework is that it will produce outputs in terms of typology (it will specify to which category of integration the game belongs) and in terms of a final, general score of integration for each game.
The final score will depend on the type of game that is being analysed. Different typologies of games will have different weighting of each framework element. For example, a game about learning mathematics will not have the same weighting of each framework element than a game about learning to move the arms for Parkinson’s disease patients. These different types of games will be divided based on their learning outcomes.
A questionnaire will be used to determine these learning outcomes for each game that needs to be analysed. The different learning outcomes are “Cognitive”, “Motor”, “Affective”, “Communicative” based on the classification of Wouters, van der Spek, & van Oostendorp (2009).
This questionnaire will be administered to the expert who needs to analyse the game himself/herself, or to the corporate sponsor of the game if the framework is used by developers.
Once determined the learning outcomes, another questionnaire will be used to classify the game based on the different types of integration and other criteria of the framework.
The weighting of each framework element to determine the final score will be determined based on the results of the learning outcomes questionnaire.

This framework is divided in 3 main groups of types of integration, namely the “Mechanics”, “Media”, “Context”.

The group called “Mechanics” is based on the classification seen on Szilas et Acosta (2011), which makes a distinction between integration by “Obstacles”, “Systemic Learning”, “Winning Strategies”, and “Contextual Learning”, and expand on it offering further sub-categories.
In the “Mechanics” category, the concepts of Difficulty and Progression of the game mechanics are introduced.
The group called Called “Media” refers to the nature of the images and sounds related to learning content used in the game.
Finally, the group called “Context” refers to the Story and fictional world of the game.

Certain categories (for example, “Systemic Learning”) are divided in other sub-categories (for example “Necessity of learning”), and for each subcategory, the game can be classified according to a binary choice (for example, “Learning required” or “learning not required”). For each binary choice, one of the options makes the game more integrated, the other less integrated.

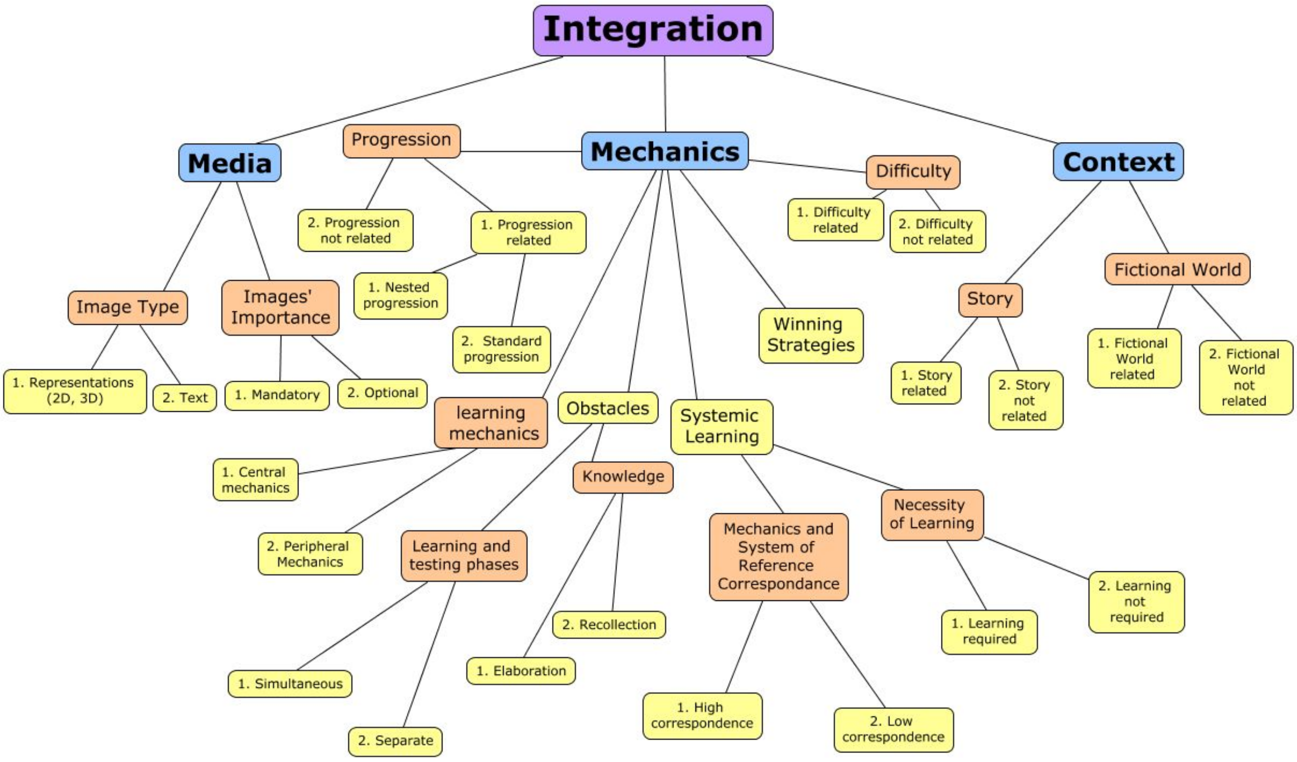


Figure 2: The Framework.

Colors:

-Blue: Three main types of integration (“Media”, “Mechanics”, “Context”)

-Orange: Subcategories

-Yellow: Options for the binary choices

Here is an explanation for each category and sub-category of the framework.

## 3. 1. Mechanics:

### 3. 1. 1. Systemic Learning

In this type of integration the player is supposed to learn the game mechanics themselves, learning them while he plays, interacting with the elements of the game. An example of such game is Climate challenge, where the player impersonates a fictional “president of Europe” and has to enact policies that are supposed to reduce and tackle climate change. The player chooses different cards that activate certain policies related to the various categories, such as economic, societal, related to energy, related to prime resources, and so on.

Slowing down climate change will come with certain consequences to other categories in the game, with the idea of a necessary sacrifice, compromise between the various components of the game. For example the player learns by interacting with the game, that certain components of the game can be influenced by other ones, such as learning how choosing policies to reduce CO2 emissions will have an impact on certain resources available and a chance of the player’s reelection as president in the game.

The idea is that the understanding of the game’s mechanics that the player acquires can be transferred to what we call the “system of reference”, in the case of Climate Challenge it’s the actual policies of various governments to tackle climate change and their real implications and consequences.

Once it’s established (with the use of the framework) that the game that is being evaluated has its learning content integrated by systemic learning, there are subcategories of this type of integration:

First of all, we have a binary choice between a game that requires the system to be effectively learned to advance in the game, and a game that doesn’t make sure in any way that the player has acquired the mechanics of the game (so it let’s the player finish the game without having acquired and understood the learning content).

