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# A Taxonomy of Educational Games

## **ABSTRACT**

Digital games are a relatively new tool for educators, who often misunderstand their value for education. This is partly since they perceive many very different types of games in the same way. We propose a taxonomy of digital games in education based on the features that are relevant to instructional design and educational research. The taxonomy outlines four genres into which games fall, depending on the cognitive functions and skills they engage. The theoretical basis for the taxonomy we develop draws from R. M. Gagne's Five Categories of Learning Outcomes, Bloom's Taxonomy of Educational Objectives, and D. H. Jonassen's Typology of Problem Solving. The links between these theories and the educational games taxonomy will allow educators and researchers to understand games in the light of their educational affordances. Instructional design based on these theories can more effectively integrate games into the classroom.

## INTRODUCTION

The adoption of digital games in the classroom has met with mixed responses. Educators who are familiar with digital games are often eager to introduce them into instruction, since the power of games to motivate students to engage in an activity is well known (Gee, 2005; Martens, Gulikers, & Bastiaens, 2004). Researchers have also described videogames as a foundation for designed educational experiences (Squire, 2006), ideological contexts for interaction (Young, Schrader, & Zheng, 2006), third spaces in which highly complex, social networks develop (Steinkuehler, 2006) and venues in which authentic mentoring and literacy practices abound (Schrader, Lawless, & McCreery, 2009; Schrader & McCreery, 2007; Schrader & Lawless, in press). However, some stakeholders in the education of young people do not share this enthusiasm, and feel digital games in the classroom might be, among other things, a distraction from learning, a waste of time, a tool for teachers to control behavior, or even an immoral influence (Baek, 2008; Kutner, 2008). This apprehension may be somewhat alleviated if digital games themselves are more easily understood, their various applications were more apparent, and their educational affordances were more obvious.

One step in making computer games more understood by educators is to explicate their value for education. If educators and other adults who are unfamiliar with games were able to learn about them in relation to their educational affordances, it might make using games in the classroom easier for educators, more effective for enhancing learning, and even more motivating for students. We propose a taxonomy of computer games that describes the genres into which educational games fit, together with the aspects of these types that apply to their use in educational settings. By organizing and categorizing educational computer games, we hope to aid educators in their research about both computer games as a domain of knowledge and individual games with which they may come into contact. Additionally, since the technology and, indeed, the names of computer games is constantly changing it is futile to describe individual games and their educational applications. More effective is this development of a taxonomy of game types so that specific games may be recognized more readily for their content, structure, and educational affordances.

It is our hope that our taxonomy will assist educators who wish to use educational games, regardless of their knowledge or understanding of them, to make salient instructional design decisions based on sound educational objectives. We further hope our taxonomy will scaffold research on educational games to promote their use in the classroom. This line of research may well evaluate the specific educational affordances of the game genres outlined in our taxonomy. Such findings may lead to the refinement or extension of this taxonomy, hopefully to the betterment of educational games research.

## BACKGROUND

### Educational vs. Commercial Games

Although many commercial games have educational affordances, the motive of the companies developing them is largely profit. This leads to the entertainment and marketability value of games taking precedence over the educational value. If the profitability of a game is of primary importance, we must question whether it has even come close to meeting its *potential* educational value. Four common features of commercial games can add to their entertainment value and marketability, but are either not desirable in an educational game or must be minimized: chance, critical competition, inappropriate material, and advertising. By “chance,” we mean any aspect of a game in which chance has a major effect on a player’s success. This is particularly important when the success of the students’ learning experience hinges on

their success in the game. Although it is true games of chance are, for many, highly engaging and highly entertaining, we know them to be highly addictive (Clarke, Lawrence, Astley-Jones, & Gray, 2009). Second is the level of competition between players. Although competition can engage players, students may become frustrated when another player is foiling their attempts to advance in the game, inhibiting their level of engagement. Further, the research reports that boys and girls do not demonstrate the same preference for competition. Although the data refer to older games, Kafai (1996) reported that on average more girls than boys prefer cooperative or single player games.

The content of games also calls some issues into question. Inappropriate material includes any references to illegal or immoral behavior, as perceived by the standards of the community. There seems no reason, objectively, to consider such material in direct opposition to the educational affordances of a game. However, the level of distraction it creates and, more to the point, the inability to promote a game for use in schools with such material makes it detrimental to educational games. Similarly, advertising within digital games has become more commonplace in recent years (Yang & Wang, 2008). It may not directly detract from the educational affordances of the game, and can make the development of a game much more cost-effective. However, a powerful capital interest having a stake in the success of a game may very well compromise its educational value in the interest of marketability. A consideration of the effect of these features will narrow the scope of what we consider educational games, but will enhance our understanding of them.

