Games and Simulations: theoretical underpinnings

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Summary: Based on the hypothesis that inconclusive research results with regard to the impact of games and simulations are linked to the absence of clear concept definitions, a systematic research literature review of articles published over the last five years was undertaken to fill this methodological gap. The subsequent research article analysis allowed for the identification of the essential attributes of games, simulations and simulation games. This abbreviated paper presents the methodology adopted, the analysis grid used, the databanks developed and a detailed description of essential game and simulation attributes.

INTRODUCTION

The purpose of this research study is to advance a discipline by sketching out theories and practices and by assessing them or modifying them as need be (Gauthier, 2003). To do so, it was necessary for the researchers to identify what is of particular interest to other researchers in the scientific community and what has led to well-established conclusions. This explains why one of the fundamental stages in the longitudinal research project called SAGE *(Simulation and Advanced Gaming Environments (SAGE) for Learning)* involves the elaboration of an inventory of all research available on games, simulations and simulation games. This literature review had several objectives: (1) establishing an abstract distinction between educational games, simulations and simulation games; (2) building and assessing a common multidimensional taxonomy; (3) bringing to light the educational impacts of games, simulations and simulation games on learning and (4) targeting the relevant variables for the development of educational game and simulation prototypes which will be tested with a health-related clientele.

This short paper first describes the methodology which underlies the systematic review of the articles, the analysis grids and the documentary databanks analyzed. Then, we shall discuss the description of essential game and simulation attributes.

1. METHODOLOGY

To conduct this systematic literature review, we used the "current state of knowledge" method which consists of "[…] a complete, exhaustive and as critical as possible review of the specific papers on the problem which one wants to process (it is, in fact, a review of the main research on the same subject)" (Aktouf, 1987: 55). Our procedure consisted of first conducting an extensive and exhaustive research for articles (more than 1,500 were found) on educational games, simulation games and simulations. Then, we analysed the summaries to select articles (amounting to more than 250) which dealt with the abstract foundations of

educational games, simulation games and simulations. Then we proceeded to analyse the articles using a textual analysis grid.

This semi-open analysis was based on the essential attributes of educational games, simulation games and simulations which were selected during the literature review undertaken by Sauvé and St-Pierre (2003). The grid was validated by the triangulation method (Lincoln and Guba, 1985) which insured data reliability control. The researchers then proceeded with a data validation operation consisting of testing several texts which had been analysed by research assistants until a higher than 80 % match was obtained and any differences in coding were minimal, thereby satisfying the standard research design requirements.

Building the computerized knowledge databases was done from Internet site searches and from the following bibliographical databases: Eric, Francis, First search education, Ariane, Tecnedoc, Emile, Current Contents, Repère and MedLine. The documentary and Internet searches were done using the following keywords: jeu, simulation, jeu de simulation, game, simulation and game, simulation gaming, simulation, éducation, apprentissage, learning, education. Articles published between 1998 and 2005 were analysed and were added to those already listed in previous studies.

2. GAMES

The essential game attributes uncovered are the following (Sauvé *et al.*, 2005):

- A **player** is an individual or **players** are a group of individuals who are put in a position of assuming a role or of making decisions within a game context. A game cannot work without at least one player (Griffiths, 1997) or several players (Gosen and Wabush, 1999). An individual can play only against him- or herself (in which case we would speak of a competition against oneself where the purpose is, for instance, to win the perfect match, to improve on one's score from one match to the next, etc.), or one can play with others (which would lend the game a cooperative character) or one can play against others or against the computer (which would lend the game a competitive character). Although the number of players may vary from one to infinity, there is usually either a prescribed number of players or a variable number of players within a given range. Several studies also describe the characteristics of players and teams and the impact of such on learning.

- **Conflict** is represented in games by dynamic, human- or computer-controlled obstacles which prevent a player or players from easily reaching his/her/(or) their goal. Obstacles must be active, even "intelligent", to create conflict and may, minimally, provide the illusion of reacting to player action (Kasvi, on 2000). Conflict also includes the notions of struggle, competition and challenge which motivate the players to maintain their gaming role and to make decisions. Struggle is often used as a synonym for conflict and is defined in the same sense. In games such as Chess, Monopoly, Bridge, etc., a struggle or competition exists between players or between teams. Competition is present as much in single-player games (which require that a

player improve his or her performance from match to match) as in team games (which require that one team be first in winning the game). In solitary games, conflict takes the form of a confrontation between the player and luck (Solitary, crap games, roulette, etc.) or between oneself and another player who uses a decision algorithm such as the computer. Finally, a challenge occurs when player action provokes an opponent's reaction, thus creating a competition or a struggle (Krierriemur and Macfarlane, 2004).