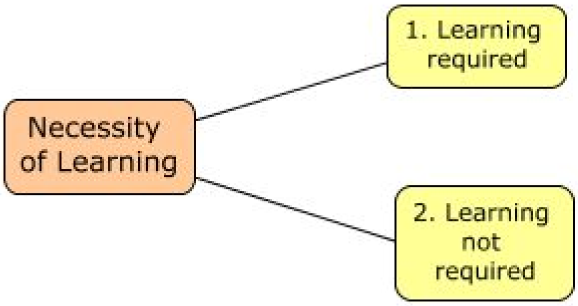


Figure 3: Necessity of learning sub-category.

For example, a game could make sure that at the end of each level, in order to advance to the next, the player has to complete some tasks that will guarantee that the player has effectively acquired the mechanics and can understand them.
The problem with some pedagogical games that contain elements of systemic learning is that the player can complete the games without necessarily utilising the full range of possible actions allowed by the mechanics. For example in the game “Climate Challenge” the player can always use the same strategy (choosing the same cards) and will be able to arrive to the end of the game without necessarily having experienced the full range of the game mechanics.
A more efficient integration is clearly the one where the game makes sure the player has learned the content as he progresses, and this should usually be done in a natural smooth way, where the player doesn’t feel forced to learn but where the acquisition of the full range of the game mechanics are naturally acquired as the player explores the game.

Another binary choice once the game is classified as being integrated by systemic learning consists in the distance between the Game Mechanics the player has to learn (for example the game mechanics of a surgeon simulation) and the System of Reference (the actual actions a surgeon has to perform in real life).
Ideally, the Game mechanics and the System of Reference should be similar enough to facilitate the acquisition of the content in the actual domain it is supposed to be applied to.
The notion that a game should reach a certain level of realism is not a novel one, and certain types of realism have been proposed as more important than others (Bates, 1994), such as the notion of “Believability”, which “seeks to develop affinity between the user and the character/s” in a pedagogical game. Believability further divides between visual appearance

and behavioral believability (for example a lifelike behavior of the characters in a game), the latter being more relevant to increase motivation than the former.

Nevertheless, some authors have proposed that efficient pedagogical simulation games should attempt to go “beyond reality”, attempting to avoid a perfectly realistic representation of reality, if that is required in order to facilitate an efficient acquisition of the learning material (Richards & Szilas, 2012).
The authors make the example of a simulation game about preventing a catastrophic event that will happen with a 5% probability. The catastrophic event should probably be triggered with a much higher probability in the game, in order for the game to actually convey the learning content. This “beyond reality” approach is beneficial mainly for emotional reasons, since eliciting emotions such as anger, surprise or disgust can increasing motivation, which facilitates learning (Blumberg & Galyean, 1995).

However, while still keeping in mind that perfect realism of events and actions should not always be sought when designing a pedagogical simulation, the mechanics used in the game that should represent real actions or knowledge in the real world, should still be able to be applied and transferred in the most straightforward way possible into the real world (the System of Reference).
Regardless of the realism level of other elements of the game (such as the story or the believability of the character’s behavior), the actual mechanics of the game should not pose transfer problems for the player.

This potential problem of transfer has been identified in the literature of pedagogical games in regards to the general knowledge of the game being applied to the real world (Habgood, 2007). More specifically for the game mechanics themselves, If they are too different from the System of Reference, the knowledge acquired in the game will not easily be transferred to the System of Reference.
A game where the game mechanics are much more distant and different than the effective system of reference will be much less well integrated. For example a game about managing a business (System of Reference) using a game of cards with complex card rules (game mechanics).
Thus, every educational game that is integrated by systemic learning, should pay attention to the correspondence between the game mechanics and the System of Reference.

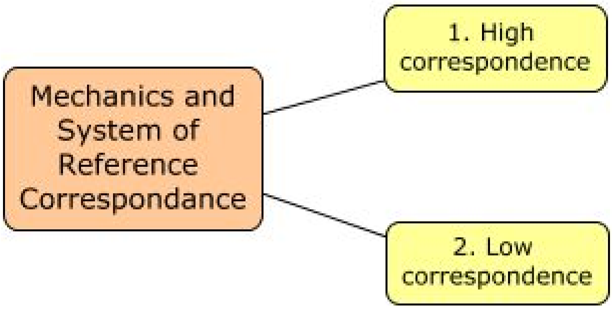


Figure 4: Mechanics and System of Reference Correspondence  sub-category.

### 3. 1. 2. Obstacles

In the case of an articulation by what we call “obstacles”, the goal of the educational game is not necessarily to learn the mechanics themselves, but to arrive at certain moments of the game where in order to continue, the player must select the right option (for example to a question in a quiz) among the available ones. An example of such games is “Tree Frog”, a side-scrolling game where a frog jumps around the levels, avoiding lava pits and other hazards, and at specific moments the player needs to jump at the correct location of a chain that blocks the passage, depending on the fraction displayed on the screen, for example if the fraction displayed is ½, the frog must jump at exactly half the chain. The flow of the game, where the frog has to jump avoiding falling into danger zones, is “interrupted” and the obstacle is presented. In such a game, the obstacles themselves is where the player learns the learning content.

Once it has been established that the game that is being evaluated integrates its learning content using “obstacles”, a binary choice has to be made regarding whether the learning and the testing phase are temporally close enough or are completely separated.
A game where the learning phase is very much temporally separated from the testing phase is a game where the gameplay is clearly divided between a moment where the player consults a certain learning material (for example reads text about the subject) and then answers questions or selects the right answer among several options.

An example of a game where testing phase and learning phase tend to be more simultaneous is a game where the player learns as he plays, for example a game where experimenting with different choices allows the player to progressively learn the material. Clearly, a game where learning phase and testing phase tend to be simultaneous is much better integrated.

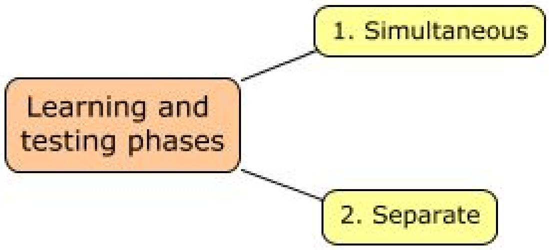


Figure 5: Learning and testing phases  sub-category.

Another binary choice that the framework requires in order to classify the game, relates to whether the content of the “obstacles” is something that requires reflexive processes by the player (“elaboration”) or if it’s a content that needs to be blindly recalled from memory (“recollection”).

For example a classic quiz game where the player has to memorise information (such as “how many protons does an atom of hydrogen have?”) and then choose the correct answer out of the available options (“1”, “2”, or “3”) has to be classified as “recollection”, whereas a game where the “obstacle” requires the player to go beyond simple recollection from memory will be classified as “elaboration”. Clearly, the “elaboration” is a much better game design choice and is conducive to a much better integrated game, where the player is much more active in the gaming experience as opposed to passively recall information.

This distinction can be reminiscent of the difference between learning facts vs learning skills, but this is not exactly the case. For example, we could have a game integrated with obstacles by elaboration that targets learning of facts (a game where a detective has to resolve small mysteries (the obstacles) with inductive reasoning) or that targets learning of skills (an obstacle in a game where the player needs to move his body in a particular way depending on the environment to practice a complex motor skill).