While there has been a good deal of research examining computer games and their educational affordances (Rice, 2007), much of this research and much of the curricula involving educational games has been developed with a particular game as a starting point (Childress & Braswell, 2006; Delwiche, 2006; Hamalainen, 2008). This is usually because the researcher chooses one game because it is relatively inexpensive, applies to the curricular domain under study, is appropriate for the grade level, or satisfies some other convenience. The curriculum is then developed “backwards.” Specifically, classroom experiences are built around the game first and then educational objectives selected based on what is deemed possible to achieve using the game in question. This is understandable, since the primary question for games researchers during the field’s infancy has been to establish that games can be used to educate at all (Huang & Cappel, 2005; Rosas, Nussbaum, Cumsille, Marianov, Correa, & Flores, et al., 2003; Steinkuehler, 2004). With that established, educators can reverse the direction of study. The educational objectives that are under study can be the starting point, and the type of game that will enhance the achievement of them can be determined. It is at this point that a taxonomy of educational games becomes valuable.

Although the commercial game industry has its own categorizations of games (Kremeier, 2002), there have been few attempts at developing an organizational system for educational games with the intent of furthering the educational use of games. Amory, in his development of the Game Object Model II (2006), outlines a design framework for games based on Object-Oriented Programming. He bases his theory less on the intent to use games in the classroom as on the intent to classify games themselves. Björk, Lundgren, and Holopainen (2003) established a description of games themselves that is instructional

Table 1

*The Taxonomy of Educational Games*

Game Genre	Linear	Competitive	Strategic	Role-Playing
Description	Success requires linear logic	Success requires linear logic, plus anticipating actions of other players	Success requires strategic planning and management of a complex system	Success requires developing and maintaining a profile of probabilities within a complex environment

Examples	Puzzles, jump-and-run, first-person shooters	Sports, combat	War and management	Large, online multiplayer environments
Gagne's Learning Outcomes	Intellectual Skill Verbal Information Motor Skill	Attitudes	Attitudes	Attitudes
		Cognitive Strategy	Cognitive Strategy	Cognitive Strategy
		Intellectual Skill	Intellectual Skill	Intellectual Skill
		Verbal Information	Verbal Information	Verbal Information
Bloom's Educational Objectives	Psychomotor	Motor Skill	Motor Skill	Motor Skill
				Evaluation
			Synthesis	Synthesis
			Analysis	Analysis
Jonassen's Problem Solving Types	Comprehension Knowledge Psychomotor	Application	Application	Application
		Comprehension	Comprehension	Comprehension
		Knowledge	Knowledge	Knowledge
		Psychomotor	Psychomotor	Psychomotor
	Decision-making Rule-Using Story Algorithmic			Dilemma
				Case Analysis
			Design	Design
		Strategic performance	Strategic performance	Strategic performance
	Logical		Diagnosis-Solution	Diagnosis-Solution
			Trouble-shooting	Trouble-shooting
			Decision-making	Decision-making
			Rule-Using	Rule-Using

in the basic nature of games. However, these models are somewhat finely detailed for the purposes of the average teacher (and, indeed, the average educational researcher). Additionally, Björk et al. are researchers connected with the commercial industry, and their intent was a more thorough understanding of games as products, rather than educational tools. Lee, Ko, Song, Kwon, Lee, and Nam, et al. (2007), focusing on excessive game play and internet addiction, categorized games into “genres”, predicated primarily on their commercial classification. Rice (2007) made some connections between games and higher-order thinking skills, but from a highly interpretive perspective. Squire (2006) categorized games according to the linkage between the context and the game play, but not according to problem solving affordances. Gee (2005) makes a clear description of how “good” games include appropriate problem solving opportunities, but not detailing which types of games present which types of problem solving. Examples of game classification such as these reveal the need for a taxonomy that focuses on the problem-solving application of certain game genres in an educational setting by educators, who may not be aware of the basic nature of games.

