DISTINGUISHING BETWEEN GAMES AND SIMULATIONS: A SYSTEMATIC REVIEW

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Summary (500 words): 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, research was undertaken to fill this methodological gap by identifying the essential attributes of games and simulations. This paper first introduces the context for our study. This is followed by a description of the analysis grid used to create a database of the literature, and the methodology employed to conduct our systematic review of this literature. The essential attributes of games and simulations are then described and the distinctions between these two concepts are presented.

Descriptors: Game, Simulation, Learning, Education

INTRODUCTION

The research network entitled *Simulation and Advanced Gaming Environments (SAGE) for Learning* (in French, *ApprentisSAGE par les jeux et les simulations*) is a bilingual Pan-Canadian initiative that studies the effects of games and simulations on improving learning through new media, recent technologies and knowledge of how people learn. Through its ten research projects across Canada, the SAGE project will help to better understand and improve learning, make it more engaging, more motivating, more relevant, more fun and accessible to a greater number of Canadians.

SAGE researchers consider it important to establish a common conceptual framework for the various ongoing projects. Similar to conclusions reached by Sauvé (1985), Crookall (1995), Wolfe et Crookall (1998), Jones (1998), Feinstein, Mann & Corsun (2002), Sauvé & St-Pierre (2003), it is clear that the lack of consensus on the terminology used with regards to games and simulations results in contradictory findings about learning. A study of the fundamental concepts (Sauvé et al, 2005) helped establish the essential attributes of games and simulations. During this study, we relied on many articles that were written without really proposing or validating the exact definition of these concepts. Other authors either opted to treat games and simulations as similar activities or proposed conceptual distinctions between a game and a simulation, which are based more on learning than the actual concepts of games and simulations. By essential attributes, we mean the elements that are indispensable and common to all the activities that we define as a game or simulation. This reasserts the importance and relevance of identifying these essential attributes and this article will focuses on this issue.

We first describe the methodology used in our study of fundamental concepts, followed by a description of critical game and simulation attributes.

METHODOLOGY

In our study, we conducted a systematic review of the available literature on the essential attributes of educational games and simulations. To conduct this analysis, we used a triangulation method based on research hypotheses to first create and validate an analysis grid for articles and research reports about the conceptual foundations of educational games and simulations. We consulted many bibliographic databases and the Internet in order to create a corpus for our analysis. We then conducted an audit of bibliographical references to identify the critical attributes and created a knowledge database in which research assistants entered data as they progressed in their literature review. Finally, we synthesized this knowledge database in order to identify the occurrences and establish critical attributes of educational games and simulations. In this section, we will present briefly the first two stages of our methodology.

The design and validation of a textual analysis grid and research reports

Based on an original hypothesis that differentiates the critical attributes of educational games and simulations (Sauvé et Chamberland, 2003), an analysis grid for articles and research reports was developed and validated by the triangulation method which ensured reliability of data coding (Lincoln et Guba, 1985). Then researchers, other than those coding the information, proceeded by counter coding the units and their identifiers for the categories and sub-categories created by the coder. This operation was applied to several articles until a higher than 90% agreement was obtained. More precisely, each time the coding was not identical from one researcher to another, it was discussed in order to understand the points of divergence and to readjust the categories, if necessary. This validation allowed us to establish the relevance of the categories and to refine the interpretation of certain units of meaning to make sure that mutual comprehension was relatively identical.

Once the grid was validated, these units of meaning and their interpretation were transferred, in the form of descriptors, to a relational knowledge database: SAGE-BC, accessible on the Internet. At the date of this article, the knowledge database contained the analysis of more than 450 articles and research reports. SAGE-BC gathers the analysis grids of articles and research reports and can be accessed at: http://www.savie.qc.ca/BaseConnaissances/index.asp?Lang=en.

Consultation of bibliographical databases

To collect articles and research reports, we consulted bibliographical databases by using the following keywords: *game*, *simulation*, *simulation game*, *simulation impact*, *education*, *learning*, *educational game*, *learning game*, *game & experimental*. Articles published between 1998 and today were identified and added to our bibliographic corpus. The compilation of this corpus was developed in two stages.

In 2004, we examined the following bibliographical databases: Eric, Francis, First search education, Ariane These/Mémoire, Tecnedoc, Emile, Current Contents, Repère, MedLine as well as Web sites about games. This first extraction allowed us to identify 1,303 references. From June to December 2005, we examined the following bibliographical databases: Academic search premier, Religion and philosophy collection, Scholar Scholar, Sage Full-text collections, Ingenta, Emerald, Web of Science. This second extraction turned up 481 references that we added to our bibliographical corpus.

In order to analyse the articles and research reports relevant to our research objectives, we established a conceptual framework that helped evaluate the relevance of 1,784 articles identified since 1998. By identifying essential attributes of educational games, simulations and simulation games, we were able to retain 1,063 articles after reading their summaries (abstracts.) Of these 1,063 articles, we found 280 texts to date and rejected 337 articles that did not include activities often identified as an educational game, simulation or simulation game. Many articles and reports focused more on the impact of educational games, simulations or simulation games but they did not define the concepts or identify the critical attributes. In conclusion, the current article is based on the analysis of 98 texts that provided a definition or discussed critical attributes of educational games and simulations.