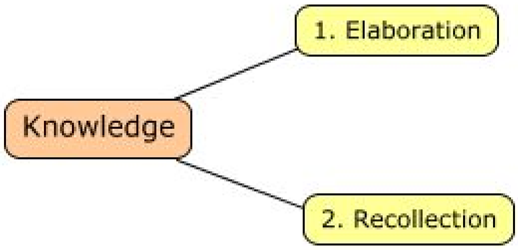


Figure 5: Knowledge  sub-category.

### 3. 1. 3. Winning Strategies

An integration by winning strategies is a type of integration where what is supposed to be learned by the player are not the mechanics themselves (such as in systemic learning), but one or more strategies that require the knowledge targeted in order to reach the goal of the game, as opposed to other available strategies that allow the player to reach this goal but that don't require the knowledge targeted by the game. In these type of games, the goal is supposed to be well defined so that it is clear in the mind of the player.

Once the goal of the game is understood, the player is supposed to try out different strategies that are available (by trial and error for example)in order to reach said goal, and only the strategy (or strategies) that require the knowledge targeted by the game are qualified as a success in the game.

The game must be very careful to not allow other types of strategies that don't require the knowledge targeted by the game to be qualified as a success, otherwise the player will "win" without actually acquiring the learning content that is supposed to be acquired through the pedagogical game.

Ideally, such games should provide an environment that offers guidance to the player so that he can find the right strategies that require the knowledge targeted by the game in order to reach the goal. Feedback that informs the player on the validity of a strategy just employed is therefore needed, and such feedback should avoid as much as possible judgements in terms of correct or wrong “answer”, but instead try to motivate the player to choose a different strategy in the most subtle and natural way possible.

### 3. 1. 4. Central and peripheral game mechanics

Another important aspect when evaluating the degree of integration of a game is whether the mechanics related to the learning content (systemic learning, obstacles, etc.) constitutes the main mechanics of the game or simply peripheral mechanics where the majority of the time the game offers ways to interact with the game that have nothing to do with the learning content.

For example a game that is based on learning the mechanics in a game of cards (systemic learning) and how the various elements interact between each other in a game about the variables affecting climate change ($CO_2$ emissions, energy supply, etc.) can be developed with the idea that the majority of the time these are the mechanics of the game's (central mechanics). On the other hand, the game could be developed in a way where these mechanics only appear at certain moments in the game and the majority of the time the player is doing something else, like earning money in the game to spend it later. In this case, the mechanics the player will use most of the time (earning money) are not the ones related to the learning content (learning about the various elements affecting climate change).

The most extreme example of questionable game design choices in this regard are games such as “King of Kings” (a game for the old Nintendo Entertainment System (NES) about learning facts about the Bible) that integrate the learning content by obstacles (with quizzes where the player has to choose the correct answer) where the majority of the time the player is jumping on platforms like in Super Mario (a mechanic that has nothing to do with the learning content).

In this case, the game is clearly divided in two very distinct phases, one for the “fun” elements (the platforming gameplay) and one for the learning content (the quizzes about the Bible). The game could be integrated in a way in which the quizzes (possibly designed in a different way) could be the mechanics that the player uses the majority of the time. This game design choice would make for a much more efficiently integrated game.

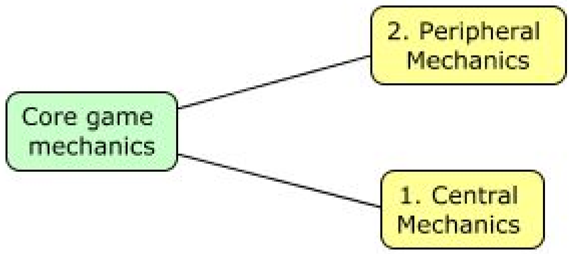


Figure 6: Core game mechanics sub-category.

### 3. 1. 5. Difficulty

The difficulty in the game is an important aspect of Game Design, more precisely, the parameters in the game that define its difficulty. For example a parameter of the game “Tetris” is the speed at which the blocks fall from the top of the screen, which increases as the time spend playing increases. In regards to serious games, the parameters of the game can be related to the learning content, or put into the game only in order to make the game more fun only. For example in a game where it is not necessary to respond quickly, adding a time limit will not be useful to the goal of the educational game, which is to teach the player the learning content. It might make the game more entertaining and engaging, but in that case changing the difficulty of the game will not really allow the participant to learn the content more efficiently. An example of a serious game where the difficulty is completely unrelated to the educational goal of the game is “Ice Flows”, a game where the player learns about the variables influencing the thickness of the Antarctic ice sheet, such as the temperature and the frequency and strength of snowfall. The player can directly change the value of such variables at any time (thanks to bars at the side of the screen) and observe the effect of the thickness of the ice sheet. The goal of the game is to change the thickness so that a series of penguins can reach fish for food in the water. After each level, the difficulty increases, by adding more fish in the water and giving them higher speed, so that the player has to constantly change the values of the temperature and the strength of the snowfall for the penguins to reach more fish. In this case, the parameters that control the difficulty in the game (quantity of fish, speed of the fish, distance between fish and penguins) will not give the player a new perspective on the learning content, they are there only to make the game more fun.

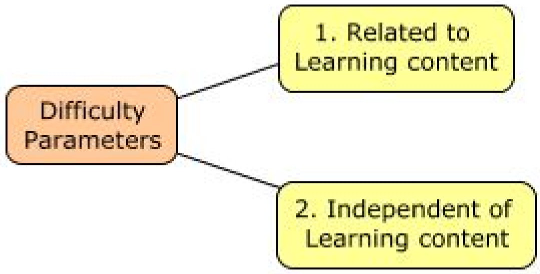


Figure 6: Difficulty Parameters sub-category.

### 3. 1. 6. Progression

Progression refers to the mechanism by which new game mechanics or new elements of the game mechanics are introduced as the game progresses. For example, in the game “Lightbot”, a game that introduces the notion of “functions” in programming. The player has to select the correct sequence of commands for the protagonist to reach its destination, for example “ahead one step”, “turn right”, “ahead one step”. The idea is that you can select one procedure and loop it several times. The game progressively introduces different mechanics after each level, for example after a while the game introduces the idea of a loop of actions that can be repeated in order to reach the goal within the limit of number of actions possible. The progression of the mechanics as the game progresses can be related to the learning content or not. For example, a serious game could progressively introduce new mechanics that have nothing to do with the learning content. Ideally, the game should offer new mechanics that allow the player to understand the learning content better as the game advances, a game design choice that makes for a much better integrated game.
To cite an example of effective integration at the level of the progression, we can cite “Ice Flows” once again. The game teaches about the variables influencing the thickness of the Antarctic ice sheet. At first it allows the player to manipulate the value of the temperature variable, so that he can observe the effects on the ice sheet thickness right away. After a few levels, the game introduced the same concept of manipulating the value of a variable but in regards to a second variable, the strength of snowfall. The player will therefore need to adjust his strategy in order to account for the introduction of this new component of the game mechanics, and observe how the two variable act together to determine the thickness of the

ice sheet. These new component of the game mechanics therefore allows for a better understanding better the learning content targeted by the game.

