Key criteria for Game Design

A Framework

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Introduction

A new culture of Learning

A huge body of studies focuses on youth digital culture and illustrates a wide consensus: new media are altering how youths learn and socialize (CEFRIO, 2011; Ito et al., 2008; Lenhart et al., 2008). Thus, a new culture of learning is emerging (Thomas & Brown, 2011) and teachers face a new audience, engaged in gaming, multitasking and social networking (Jenkins, Clinton, Purushotma, Robison, & Weigel, 2006). As a result, a growing gap separates youth digital culture from the mainly academic school culture.

Within this context, many voices have claimed for a renewed pedagogy for the 21st century citizen (Serres, 2011) and in a recent report, the European Commission advocates for conceptualizing creativity and innovation as transversal and cross-curricular skills (Cachia, Ferrari, Ala-Mutka, & Punie, 2010). Meanwhile, Game-Based Learning is now considered as an alternative pedagogy adapted to new learners, a strategy for embracing change (Crawford, 1982; Shaffer, Squire, Halverson, & Gee, 2005; Thomas & Brown, 2011; Williamson, 2008) and different initiatives have been taken to promote the uses of serious games in schools or universities (Wastiau, Kearney, & Van den Berghe, 2009).

Game: from artifact to situation

The word *game* has been used for concepts related to very different contexts such as sports, arts or entertainment and there are many definitions for this term. Following Caillois (Caillois, 1958), Brougère (Brougère, 2005) two main criteria emerge to determine if a situation is a game or not. The first criteria is that a game is a model of a real situation, a meta-activity. The second criteria is that the player is allowed freedom, he is allowed to take decisions (autonomy criteria). Other criteria identified by Brougère result from the two previous ones. The freedom to take decisions is limited by norms and conventions shared by the players (rules criteria). Moreover, as a game is not a real situation, the consequences of the play are minimized (frivolity criteria). In addition, even if the results of the play depend on the player's decisions, uncertainty always remains in regards to the ending (incertitude criteria). This set of criteria is valuable in distinguishing Game-Based-Learning situations from Problem-Based-Learning and Project-Based-Learning that are different, but close, educational settings.

The expression "serious games" was probably first introduced by Abt (Abt, 1970) to name a game as a "context" that has an "*explicit and carefully thought-out educational purpose and [is] not intended to be played primarily for amusement*". Since then, the expression has been widely spread to name computer games designed for applications aiming at "serious" purposes such as advertising, recruiting employees, training staff and learning. This term has multiple meanings but it is mainly used to name computer games designed for utilitarian objectives. Nevertheless, there are arguments advocating the adoption of a broader point of view and for considering

games as contexts (Steinkuehler & Duncan, 2008) or situations (Sanchez & Jouneau-Sion, 2010) rather than artifacts; from this stems the possibility of merely focusing on the interactions that emerge from the situation, rather than on the game itself. Mitgutsch (Mitgutsch, 2007) argues for a similar point of view and refutes the term Digital Game-Based Learning in favour of Digital Play-Based Learning to emphasized the role of the interactions within the situation.

Game-Based Learning: underlined theoretical assumptions

Game-Based learning is grounded on a Piagetian point of view of learning and most games are based on a constructivist approach. In this paradigm, learning is considered to be adaptive. Thus, the learner/player incorporates the game experience into an already existing framework, while reframing his mental representations to fit new experiences. There is a strong link between the problem to solve, the challenge to face and the knowledge to acquire, said knowledge being then considered as an instrument to master the situation (Balacheff, Cooper, & Sutherland, 1997). Game-Based Learning is also based on serendipity. Indeed, a game offers the opportunity to make fortunate discoveries while the learner/player is looking for something unrelated by inhabiting a virtual world where actions are driven by exploration. As a result, learning is situated (Lave, 1988) and allows for the bringing together of the elements of cognition (conceptual experience and knowledge), perception (perceptual knowledge and interactions) and action (factual knowledge and actions) (Sanchez, Ney, & Labat, Forthcoming). Furthermore, playing a role leads the player/learner to strongly identify with his character. Thus, he benefits from an immersive experience within the game. At the same time, the avatar is a "*mirror to reflect on his or her own values and choices*" (Jenkins, et al., 2006) and allows him to see "*the virtual character as one's own project in the making* " (Gee, 2003).