In this article, we focus more on the critical attributes of educational games and simulations, since not many authors outlined the critical attributes of educational and simulation games. Therefore, in the following sections, we summarize the essential attributes of games and simulations taken from reports of Sauvé et al (2005).

ESSENTIAL ATTRIBUTES OF EDUCATIONAL GAMES

Numerous authors have studied games and have provided a description that defines their essential elements. Through our study of these diverse definitions, five attributes have emerged that encapsule the concept of “game’ (Sauve et al, 2005): player or players, conflict, rules, predetermined goal of the game, and its artificial nature. Since the focus of this research is on educational games, the pedagogical nature of the game provides a sixth attribute.

The player or players

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. An educational game cannot work without at least one player (Griffiths, 2002) or several players (Gosen et Wabush, 1999). An individual can play against him- or herself (in which case we would speak of a competition against oneself where the purpose is, for instance, to play the perfect match, or to improve on one’s score from one match to the next), 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 permitted within a given range. Several studies also describe the characteristics of players and teams and the impact of these on learning.

Conflict/ Cooperation

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 make decisions. Struggle is often used as a synonym for conflict and is defined in the same sense. In games such as Chess, Monopoly, and Bridge, a struggle or competition exists between players or 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 wins the game). In single player games, conflict takes the form of a confrontation between the player and luck (for example, solitare, crap games, and roulette) or between oneself and another player, who may be a computer using a decision algorithm. Finally, a challenge occurs when player action provokes an opponent’s reaction, thus creating a competition or a struggle (Kirriemur et McFarlane, 2004).

Cooperation emerges when players ally themselves against other players in order to reach a common goal. Group tasks are always present and required in team games (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

Rules comprise another essential attribute of games (Jenkins, 2005). 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 (Gray et al, 1998). Rules perform three types of functions (Thiagarajan et Stolovitch, 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 contributions expected from each player (Thiagarajan, 1998). Control rules describe the consequences for players who do not follow the previous rules (Martin et al, 1998). 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 recognized 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, 2004). 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.

Predetermined goal of a game

The predetermined goal of a game refers to the end of the game and to the notion of victory, winning or reward (Salopek, 1999; Dickey, 2005). 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, and (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

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). Some would qualify this as something other than a game, that is, a simulation game.

Educational character or its potential for improving 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 implicitly centred on learning since the purpose is hidden from the player and the notion of pleasure which it engenders is rather extrinsic. In contrast, the purpose of a *didactic* game is clearly focused on the task of learning and that is explicitly identified, 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, and more recently Whelan (2005), 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), and the development of behavior and attitudes. In order for these types of learning to occur, the games must contain the mechanisms to promote them. These mechanisms, which all educational games should have, include immediate feedback, interaction, active participation by the learner, player control of their learning, repeated practice, challenge, motivation, dialogue between players, and teamwork Barnet et al, 2005; Griffin & Butler, 2005; Schwabe & Göth, 2005; Shreve, 2005; Virvou et al, 2005; Ward & O'Brien, 2005). Giordan (1998) and Merieu (2002) assert that these mechanisms allow for the use of a socioconstructivist pedagogy inherent in games that responds to the needs of the new generation of learners.

The "gamer generation" has a cognitive style characterized by multitasking while learning, short attention span during learning, and an exploratory and discovery approach to learning (Asakawa & Gilbert, 2003; Bain & Newton, 2003; Prensky, 2005). During the game, the learner plays first, understands after, and then generalizes in order to apply this learning in a new situation (Saethang & Kee, 1998; Shaffer et al, 2004). These authors, drawing on a constructivist approach, affirm that the learner becomes active during the game and participates in the construction of his/ her knowledge. Oblinger & Oblinger (2005) suggest that games respond to today's adolescents, who have a profile as communicators, intuitive and visual. They have strong visual/ spatial aptitudes no doubt developed through their videogame practice. They prefer to learn through experimentation rather than by direct instruction; they move easily and quickly from one setting or activity to another if the first does not interest them. They respond rapidly to questions and demand a rapid response in return. In brief, young learner expect from their learning" interactivity, interaction, active visualization, kinesthesis, and immediacy.

In summary, the literature reviewd helped us define a game, starting from its essential attributes, as a fictional, fantasty or artificial situation in which players, put in a conflict with one another or against other forces, are governed by rules that structure their actions in order to meet learning objectives and a goal determined by the game (for example, winning, being victorious or overcoming an obstacle).

ESSENTIAL ATTRIBUTES OF SIMULATIONS

In order to identify the essential attributes of simulation, we focused on writers who used simulation to address learning objectives (Sauvé et al, 2005). Four attributes were identified: a model of reality defined as a system; a dynamic model; a simplified model; and a model that has fidelity, accuracy and validity. A fifth attribute can be added to this list: the simulation should address directly the learning objectives.