Cooperation emerges when players ally themselves against other players in order to reach a common goal. Always present in team games, group tasks are required (Gray *et al* ., 1998) which are governed by rules. In team games, levels of cooperation and competition vary and must therefore be moderated by rules to make sure that all team members master the contents. For example, in the Earth Ball game, players are challenged by certain obstacles or difficulties which can only be overcome by the pooling of player resources.

- **Rules** are a set of guidelines, being either simple or complex, which describe the relationships existing between players and the game environment. These guidelines specify the extent and the nature of allowable player action and they establish the sequence and the structure according to which participant actions may take place (Topping and Ehly, 1998). Rules perform three types of functions (Thiagi and Stolovitch, on 1980). Procedural rules describe the game components, that is, the number of players or the number of teams, the role of each of the participants, their activities and the move or moves that can be made. Game-over rules govern how the game is won and specify the results as well as the limits expected from each player (Thiagi, 1998). Control rules describe the consequences for players who do not follow the previous rules (Martin *et al* ., 2002). For example, a player who makes false accusations is excluded from a detective game.

Brougere (1999) states that rules are either the result of an external regulation which is accepted by players or the result of an agreement or a negotiated settlement between players which the game seeks to promote. In any case, rules must be clear, organized, complete, pre-set and accepted by all players before starting a game. Without such pre-set rules for and recognized rules by all players, a game becomes a playful activity where one or several players are free to create their own rules or modify them according to their whims and/or game progress (de Grandmont, no date). However, in a growing number of electronic games, players are called upon to deduce the rules through play, thus adjusting their decision-making as their understanding of the stakes involved in the game increases.

- The p**redetermined goal of a game** refers to the end of the game and to the notion of victory, winning or reward (Salopek and Jennifer, 1999). It indicates how the game ends and, for educational games, it includes the objectives which the player(s) seek to attain. It is governed by rules which determine (1) who wins and, often, who loses, (2) when and how the game can end. These rules may also specify time limits as well as points accumulation limits leading to success or elimination. The desire to reach this goal affects choices made by players during a match. According to game type, this may involve overcoming an opponent or opponents by competing in skill and

craftiness with him/her/or them, or by triumphing over chance or overcoming an obstacle in the aim of winning, of being victorious or of being rewarded.

- The **artificial character** of games refers to two rather different notions according to the authors consulted. For Sauvé and Chamberland (2003), it is a fictitious activity without reference to reality (for example, the Tic Tac Toe game) or that escapes the usual standards which apply to reality. In this sense, Bingo or card games do not refer to reality. It is through immersion in such a fictitious situation that a player can experience a fun, unreal and sometimes even absurd dimension. If the limits of reality were applied, the activity would no longer be a game. Garris *et al.* (2002: 240) refer to this fanciful aspect which they define a constructed environment as "mental, physical or social images which do not exist". This attribute is not unanimous in the research community. Several authors tend to omit defining game attributes which allows them to include the notion of reality (Crawford, 1984; Eyraud, 1998; Kasvi, 2000). Hoewever, some authors might qualify such as being simulation games.

- **The potential for promoting learning**. An activity is thus a game when it possesses the attributes described previously, as is the case of chess. Regularly playing chess makes us better at it but it does not, for that matter, make chess an "educational" game. De Grandmont states that a game which is not used in an educational or a didactic context is a game for fun. Essentially, the purpose of an **educational** game is only implicitedly centred on learning since it is hidden from the player and the notion of pleasure which it engenders is rather extrinsic whereas the purpose of a **didactic** game is clearly focused on the duty of learning and it is explicitly identified as such, appealing to the intrinsic pleasure of performance. In both cases, games have to contribute to learning which we define as a process of new behavior or knowledge acquisition through the influence of interaction with one's environment. According to the authors consulted, learning by games translates into the acquisition of new knowledge, the transfer of learning, the development of intellectual skills (abstraction, anticipation, strategy-building, problem-solving, lateralization, spatial representation, function-movement relationships), the development of behavior and attitudes, etc.

3. SIMULATIONS

The following are the essential attributes of simulations (Sauvé *et al* ., 2005):

- A **model of reality defined as a system**. A model is first defined as an abstract or concrete representation of a real system in which components are clearly defined. Such a model is based on reality as defined by the perception which an individual has of a system, an event, a person or an object. Such perceptions of reality differ from one individual to another. Milrad (2002) states that a model which supports learning has to feign real situations and provide feedback to participants which will allow for an improved knowledge of reality. Reality can take on several forms but, as for the concept of simulation, it generally reproduces a dynamic system (Arthur e*t al* ., 2002).