Once it’s established that the progression helps the acquisition of the learning content, there is another binary choice according to the framework. The first (called “Nested Progression”), where the old game mechanics are integrated with the new ones. For example a game for patients with Alzheimer's Disease to practice their short term memory, where they first learn to pick certain ingredients in a groceries from a list they were previously suppose to learn by heart, and later have to assemble in different way (mix, blend, cut, etc.) to form recipes. The previous mechanics (picking certain ingredients from the groceries store) are being integrated into the new mechanics (learning different ways to assemble ingredients to form a recipe).

This “Nested” approach is also based on the idea that the old mechanics are practiced every time the new mechanics need to be utilised, so that learning of the previous mechanics is constantly improved. An example of a “standard progression” (not nested) would be of a game that introduces new mechanics or components of the mechanics as the game progresses but in a way where mechanics are not practiced in conjunction, usually abandoning previous mechanics in favor of the new ones.

An example of such a game is “Simple Machines”, a serious game that tries to teach kids the principles of simple machines (like inclined planes, wedges, or levers) by a series of simulation exercises. This excellently designed game is divided in different sections and each one teaches the player about a specific type of simple machine, so that as the game progresses, new mechanics or components of the mechanics are introduced. However, once the mechanics related to the a simple machine have been practiced and the section is over, the new mechanics in the following sections don’t include the previous ones. For example, during one of the last sections about cogwheels, it would have been interesting to include previous mechanics already practiced, (such as the ones related to a catapult), in order to keep practicing the previous mechanics.

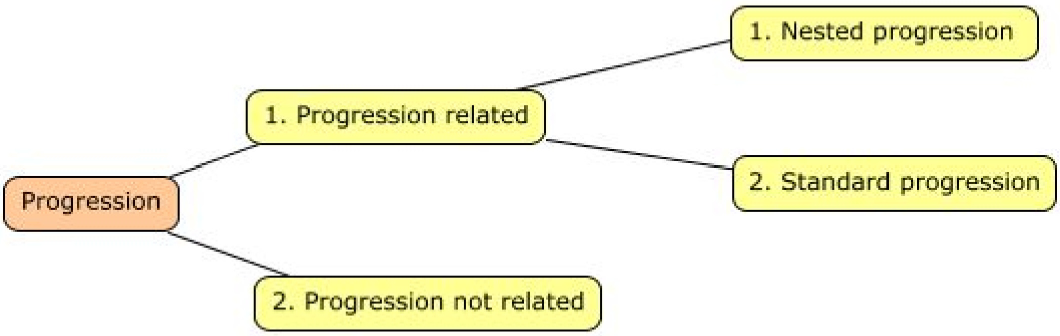

Figure 7: Progression sub-category.

## 3. 2. Media and Context:

### 3. 2. 1. Story, Fictional World, Images

Other than the mechanics, a game includes what we call the "Context" (such as the story of the game, or its fictional world) and the "Media" (the graphics, the sound).
This section will be dedicated to these two elements, and how well a game can integrate its learning content within these aspects of a game.
First of all, regarding the "Context" of a game, we have the "Story" and the "Fictional world". The story of a game refers to the narration, the unfolding of the events with a beginning and an end (such as a love story that ends in tragedy), whereas the fictional world refers to the spatial context these events take place (such as "ancient Greece" for example).

The fictional world can have elements that are related to the learning content or a fictional world completely unrelated to the educational material targeted. In the literature this type of integration has been called "Intrinsic (or "endogenous") Fantasy", versus the opposite, an "Extrinsic (or "exogenous") Fantasy" (Malone, 1981).
As the literature suggested, it's much better to build a game by "Intrinsic Fantasy" than "Extrinsic Fantasy", so this game design choice will raise the final integration score according to the framework.

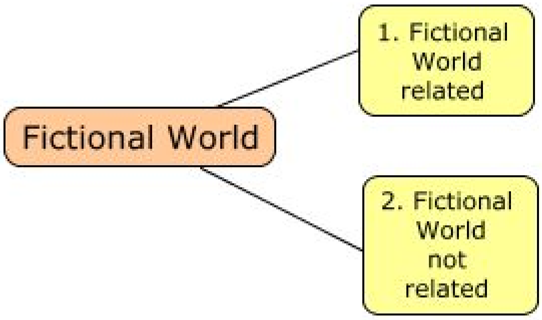


Figure 8: Fictional World sub-category.

In Similar ways, the Story can be related or not related to the learning content, with the former option begin the best to increase the final integration score according to the framework.

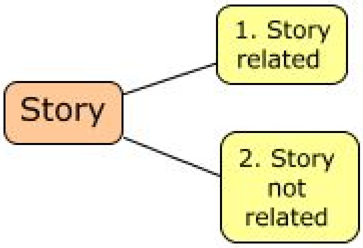


Figure 9: Story sub-category.

Then we have what we call the specific “images” in the game that are supposed to convey the educational material.
These “Images” in the game can be of two types. First, a representation of an object (which can be a 2D representation or a 3D one, animated or still), for example images of an atom or a black hole. The other type is in text form, for example a textual explanation of the functioning of an atom or of a black hole.

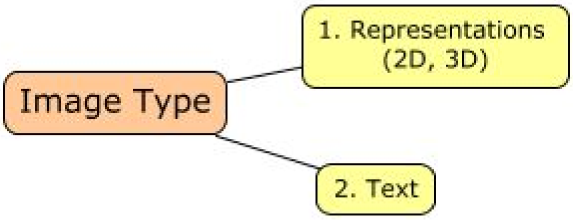


Figure 10: Image Type sub-category.

These "Image" elements can be put in the game as "Mandatory" elements (the game requires the player to watch/read them or learn about them), or "Optional", such as "pop-ups" that can be opened and read if the player desires to, but that are not necessary to the progress of the game (such as in the game "Versailles"). The "Mandatory" game design choice being the one that is best regarding integration in a game, since the game takes more steps (than a game with predominantly optional images) to makes sure that the player acquires or at least comes into contact with the learning content.

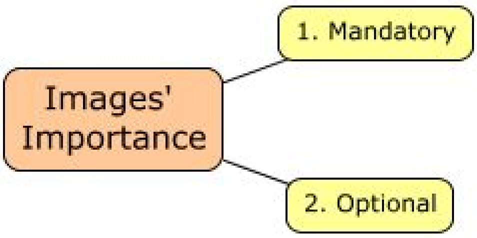


Figure 11: Images' Importance sub-category.

In order for the learning content to be properly integrated into a game, it is advisable that the educational material is disseminated into as many aspects of a game as possible (story, fictional world, images), but always keeping in mind that the mechanics should remain the main focus.