Aims & purposes

This paper aims to provide a framework for game design and game implementation. It is based on a review of the literature about Game-Based Learning. The following paragraphs focus on five key criteria - both adapted from Malone & Lepper (1987) and from a personal previous work (Sanchez, 2011; Sanchez, Delorme, Jouneau-Sion, & Prat, 2010; Sanchez & Jouneau-Sion, 2009) - that need to be taken into account to implement a Game-Based Learning approach in the classroom. The original grid (Annex 1, p 12) summarizes these criteria.

1. Motivation

The main point generally discussed in the Game-Based learning literature is the power of serious games to motivate students. Indeed, there is no doubt that games fit the expectations of most students, as they are widely used for entertainment. The power of games to foster motivation and involvement is described by the concept of *flow* (*i.e.* the highest degree of motivation by "*being completely involved in an activity for its own sake*" (Csikszentmihalyi, 1990). Motivation should also be linked to the concept of conation (*i.e.* the act of striving to perform at the highest level) (Reeves, 2011).

Self Determination Theory (Ryan & Deci, 2000) offers a framework to identify the game characteristics that foster student motivation. According to Ryan & Deci (*Ibid.*), motivation results from different universal and innate needs, which include the need for competence, for autonomy, and for relatedness.

The feeling of competence increases when students have to reach clear goals and get positive feedback. By playing a serious game, the learner/player takes decisions that are motivated by his consciousness of the situation rather than the teacher's expectations (Ahuja, Mitra, Kumar, & Singh, 1995). It is essential that the game provide frequent feedback allows the learner/player to recognize his achievements. Moreover, the level of difficulty needs to be adapted to the skill of the learner/player (Malone & Lepper, 1987), but can be increased as the learner/player meets success (Mayo, 2009). This dimension raises a core question, called adaptation, as an important feature that allows to individualize the game experience (Hocine, Gouaïch, Di Loreto, & Abrou, forthcoming).

Autonomy entails the freedom to make choices, to take decisions and to choose a strategy. Autonomy results both from the willingness of the learner/player to accept the challenge embedded in the game and to feel responsible for solving the problem, while remaining free to take decisions. This freedom is framed by the rules of the game, which are a set of norms and conventions that have to be respected. They both allow and limit freedom. Therefore, according to Vygotski, "in play the child is free. But this is an illusory freedom" (Vygotski, 1966).

The need for relatedness entails competition and "*game worlds are meritocracies*" (Reeves, 2011). Earning points, getting badges or accessing the next level can play an important role in sustaining motivation. However, competition is only one of the facets of the game. The success often results from the ability to collaborate. In Massive Multiplayer Online Games (MMOG) players ally together to face difficult challenges that cannot be solved individually. In addition,

using a digital platform to connect students fits with their habits for being involved in online networks and can fulfil their need for interaction.

2. Content

As a meta-activity, a game is a model of a given situation and simulating a part of the world allows the player to explore a physical or human situation of this world (Egenfeldt-Nielsen, 2006). The model implemented in the game results from the transposition of a real situation (a situation of reference) into the context of the game. Therefore, this embedded model is a set of concepts and values selected by the game designer and not reality itself. As a result, games can be considered as metaphors of reality, similar to simulations and microworlds. In addition, the simulation's validity is limited (domain of validity) and one of the main arguments underlined by teachers who don't use computer games for their teaching is the lack of relevance of the content and its inadequacy regarding the situation of reference (Kirriemuir & McFarlane, 2004). Indeed, there is a risk in encouraging students *"to get used to manipulating a system whose core assumptions they do not see and which may or may not be 'true'"* (Turkle, 2005). For example, the knowledge implemented in *Spore* - a very successful video game- is clearly based on intelligent design theory. *Spore* does not respect the Darwinian conception of evolution, as *Spore* allows the player to act as an intelligent designer by creating new life forms, choosing their characteristics and making them evolve in a way that results from their decisions. *Spore* is mainly used for leisure and amusement, but some teachers employ the game to teach intelligent design (Sanchez & Prieur, 2009). However, it is worth noting that Spore is also used by teachers who teach Darwinian theory (*Ibid*.). In this case, the game experience is followed by a debriefing session to help students deconstruct the model and compare it to recent and scientific theories. This example shows that game adoption for learning purposes is not a direct consequence of the relevance of the content.