- **A dynamic model**. Swanson and Ornelas (2001) explain that a critical factor which differentiates a simulation from other types of models is that simulations copy the essential elements of reality in a dynamic model and allow participants to control this reality in order to study it, according to their own desired pace as well as when it is convenient to do so. By definition, a model is static because its components are not designed to be modified. A simulation becomes a dynamic model when it reproduces, to some extent, the behavior of a real system in real-time through the movement of its components. In other words, there is a manipulation of the model through the combination of individually-selected variables. Any effective simulation places learners in real situations in which they can act and make decisions with the aim of obtaining real-time feedback (Maier and Grobler, on 2000).

- **A simplified model** is defined by the distance between the model of reality which has been produced and reality itself as well as the introduction of a degree of abstraction necessary for understanding the system's functions and inherent tasks (Borges and Baranauskaus, 1998). Garris *et al*. (2002) define this simplification by the incomplete representation of reality but which, nonetheless, reproduces its essential characteristics. These essential characteristics are considered as relevant to the designer to reach set objectives for which the simulation has been built, be it educational or not. Designed to arouse interest in learners or to become a teaching object for a specific purpose, a simulation is thus a mockup of reality, certain elements of which having been removed in order to highlight others.

A reliable, precise and valid model. "Reliablility" is defined as "The degree of similarity between the training situation and the operational situation which is simulated. It is a two dimensional measurement of this similarity in terms of : (1) the physical characteristics, for example visual, spatial, kinesthetic, etc ; and (2) the functional characteristics, for example the informational, stimulus, and response options of training situation". (Hay et Singer, 1989, p.50***).*** Garris *et al*. (2002) add to that definition structural validity, i.e. processes which appear in the simulation, as well as its value in predicting reality given the degree of psychological realism in the simulation. From the point of view of learning, Claudet (1998) states that simulations reproduce situations, dilemmas and actors who participate in them as realistically as possible in order to provide learners with the opportunity to put into practice and to transfer their experience in a "quasi-real" situation.

The notion of validity refers to the degree of uniformity and coherence in the environment specifications in comparaison to reality (Garris *and al* ., 2002). Pedgen *et al* ., (1995) state that results obtained by simulations have to be the same as those obtained in the real world with the system serving as a model for the simulation. Although simplified, the model must be precise because the essential function of a simulation is to provide users with a better understanding of reality. This is particularly important in the case of an educational simulation. The notion of precision with which the model represents reality is closely connected to an earlier introduced notion, that of the simplification of reality. Indeed, the simpler a model is, the more it runs the risk of distorting the reality under study. In order to choose the characteristics stemming from the reality which are to be included in the model,

the simulation designer thereby has to determine which phenomena will be reproduced with precision.

- **The potential to promote a better understanding of the model-related reality.** Research in education (including continuing education) has demonstrated that simulations promote the competency development, both basic and complex. For instance, the level of competency required by medical professionals is better acquired in an environment which uses varied examples in a realistic context and which provides educational activities of situations which imitate the real world (Demediatris *et al* ., 1999; Swanson and Ornelas, 2001; Zhu, Zhou and Yin, 2001). Simulations are particularly appropriate in producing such environments because they offer high-level interactivity, strengthen concept and theory acquisistion and place objects or systems within the center of learning (Johnson *et al* ., on 1998; Charrière and Magnin, 1998).

Regardless of the type or size of simulation used, Milrad (2002) asserts that the main purpose of simulations remains offering an environment (1) which promotes the development of mental models in learners; (2) which allows for efficiency testing of the models used to explain or to predict events in a system and (3) which optimalises the discovery of the relationships between variables and the confrontation of divergent approaches.

CONCLUSION

A systematic review of research articles began in March, 2004 to ascertain the current situation with regard to the abstract foundations of games, simulations and simulation games in an educational context. This paper has presented the results dealing with games and simulations.

Upon examination of their essential attributes, it is clear that simulations are not games. A game is a fictitious, whimsical or artificial situation in which players are put in a position of conflict. At times, players square off against one another; at other times, they are together and are pitted against other forces. Games are governed by rules which structure their actions in view of an objective or a purpose which is to win, to be victorious or to overcome an obstacle. A simulation is a simplified, dynamic and precise representation of reality as defined by a system.

In a game, there is always at least one player and one winner but such is not the case for certain simulations which function without any human involvement and which do not aim at winning. When a player or players are involved with a simulation where they interact with simulation components and where the notion of winning and losing is present, then the concept of the simulation game emerges.

A simulation does not necessarily imply conflict or competition and users don’t try to win, which they do when playing a game. If conflict does appear in a simulation as an essential attribute and not as content, the concept of simulation game once again resurfaces. Besides, the value of a game cannot be judged by its resemblance with reality. On the contrary, a simulation is a dynamic and simplified model of reality and it is judged by its realism, by its

correspondence to the system which it represents. A game is created without any reference to reality, which is never the case for a simulation or a simulation game.

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