# 4. The Learning Outcomes Questionnaire:

## 4. 1. How it works

In order to establish the learning outcome of the game that is being analysed, so that the weighting of each framework element for the final score can be chosen, the learning outcomes questionnaire must be administered.
In the case of an expert analysing a game and wanting to evaluate it, the questionnaire needs to be filled by the student himself. In the case of the framework being used to help game development, the questionnaire can be filled by the corporate sponsor of the game, in the design phase. Once the learning outcomes have been determined, the developers can start to create the game knowing in advance what kind of integration to pay attention to so to adjust the development process and prioritise on certain ideas or tasks and on resource allocation. For example, if the learning outcomes questionnaire shows that the game has primarily “Motor” outcomes, the developers will need to look for an articulation between the game and the learning content that is more focused on the mechanics and to difficulty, as opposed to giving more importance to the story of the game.
The questionnaire is composed of 8 items on a Likert scale from “Strongly Disagree” (-2) to “Strongly Agree” (2). The items are divided based on the type of learning outcome, and its sub-components. The “Cognitive” learning outcome is divided in 2 items, 1 that refers to declarative knowledge, and 1 that refer to cognitive skills (like problem solving).
The “Motor” learning outcome is divided in 2 items, the first for acquisition of motor skills, and the second one for compilation and integration of several motor skills.
The “Affective” learning outcome is divided in 2 items, the first that evaluates whether the primary goal of the game is to change the player’s attitude, the second one if the primary goal is to increase the interest of the player for the domain of the game.
Finally, the “Communicative” learning outcome is divided in 2 items, the first one that evaluates whether the game requires communication and cooperation skills, and the second one refers to the ability to negotiation abilities.

Each item is coded numerically based on the participant’s answers (for example “Agree” = 1), and the score for each learning outcome is the sum of the scores for all its items.
For each learning outcome type, there can be a positive or negative score, and if the score is positive, that means the game targets that learning outcome type. For example if the final

score for the “Motor” learning outcome is “3” and the final score for “Communicative” is “-4”, this means that the game targets motor skills but not communicative skills.

The idea of using this questionnaire is that each pedagogical game primarily targets one of these learning outcomes, so that the game that is being evaluated targets the learning outcome that receives the highest score.
Each game should have one type of learning outcome stand with the highest score, If one or more learning outcome received the same score, the developers or the expert evaluators will have to choose which is the primary learning outcome among the ones with the same score targeted by the game, with a more careful consideration of the game’s goals.
Once established the primary learning outcome target, each learning outcome has a specific weighting of each framework element for the final score of integration (which will be determined thanks to the “Guide questions” questionnaire).

## 4. 2. The items for the Learning Outcomes questionnaire

Here are the items of the Learning Outcomes Questionnaire.

*(1) What the player has to learn can be described in textual form and it’s explicit (such as a list of ingredients for a recipe or facts about a subject, as opposed to the skill of playing with a ball).*
*Yes (cognitive)*
*No*

*(2) the player learns what he is supposed to learn by solving problems, learning new strategies.*
*Yes (cognitive)*
*No*

*(3) thanks to the game, the player learns to better move his body in real life.*
*Yes (motor skills)*
*No*

*(4) thanks to the game, the player better learns how to perform several body movements in real life at once, in a synchronised fashion*

*Yes (motor skills)*

*No*

*(5) The main goal of the game is to change the player's attitude towards the subject of the game (such as change his attitude about recycling)*

*Yes (affective)*

*No*

*(6) The main goal of the game is to increase the player's interest towards the subject of the game (such as increasing the player's interest in politics)*

*Yes (affective)*

*(7) What the player learns has to do with social skills. The player learns to communicate more effectively with other players or characters in the game*

*Yes (communicative)*

*No*

*(8) The player learns to better negotiate or compromise when communicating with different characters or players in the game*

*Yes (communicative)*

*No*

### 4. 3. The weighting of each element of the framework depending on the learning content

Here are the 4 different ways of weighting each framework element, based on the primary learning outcome of the game that is being evaluated:

## 4. 3. 1. Primary learning outcome targeted: Cognitive

For a game where the primary learning outcome targeted is of cognitive nature, an integration by systemic learning gives the highest amount of points, and a game with an integration by winning strategies receives a higher score than a game integrated by obstacles, winning strategies being a more efficient way to integrate learning content (Szilas & Acosta, 2011).
In a cognitive learning outcome, difficulty and progression are also important, and definitely more important than aspects such as the story or the fictional world. For these reasons, more points are awarded if the game has difficulty parameters and a progression of the mechanics that is related to learning content, compared to whether the story and fictional world are relevant to the learning content.

## Mechanics:

**Obstacles**: (3)

Knowledge:
-Elaboration (2)
-Recollection (0)

Learning and testing phases:
-Simultaneous (1)
-Separate (0)

**Systemic learning (7)**:

Mechanics and System of Reference correspondence:
-High correspondence (3)
-Low correspondence (0)

Necessity of learning:
-Learning required (4)
-Learning not required (0)

**Winning Strategies: (7)**

Learning mechanics:
-Central mechanics (3)
-Peripheral mechanics (0)

Difficulty:
-Difficulty related to learning content (2)
-Difficulty not related to learning content (0)

Progression:
-Progression related to learning content (2)
-Progression not related to learning content (0)

Progression related to learning content:
-Nested progression (1)
-Standard progression (0)

### Media:

Images:
-Representations (2)
-Text (0)

Images:
-Mandatory (1)
-Optional (0)

### Context:

Story:
-Related to learning content (1)
-Not related to learning content (0)

Fictional World:
-Related to learning content (1)
-Not related to learning content (0)

## 4. 3. 2. Primary learning outcome targeted: Motor

For a game where the primary learning outcome targeted is of motor nature, the types of integration around the mechanics are clearly the one that awards the most amount of points, considering that other aspects such as the story and fictional world are going to play less of a role than for other learning outcomes, such as affective.

Systemic learning, Winning strategies, Obstacles as well as aspects such as the difficulty are the ones that awards the most amount of points. Very few points are awarded for aspects such as story or fictional worlds, because rarely these will be awarded and are not as relevant as the other factors.

## Mechanics:

**Obstacles**: (7)

Knowledge:
-Elaboration (1)
-Recollection (0)

Learning and testing phases:
-Simultaneous (3)
-Separate (0)

**Systemic learning**: (6)

Mechanics and System of Reference correspondence:
-High correspondence (2)
-Low correspondence (0)

Necessity of learning:
-Learning required (2)
-Learning not required (0)

**Winning Strategies: (10)**

Learning mechanics:
-Central mechanics (2)
-Peripheral mechanics (0)

Difficulty:
-Difficulty related to learning content (4)
-Difficulty not related to learning content (0)

Progression:
-Progression related to learning content (1)
-Progression not related to learning content (0)

Progression related to learning content:
-Nested progression (1)
-Standard progression (0)

### Media:

Images:
-Representations (0.25)
-Text (0)

Images:
-Mandatory (0.25)
-Optional (0)

### Context:

Story:
-Related to learning content (0.25)
-Not related to learning content (0)

Fictional World:
-Related to learning content (0.25)
-Not related to learning content (0)

## 4. 3. 3. Primary learning outcome targeted: Affective

For the affective learning outcome, mechanics start to become less important than the other aspects that are supposed to convey the learning content, such as the images in the games, the story, the fictional world, since the primary goal of the game is to increase the motivation and interest for a particular domain (such in science in general) or to change the attitude of the player on a specific topic (such as recycling, or the importance of climate change).