However, the relevance of game content is an important issue to address. A "good game" is anchored in the real world. A game ought to be a credible representation of the domain of interest and ought to encompass the appropriate knowledge (Reeves, 2011). Regarding games about sustainable development, one can say that most of them offer a model too elementary to permit the students to understand the complexity of the subject. For example, by playing with *Lachez-prise*[1] children can discover some "good habits" for environment protection, but the game does not give any information about how these habits impact the environment. One easy way to meet the objective addressed by *My 2050 World*[2] is to multiply the number of nuclear power stations and to increase the area devoted to biofuel production. The side effects of this strategy on environment pollution or food availability are neglected and the game doesn't mirror the complexity of the problem. Other games are more sophisticated, but the model

[1] http://www.lachezprise.qc.ca
[2] http://my2050.decc.gov.uk/

embedded in the game stays elementary. For instance, in *Ecoville*[3] the challenge consists in building a "green city", but the social dimension of the question is mainly neglected. On the contrary, *Voyage au bout du charbon*[4], allows the player to be immersed in the life of Chinese coal workers. The game focuses on the human aspect of the problem and far less on environmental issues. Thus, teachers or students ought to be informed that each game depends on the knowledge, values and decisions of the game designer and that the choices made may impact both the player strategies and the knowledge that he is supposed to develop about the situation modelled by the game.

Another important issue that must be addressed is the link between content and gameplay (Habgood, 2007). Games are said to be intrinsic if core game mechanisms (gameplay) and learning content are integrated (*i.e.* the required knowledge to succeed in the game is the goal of the learning). In an extrinsic game, content and gameplay are separated (*i.e.* the game entails alternate phases of play and school-like exercises). In his doctoral work, Habgood (*Ibid.)* demonstrates that the intrinsic version of a game has a significantly better impact than the extrinsic one. Thus, integrating the learning content of the game within the structure of the game sounds important.

3. Freedom, rules & feedback

As a core characteristic of a game (Brougère, 2005), freedom is one of the most important elements that should be fostered by the game designer. Freedom means that the player/learner is allowed to take decisions and to shape his own strategy. Freedom is based on the assumption that children are bearers of expertise. Thus, empowering students to think like designers, to organize themselves within the game and to express their own creativity makes them autonomous and capable of acting in the role of experts (Kirriemuir & McFarlane, 2004).

As a counterpart to freedom there are rules. Rules are a set of norms and conventions shared by the players that limit freedom. Even if rules are arbitrary, they need to be acceptable according to the beliefs of the learner. (*i.e.* the learner/player is not asked to act in an improper way). They need to be relevant regarding the model embedded in the game (*eg.* a player is asked to act according to his character in a role play game) and clear (*i.e.* the rules are easy to learn).

There are two challenges to face when children have the opportunity to exert their freedom. The first challenge is not confusing them with too many options. Indeed, "*with the right level of control in […] games, players will feel that they are the makers of their own fortunes*" (Habgood, 2007). The second challenge is providing appropriate feedback. The learner/player needs to get the opportunity to assess his strategy by himself and then decide if a decision that was made or

[3] http://www.ademe.fr/particuliers/jeu2/ADEME/ECOVILLE-2
[4] http://www.lemonde.fr/asie-pacifique/visuel/2008/11/17/voyage-au-bout-du-charbon_1118477_3216.html

a given action that was enacted within the game was relevant or not. The concept of *didactical milieu* of Brousseau's Didactical Situation Theory (DST) (Balacheff, *& al*., 1997) is crucial to understanding the role of feedback in a game.

According to Brousseau (*Ibid.*), knowledge can be considered as an instrument for dealing with situations. Thus, knowledge emerges when a learner interacts with a *didactical mili*eu (*i.e.* a set of physical, social and symbolic elements within the learning environment). A didactical milieu encompasses all the elements of the situation that the learner deals with during his activity. If the feedback provided is regular, the learner can anticipate. Then, he can take into account the consequences of his actions and adapt to the situation by applying a new strategy if needed. Therefore, interaction is crucial and a game can be considered to be a space of reflexivity (Sanchez & Jouneau-Sion, 2010) where the learner/player faces a challenge and can autonomously deal with the situation. His autonomy results from the freedom to take initiative in the game and the possibility of evaluating his/her past decisions and chosen strategies according to the provided feedback. Thus, games entail an embedded assessment used by the player/learner for recognizing achievements and failure. Feedback depends both on the model implemented in the game and on the rules of the game. Thus, the learner/player adapts his actions and learns how to behave according to the game constraints.