A model of reality defined as a system.

The model is first defined as an abstract (digital) or concrete (analog) representation of a real system in which the variables are clearly specified and their behaviour around a phenomenon is similar to that of the system being modeled. (Arthur, Malone & Nir, 2002). Reality is generally defined as an individual's perception of a system, event, person, or object. This perception can vary and be interpreted differently across individuals. 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 et al, 2002). Moreover, Cioffi et al (2005) noted that the simulation offers a miniature version of a sphere of concrete activities in real life. Medley et Horne (2005) findings completely agree with our research when they maintain that simulation is a realistic model that can simulate real-life scenarios. Therefore, educational simulation is similar to real life (Martin, 2003; Swanson & Ornelas, 2001) and offers a type of controlled reality, where learners can experiment with aspects of reality that otherwise would be impossible to study outside of real life.

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 & Grobler, 2000 ; Goldenberg et al, 2005).

Simplified model

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 &

Baranauskaus, 1998; Cioffi et al, 2005). Garris et al (2002), Medley & Horne (2005), Hung et al (2005) 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 true, precise and valid model

"Fidelity" 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 & Singer, 1989: 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 et 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.

Educational character and its potential in helping understanding of the model-related reality

Research in education (including continuing education) has demonstrated that simulations promote 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 et Ornelas, 2001; Zhu, Zhou & 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, 1998; Charrière & Magnin, 1998).

Regardless of the type or size of simulation used, Milrad (2002) asserts that the main purpose of simulations remains the offering of 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. Goldenberg et al (2005) and Hung et al (2005) reached similar conclusions as Milrad (2002) in relation to this last objective (3).

Schnotz et Rasch (2005: 48) consider that the educational character of simulations includes two types of functions that are based on a decrease in the cognitive load: enabling function and facilitating function. Enabling function: "If they reduce the cognitive load of tasks in order to allow cognitive processing that would otherwise be impossible, then animations have an enabling function". Facilitating function: "If they reduce the cognitive load of tasks that could otherwise be solved only with high mental effort, then animations have a facilitating function."

In short, the literature allowed us to reassert that simulation is a simplified, dynamic and precise representation of reality defined as a system.

CONCLUSION

Our study focused on the conceptual foundations and distinguishing features of games and simulations. Besides establishing this differentiation, we addressed the essential attributes of operational definitions of these two concepts: games and simulations. By essential attributes, we mean the features that are indispensable and common to all activities that quality as a game or a simulation.

Upon examination of their essential attributes, it is clear that games and simulations are distinctive concepts. 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. They are integrated into an educational context when the learning objectives are associated formally to the content and the game enhances learning in the cognitive, affective and/or psychomotor domains.

On the contrary, simulation is a simplified, dynamic and precise representation of reality defined as a system. 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, what is never the case for a simulation or a simulation game. Simulation is not necessarily a conflict, a competition, and the person who uses it is not looking to win, what is the case in a game.

Simulation is defined as a simplified, dynamic and accurate model of reality that is a system used in a learning context. Through its model, judged by its fidelity and its similarity to the reality it represents, a simulation is distinguished from a game that makes absolutely no reference to reality (although a “simulation game” combines these, and this is the subject of another paper). These attributes of a simulation are essential to its use in addressing educational objectives and to allowing learners to study complex and real phenomena, which is not the case with a game.

Simulation does not necessarily involve conflict or competition, and the users are not trying to win, as they are always doing in a game. Many educational simulations, unlike games, can function without human intervention, for example, the dynamic representation a planetary movement in the solar system.

Even if certain simulations identify one or more “winners” or “losers,” this attribute (inherent in games) is not essential to its definition. All educational games, as distinct from other learning activities, add the notion of winner/loser in a competition. For example, imagine a person who responds to questions and receives points. Once the activity ends, there is nothing to indicate that (s)he has won. All games establish rules that allow the determination of a winner and one or more losers. These are the same rules that provide the challenge and competition in the game. If one or more players participate in a simulation and interact with its various components, the notion of a winner and loser s introduced, this activity defines a new concept of “simulation game.” This concept will be discussed in a later paper.

We wish to underscore that the identification of the essential attributes of “game” and “simulation” is important because this avoids the methodological weaknesses of many studies that we examined during our review of the literature on the impacts of games and simulations on learning. The notable weaknesses are: (1) poor theoretical framework; (2) weak and or deficient methodology (e.g., missing operational definitions of the study variables); and (3) a lack of a connection between the theory and application in the research environment (e.g., often the activity being studied is neither a game nor a simulation).

In closing, we offer the following quotation (Feinstein & Cannon, 2002) that provides the motivation for this literature review:

> This article rises out of frustration, the frustration from reading a wide variety of papers each using words like simulation, game, role playing, gaming, and symbolic modelling either without definition or inconsistency from one work to another.

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