## Mechanics:

**Obstacles**: (1)

Knowledge:
-Elaboration  (2)
-Recollection (0)

Learning and testing phases:
-Simultaneous (1)
-Separate (0)

**Systemic learning**: (3)

Mechanics and System of Reference correspondence:
-High correspondence (1)
-Low correspondence (0)

Necessity of learning:
-Learning required (1)
-Learning not required (0)

**Winning Strategies: (4)**

Learning mechanics:
-Central mechanics (4)
-Peripheral mechanics (0)

Difficulty:
-Difficulty related to learning content (1)
-Difficulty not related to learning content (0)

Progression:
-Progression related to learning content (1)
-Progression not related to learning content (0)

Progression related to learning content:
-Nested progression (1)
-Standard progression  (0)

## Media:

Images:

-Representations (5)
-Text (1)

Images:
-Mandatory (5)
-Optional (1)

### Context:

Story:
-Related to learning content (4)
-Not related to learning content (0)

Fictional World:
-Related to learning content (4)
-Not related to learning content (0)

## 4. 3. 4. Primary learning outcome targeted: Communicative

In a game that targets "communicative" as the primary learning outcome, a more balanced weighting of the points awarded needs to be considered. In this case, the mechanics are important, the difficulty and progression are not to be forgotten, and the story and fictional world need to support the goal of a game. These are usually types of games where a social component can be inserted, such as a game that requires other players to participate (multiplayer).

### Mechanics:

**Obstacles**: (2)

Knowledge:
-Elaboration (1)
-Recollection (0)

Learning and testing phases:
-Simultaneous (1)

-Separate (0)

**Systemic learning**: (2)

Mechanics and System of Reference correspondence:
-High correspondence (2)
-Low correspondence (0)

Necessity of learning:
-Learning required (2)
-Learning not required (0)

**Winning Strategies: (4)**

Learning mechanics:
-Central mechanics (3)
-Peripheral mechanics (0)

Difficulty:
-Difficulty related to learning content (3)
-Difficulty not related to learning content (0)

Progression:
-Progression related to learning content (3)
-Progression not related to learning content (0)

Progression related to learning content:
-Nested progression (1)
-Standard progression (0)

## Media:

Images:
-Representations (2)
-Text (1)

Images:
-Mandatory (1)
-Optional (0)

## Context:

Story:

-Related to learning content (6)
-Not related to learning content (0)

Fictional World:
-Related to learning content (6)
-Not related to learning content (0)

# 5. The “Guide Questions” Questionnaire:

## 5. 1. How it works

Once the primary learning outcome targeted by the game has been determined by the Learning outcomes questionnaire, it is time to classify the game based on the framework itself using the “Guide questions” questionnaire.
The questionnaire is composed of 15 items, each one evaluating a different component of the framework (“systemic learning”, “obstacles”, the “difficulty” and so on). The items are questions where 2 or 3 possible answers are available that will determine whether the game is to be classified to either binary option for each element (for example, whether the difficulty in the game is classified as “Related” or “Not Related”).

The final result will be of two types. First, a result that will indicate to what types of integration the game belongs to, without any reference to an actual numerical score.
The second one will be a numerical score that will represent a quantitative evaluation of the game design choices related to the integration between the game and the learning content.
To each game design choice (for example “obstacles where learning phase is simultaneous to its testing phase”). will be awarded a set of points, according to the weighting of each framework element for each primary learning outcome targeted (for example a “motor” learning outcome).
The final score will indicate to what degree the game evaluated is efficiently integrated.

Score lower than 10 = Very poor integration

Score between 10 and 14 = Limited integration

Score between 15 and 19 = Good integration

Score between 20 and 30 = Very good integration

Score higher than 30  = Perfect integration

Each game being evaluated should target one main type of integration by its mechanics (Systemic learning, Winning strategies, Obstacles), if more than one are included, (for example Systemic learning + Obstacles for a game that has both at different moments) the items of the questionnaires will make sure that the only the primary type of integration is taken into account.

In case of a low score for developers of a game, it is relatively easy to look at the framework to see the binary choices made for the game that are responsible for the low score and to try to improve each framework element specifically. For example, if a game is classified as “Difficulty not related to learning content”, the developers should ask specifically how difficulty parameters can be better chosen so that they relate to the learning content and favour its acquisition for the player, and so on for each element of the framework responsible for a low score.

## 5. 2. The Items for the “Guide questions” questionnaire

Here are the items for the “Guide questions” questionnaire:

Item for Central/Peripheric Mechanics:

*(1) “during the game, the majority of the time is spent having fun without learning, and then at certain moments the game changes and wants to teach you something.”*

**-True, the majority of the time i’m playing “for fun” without learning what i’m supposed to learn (PERIPHERIC)**

**-False, the majority of the time the game teaches me something about what I’m supposed to learn (CENTRAL)**

*Item for Obstacles mechanics:*

*(2) “the majority of the times, the player learns because at certain moments the player needs to select the correct answer among the possibilities in one way or another”*

**-Yes, the majority of times that’s how the player learns (OBSTACLES)**

**-No, that’s not at all what the game does**

**If you answered “No”, skip the next two questions and go to question 5.**

**If you answered “Yes”, skip questions 5, 6, 7, 8.**

Item for simultaneous/non simultaneous learning for obstacles:

*(3) The game can be divided by two main phases. A learning phase, where he learns the material, and another where the player needs to select the correct answer among the possibilities in one way or another.*

**-Yes, the player learns the material, and then selects the correct answer at another time. (NOT SIMULTANEOUS)**

**-No, the player learns at the same time that he has to select the correct response. (SIMULTANEOUS)**

Item for elaboration/recollection in obstacles

*(4) “When the player needs to choose the correct answer among the available ones, he is just remembering the correct answer, not much thinking is required to elaborate an answer, he just needs to remember it”*

**True, he recalls the correct answer from memory (RECOLLECTION)**

**False, he actually needs to think about the answer, elaborate information, and think about the problem or question he has to answer (ELABORATION)**

Item for Systemic learning mechanics:

*(5) “what the player is supposed to learn are the mechanics of the game itself, for example he learns the dynamics of war by playing a World War II simulation. He learns that certain elements in the game have an effect on certain other elements by playing the game (for example increasing civilian casualties will have an effect on the troops’ morale and motivation)”.*