4. Mistakes, failure & emotional aspects

Frivolity is another core dimension of games (Brougère, 2005). The learner/player can make mistakes without real consequences and he is encouraged to continue trying (Gee, 2003). As actions or decisions do not impact the real world, play occurs in a safe space where the learner/player feels secure. Therefore, learning occurs without anxiety. Moreover, as a "*projective identity*" (*Ibid*.) the avatar allows one to project one's values and desires and endorses mistakes and failure. Nevertheless it is important to avoid punishing the learner/player for things out of his control. (Habgood, 2007)

On the other hand, the frivolity of a serious game is not always well established and the involvement of students can have unexpected consequences. As described in a previous article concerning a study concerning a game about land use management (Sanchez & Jouneau-Sion, 2009), students published their proposals online for the location of a railway loop designed to test a high speed train. Real citizens concerned by the location chosen by the students posted violent and tragic reactions on the website to protest. This example shows that the borders between the game world and reality are sometimes blurry; it is the responsibility of the teacher to make them clear and, therefore, to keep the frivolity of the game.

The power of serious games also results from the fact that they allow for the consideration of the emotional aspect of the intersubjective experience of learning: humour, quality of graphical environment, social interactions, self-confidence, fantasy, curiosity (Malone & Lepper, 1987),

success and rewards (Habgood & Overmars, 2006) are extremely important for maintaining a player's interest in a game's challenges. All these elements can enhance positive feelings and foster arousal. It has been claimed that this emotional aspect has an effect on the cognitive processes of attention, memory and decision-making (Damasio, 1996) and Game-Based learning offers the opportunity to take this into account. However, some educators are reluctant to introduce amusement into their teaching practice as there is a long tradition that opposes work to play.

5. Game integration in the learning process

Research in Game-Based Learning demonstrates that students do not develop declarative knowledge without reflection and debriefing (Garris, Ahlers, & Driskell, 2002; Habgood, 2007; Sanchez, forthcoming), which emphasizes the importance of the teacher, as the knowledge developed by using the game is mainly implicit. The role of the teacher is thus crucial in helping students become aware of the implicit knowledge that they use in a specific situation in order to solve a specific problem. This step is called debriefing (*Ibid*.) or "after action review" (Aldrich, 2009). Brousseau uses the term institutionalization (Balacheff, *& al*., 1997) for signifying that the teacher is responsible for pointing out that the contextualized and personal knowledge used for gaming is universal and scientific. Egenfelt-Nielsen summarizes this point by noting that "*if the players are not aware of the learning elements, this will undermine the learning experience and, especially, the transfer value. The transfer has to be made explicit, and here the teacher can play*" (Egenfeldt-Nielsen, 2006).

Another point to take into account to implement a Game-Based Learning approach is that children themselves are often reluctant to consider that gaming can foster learning (Egenfeldt-Nielsen, 2010). Game *vs* work, fun *vs* learning, freedom *vs* control... the paradox remains for the player himself. Thus, Game-Based Learning meets an important challenge: game designers and teachers have to succeed at preserving the entertaining aspects of the game with their primary goal remaining the learning itself, as opposed to that of making learning fun. Indeed, to underline the failure of edutainment to keep the fun of gaming, some attempts at transforming academic exercises into serious games have been named "*sugar coating learning*" (Egenfeldt-Nielsen, 2003) or "*chocolate-covered broccoli approach*" (Bruckman, 1999). Keeping the fun in gaming implies making a clear distinction between the time devoted to play, which should be a real immersive experience without constraints or real consequences, and the time devoted to preparing the game or debriefing. Thus, it is the teacher's responsibility to make the borders of the game explicit, to help the students enter and leave the game.

Conclusion - Ensuring acceptability, usability & utility

According to Tricot & al. (Tricot, Plégat-Soutjis, & Camps, 2003) three dimensions ought to be taken into account to insure the effective use of technologies for an educational context. The same criteria can apply to the introduction of a Game-Based Learning approach.