**-Yes, the player learns the mechanics themselves, learns about the effect on certain elements by modifying other elements (SYSTEMIC)**

**-No, that’s not how the game teaches the player what he is supposed to learn**

**If you answered “No”, skip the next two questions and go to question 8.**

**If you answered “Yes”, skip question 8.**

Item for required/not required acquisition of the learning content in systemic learning:
*(6) “the player can arrive at the end of the game without really having understood the things he is supposed to learn”*
**-Yes (NOT REQUIRED)**
**-No, the player cannot really finish the game without having really learned what he is supposed to learn (REQUIRED)**

Item for High/low correspondence between the mechanics and the System of Reference:
*(7) “What the player effectively learns in the game, can be easily translated into how he actually has to use in real life (for example a simulation of a therapist, trying to interact in the same way that he would in real life, as opposed to a complicated game of cards about politics that doesn’t actually translate well into real life voting)”*
**Yes, what the player learns in real life is pretty straightforward and will easily be translated into what the player actually has to use in real life (HIGH CORRESPONDENCE)**
**No, in order to teach the player what he has to learn, the game uses a system that will not make it easy to translate what he has learned in the game into real life (LOW CORRESPONDENCE)**

Item for winning strategies mechanics:
*(8) “The game gives feedback during the game so that the player chooses the correct strategy (or series of actions) that requires to know what the game wants you to learn”*
**-Yes, the player explores the game trying different strategies, until he finds the correct one that requires to know what the game wants the player to learn (WINNING STRATEGIES)**
**No, that’s not how the game works**

Item for Intrinsic/extrinsic fantasy:
*(9) "the game is set in a world that has nothing to do with the content the player is supposed to learn (for example a game about the French Revolution set in a Super Mario World)"*
**-Yes , the fictional world the game is set in doesn't seem to be that much related to what the player is supposed to learn (EXTRINSIC FANTASY)**

**-No, the fictional world the game is set is very much related to what the player is supposed to learn (INTRINSIC FANTASY)**

Item for story related/not related to learning content:
*(10) "in the game, the story (the narration, the unfolding of the different events) has not much to do with what the player is supposed to learn (for example a game about learning how to perform a reanimation on a subject with a cardiac arrest, with a love story as the background of the game)"*
**-Yes, the story in the game doesn't have much to do with what the player is supposed to learn (STORY NOT RELATED)**
**-No, the story in the game is very much related to what the player is supposed to learn (RELATED)**
**-There is no actual story in the game (STORY NOT RELATED)**

Item for difficulty related/not related to learning content:
*(11) "The factors that make the game difficult or easy (like the number of enemies in a first person shooter, or a time limit in a quiz game), help the player to learn what he is supposed to learn (for example the number of clients that is raised after each level in a bartender simulation game, will help the player learn how to better deal with a crowded restaurant in real life)"*
**-Yes, the factors in the game related to its difficulty level help the player learn what he is supposed to learn (DIFFICULTY RELATED)**
**-No, what makes the game difficult of easy has nothing to do with what the player is supposed to learn (DIFFICULTY NOT RELATED)**

Item for Progression related/not related to learning content:
*(12) "As the game advances, new game mechanics are progressively introduced, each one helping the player what he is supposed to learn"*
**-Yes, new game mechanics are progressively introduced (PROGRESSION RELATED)**
**-No, that's not how the game works (PROGRESSION NOT RELATED)**
**If you answered "No", skip the next question**

Item for Nested/not Nested progression:
*(13) "These new mechanics that are progressively introduced, do they integrate each other so that the new mechanics require the old mechanics (for example a game for medicine*

*students about learning to how to operate a patient's brain, where the first levels are about learning to use an operating machine (first mechanics learned), while the latter levels require you to use that machine to effectively operate a patient's brain (new mechanics that integrate previous mechanics))*

**-Yes, the new mechanics integrate the previous ones (NESTED PROGRESSION)**

**-No, the mechanics that are introduced are independent from the ones before (NON NESTED PROGRESSION)**

*Item for Text/Representation Images:*

*(14) "A lot of the times, the content the player is supposed to learn in the game is in text form (such as an explanation on how an atom works), rather than with actual images, such as illustrations, animations, 3D objects"*

**-Yes, for the most part, the content is in text form (TEXT)**

**-No, there are many illustrations, animations, 3D objects, etc (REPRESENTATION)**

*Item for Mandatory/Optional Images:*

*(15) "For the most part, the text of images the player is supposed to learn in the game are "optional", meaning that the player can decide to open them or read them (like a pop-up) but it is not necessary to do it to continue in the game"*

**-Yes, the content in the game are to be access as an option for the most part (OPTIONAL)**

**-No, it is necessary to access and process this information to continue in the game (MANDATORY)**

## 7. An Example of analysis: Climate Challenge:

As an example of classification of a pedagogical game we can make in order to exemplify the framework is the serious game "Climate Challenge" described in section dedicated to systemic learning.

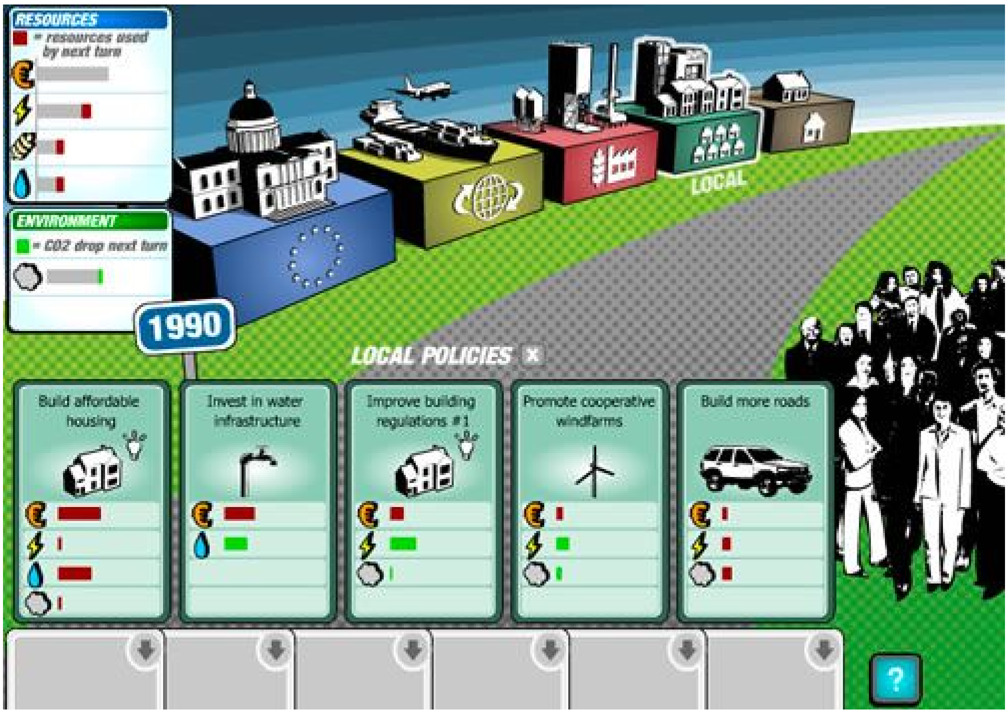


Figure 12: The cards in Climate Challenge

First of all, The game clearly targets a cognitive learning outcome, since it is supposed to convey the difficulty of enacting policies to tackle climate change, the variables, industries, challenges that are involved, and a notion of "sacrifice" and "compromise" between different factors (the player cannot maximise his monetary budget, CO2 emissions reductions and chances to get reelected at the same time). Therefore, in order to calculate the points for this game, the cognitive learning outcome sheet needs to be used.

Regarding the mechanics, the game is integrated by Systemic learning (8 points), with a good correspondence between the mechanics and the System of Reference (4 points), since the variables, type of choices and compromises in the game are realistic and very much indicative of the real policies that are enacted by countries trying to tackle the problem of climate change. Regarding the Necessity of Learning parameter, the game doesn't require the player to necessarily learn, understand the learning content (0 points), since he can finish the game using the same strategy, cards, with the game not making sure that the learning content is actually conveyed once the player arrives to the end of the game.

Regarding the Learning mechanics parameter, the game mechanics related to the learning content are clearly Central and not Peripheric (3 points), since at all times the mechanics of the game are very much related to what the player is supposed to learn.

When it comes to the Difficulty of the game, Climate challenge's difficulty parameters are related to the target CO2 emission reduction, the amount of resources the player has to acquire in order to use a particular card, and so on. The difficulty of the game is thus related to the learning content (2 points).

Regarding the Progression in the game, Climate Challenge introduces all variables and mechanics on the table since the beginning, in a way that at after each turn, new mechanics related to the learning content are not introduced (0 points)

When it comes to the Media of the game, the game employs Representations related to the learning content (2 points) and the learning material is clearly mandatory in order to play the game (1 points).

Finally, the Story (the struggle of a president to make certain choices in order to reduce CO2 emissions, get reelected, create prosperity) and Fictional world (a future Europe potentially devastated by climate change) are both related to the learning content (2 points)

The final score for Climate challenge is 22, which puts it in the "Very Good" category.

The elements that could give the game an even higher score are Necessity of Learning (the game could allow the passage to the next level only if some conditions are respected) and Progression (the game could insert the different variables (energy, money, CO2 emissions, and so on) progressively after each level, with each level adding a different variable to be taken into account).

# 7. Discussion and Conclusions:

In this work I conceived a framework that is supposed to unify the relevant literature concerning the notion of integration between the game and the learning content in educational games. The current literature is often contradictory and incomplete and I tried to fill the gaps introducing new concepts while at the same time anchoring my propositions to ideas already explored by the relevant authors in the field.

The general consensus on this topic is that game mechanics are much more relevant when it comes to integration than other aspects such as the fictional world or text into the game. Although partially correct, this approach forgets that many successful educational games, in addition to integrating most of the learning content in the mechanics, do not forget the role of other aspects such as what Habgood (2005) calls the “production values” of the game (such as the graphics, the fictional world, the story etc.).

My framework therefore tries to link all these different elements while at the same time giving more weight to some of them (such as the mechanics).

The framework also includes the notion of learning outcomes (the type of learning content, such as a list of notion to learn by heart or motor skills) with the idea that certain games that target certain learning outcomes more than others, need different standards when evaluating their type and degree of integration. The Learning outcomes questionnaire is a standardised tool that can be used to assess the primary learning outcome targeted by the game, so that the weighting of each framework element to the final score of integration can change as a function of this primary learning outcome targeted.

In order to categorise and give a score to the game, a standardised questionnaire (the “Guide questions” questionnaire) is administered. This questionnaire is supposed to serve as a guide to students who are learning about the notion of integration (and who are having some difficulties with some of the more abstract and less defined concepts), and to developers who are developing an educational game that tries to have a good degree of integration. Developers can use the tool during both the design phase (in order to make some game design choices while discarding others), and development phase.

The questionnaires offer outputs that are both categorical (they specify the type of integration used in the game) numerical (a final score of integration that also depends on the learning outcomes targeted).

The framework tries to be an operational and unifying tool to analyse the notion of integration in pedagogical games, but more efforts will need to be made in order to improve it.

For example, as already stated, the framework takes into account the primary learning outcomes targeted by the game (which will determine the weighting of each framework element to use in order to calculate the final integration score for the game). However, the framework could also integrate other relevant variables, in order to make the final score more personalised for each game, such as the type of player targeted. For example, the BrainHex questionnaire (Nacke, Bateman, & Mandryk, 2014) tries to categorise gamers in different categories, such as the Seeker, the Survivor, the Daredevil, the Mastermind, the Conqueror, the Socialiser, the Achiever.

A future framework could include these categories administering one of such questionnaires alongside the learning outcomes questionnaire in order to adjust the weighting of each framework element that will determine the final integration score.

Other contextual factors can include the long term or short term nature of the learning content that is supposed to acquire, and so on.

The current framework and its questionnaires will also need to be validated. For example, with inter-rater reliability analyses. The goal of such analyses would be to confirm that different subject completing the questionnaire effectively agree on the results for a specific game and to what degree.

This kind of analysis can be used not only in order to validate or not the framework and its questionnaires, but to investigate which specific items of the questionnaire produce more or less concordance between subjects completing the questionnaires. For example we could find that for items of the “Guide questions” questionnaire related to the game mechanics offer excellent accordance between subjects filling the questionnaire, whereas items related to elements such as the Story, the Fictional World or the Images, show a lot more disagreement between subjects.

Such disagreements could lead a more refinement of these components of the framework, either in the framework itself, or in the questions of the questionnaire.

Another way to validate the framework and its questionnaires would be to use them to predict certain objective measures such as learning efficacy and motivation. The overall goal of developing a game that is better integrated is to improve its efficiency in these domains. For example, we could use a list of pedagogical games and rank them using the integration scores using the “Guide questions” questionnaire, and investigate whether the highest ranking games actually are the ones that produce better learning or more motivation in the eyes of target players. Otherwise, we could use a similar experimental design of the one used by Habgood (2005). Habgood compared a version of Zombie Division (a game he created for this purpose) in two versions, one with intrinsic integration (where the math problems had to be solved using the game mechanics and during the “fun” part of the game itself) and one with extrinsic integration (one in which the math problems were administered at the end of every level) and he compared the learning efficiency and ability to improve motivation for each version of the game.

He observed that the intrinsic integration version improved the motivation to play but resulted in similar learning efficiency.

In a similar way, it would be useful to compare two version of the same game based on specific elements of the framework (such as a version for “difficulty related to learning content”, and another version for “difficulty not related to learning content”), and compare these two versions in terms of learning efficiency and motivation.

Such experimental designs could be used to test whether the elements of the game actually predict better acquisition of the learning content (and motivation) targeted by serious games, and for which ones.

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