Acceptability is the first dimension. It relates to the individual or collective mental representation of the value of a technology. The adoption of a game depends on how the students, the teachers and the institution evaluate the added value of the game for the learning process. It is necessary to keep in mind that children and teachers are often reluctant to consider that gaming can foster learning (Egenfeldt-Nielsen, 2007). Moreover, "*serious games are still perceived, designed and positioned in a way that hinders broad adoption*" (*Ibid.*).

Another dimension is usability, which reflects the possibility of using the game in a given learning context. Usability depends on the quality of the interface and the suitability of the game according to technical and pedagogical considerations. For example, the lack of time available to teachers to familiarise themselves with the game and the methods of producing the best results from its use are crucial aspects (Kirriemuir & McFarlane, 2004).

The third dimension is the utility criteria, which is more focused on didactical aspects (*i.e.* the impact of the game on the learning process). It depends on the tasks performed by the students and the relevance of these tasks according to the expected learning outcomes.

A second grid (annex 2, p 13) indicates different elements that relate to the three above dimensions. It is partly based on the work of (Aldrich, 2009). The grid can be used to assess a game and to make sure that no key element is left out. It is worth noting that some elements are contradictory. For example, increasing the level of fantasy can lead to a decrease in the level of acceptability for teachers. Therefore, the quality of game design results from a balance between conflicting aspects. In addition, it is important not to focus on the artifact itself, but on the way the artifact is implemented in the classroom (Mitgutsch, 2007). Therefore, the reflection about a game should take into account the learning context in which the game is implemented.

Annex 1: Key criteria for Serious Game Design

1. Motivation - competence

		0	1	2	3	4	5	
1.1	Goals: unclear							Goals: clear
1.2	Level of difficulty: too high or too low							Level of difficulty: adapted
1.3	Ignorance of achievements							Constant awareness of achievements
1.4	Non motivating challenge							Motivating challenge

2. Motivation - autonomy

2.1	Narrow array of choices and decisions							Wide array of choices and decisions
2.2	Strategy is imposed by the game							Strategy can be chosen

3. Motivation - relatedness

3.1	No competition							Competition
3.2	No rewards							Rewards
3.3	No collaboration							Collaboration

4. Content

4.1	Non relevant							Relevant
4.2	Not suited to the learning objectives							Suited to the learning objectives
4.3	Not adapted to the curriculum							Adapted to the curriculum
4.4	Extrinsic							Intrinsic

5. Freedom, rules & feedback

5.1	No freedom							Freedom
5.2	Level of control: too high or too low							Level of control: adapted
5.3	Unclear feedback							Clear feedback
5.4	Non acceptable rules							Acceptable rules
5.5	Unclear rules							Clear rules
5.6	Non relevant rules							Relevant rules

6. Mistakes, failure & emotional aspects

6.1	Mistakes are not permitted							Mistakes are permitted
6.2	No feeling of security							Feeling of security
6.3	No projective identity							Projective identity
6.4	No humor							Humor
6.5	Game environment : unattractive							Game environment : attractive
6.6	Game environment : not user-friendly							Game environment : user-friendly
6.7	No fantasy elements							Presence of fantasy elements

7. Game integration

7.1	Beginning of the game: not clear							Beginning of the game: clear
7.2	End of the game: not clear							End of the game: clear
7.3	No debriefing							Debriefing

Annex 2: Acceptability, usability & utility

1. Acceptability (students, teachers, institution)		0	1	2	3	4	5
1.1	The content is relevant (no errors)						
1.2	The content fits the expectations of the students						
1.3	The content fits the characteristics of the students (age, prior knowledge…)						
1.4	The content fits the curriculum						
1.5	The time devoted to play fits the school timetable						
1.6	The game price is reasonable						

2. Usability (ergonomy, technology, pedagogy)							
2.1	The game installation is easy and not time-consuming						
2.2	The game runs on school devices (or students' personal devices)						
2.3	The game fits the school communication infrastructure (firewall…)						
2.4	The time devoted to learning how to use the game is reasonable						
2.5	The game provides guidance and affordance						
2.6	The game provides clear and relevant feedback						
2.7	Adaptability to the school context						
2.8	The teacher can access the scores or logs of the students						
2.9	Help is available for both the students and the teacher						

3. Utility (didactics)							
3.1	The game is suited to the pedagogical objectives of the teacher						
3.2	The tasks of the students within the game are relevant						
3.3	By playing, students improve their knowledge						
3.4	By playing, students develop relevant competencies						

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