## THE EDUCATIONAL GAMES TAXONOMY

The theoretical basis for the taxonomy we develop in this chapter is a combination of R. M. Gagne’s Five Categories of Learning Outcomes (1974), Bloom’s Taxonomy of Educational Objectives (1956), and

D.H. Jonassen's Typology of Problem Solving (2000). Gagne's Five Categories, as a canonical organization of the major outcomes of education, outline the overall capabilities each game genre generally engages. Although various authors have critiqued and/or revised Bloom's original work in various ways (Anderson and Krathwohl, 2001; Furst, 1981; Ormell, 1974), his taxonomy remains a major directive for instructional design. Bloom's Taxonomy provides reasoning for deciding which genres are suitable for developing cognitive skills of varying levels. Finally, Jonassen's Typology gives specific information about a game player's problem solving behavior. The intent is that all educators (e.g., researchers, instructional designers, teachers, etc.) will be capable of designing instruction by first determining the learning outcome the students should achieve, based on the learning standards (Wiggins, 1992). This will lead to the selection of one or more levels of educational objectives. Then, one or more problem-solving types that will assist in attaining these objectives can be selected. At this point, our taxonomy can aid the educator in choosing an appropriate game genre and thus a particular game. Admittedly, this process is not necessarily linear or prescribed. However, the sequence follows a logic that can serve as a starting point in any design process involving educational games.

The taxonomy of educational games separates games into four categories or genres. Although there are a multitude of types of games defined by the game-play experience (i.e., first-person shooters, flight simulators, sports games), these characteristics are not always useful in education. Therefore, for the purposes of instructional design and educational research, it is most valuable to identify games according to their educational affordances. Of the possible educational objectives for which educators might use games, they lend themselves most readily to the teaching of cognitive skills. Thus, these genres describe games according to the varieties of cognitive skills employed.

## Genres

For many years, society has considered video games as a single concept, often disparagingly. Those not familiar with them bemoan games as the downfall of today's youth and the antithesis of academic development and focus on school (Bartholow, Sestir, & Davis, 2005). It is true that many people play games to the detriment of maintaining a balance of interests and activities, and some games lend themselves to this type of obsession. However, understanding how some types of games are different from others can aid the understanding of how and when games can be beneficial for learning. Thus, in our taxonomy (Table 1), we propose describing games according to the following genres, with the caveat that although most games can be classified fairly clearly into one genre, any game may include features of multiple genres. The names given to these genres are similar to the genres described for commercial games. However, we based our choice for each on the educational nature of the games within it, as an indicator of their particular educational applications. Additionally, the higher-level genres very often include game play within one or more of the lower genres as part of the complexity of their features. Thus, rather than an absolute taxonomy such as is found in the natural sciences, this is meant as a descriptive classification system such as is found in the social sciences.

First of these genres is *linear* games, which are often described as "arcade" games. These are the most common type of game, and the most popular (Gee, 2003). Somewhat more advanced than these are *competitive* games, including sports games and simple fighting or combat games. Also frequently competitive, but using much more advanced forms of cognition are *strategic games*, which are often complex war games or games involving the management of a system. At the top end of our spectrum are *role-playing games*, or *RPGs*. These are variations on the board games developed in the 1970's. Each player creates a unique profile of probabilities that determines their success, and enhances those probabilities throughout the game. These genres do not describe games according to what the player sees, but rather what the player *does*, or more specifically how they *think*. There are varieties of graphic interfaces possible for any genre of game, and so games that are very similar in appearance may be in very different genres. Some very simple puzzle games use complex 3d graphics and a high aesthetic, whereas some very complex problem solving games use a very simple, plain interface or perhaps are even

text-based. Thus, many games that appear to be very different may be classified in comparable ways. Specifically, the cognitive skills required by them and their educational affordances may be very similar..

## *Linear Games*

Linear games are those that use linear logic, although the actions employed in playing them may not be linear. Like simple algebraic problems, the variables involved in the problem are clear. Although they may be difficult games, the steps necessary to succeed are sequential. These games require only knowledge of information and well-structured problem solving, and so most of their value in education is exposure to content. However, this type of content interaction is reminiscent of traditional drill-and-practice learning, and research has shown they mostly have the same amount of value in education (Rosas et al., 2003). From a play-based perspective, these are often puzzle games, shooting games, or what are often termed “jump-and-run” games in which the player moves through the game collecting objects and avoiding obstacles or what are described in game parlance as *non-player characters*, or *NPCs*. NPCs are entities in a game that are not like simple obstacles, because they act in response to the player’s actions (a falling rock is an obstacle; a rock-monster that chases you is an NPC). These are extremely popular games because they are usually very straightforward in their rules and are often very repetitive. Often they require very little complex problem solving ability while requiring highly developed fine-motor skills. The actions required to win are clear, the learning curve is low and there is frequent payoff for effort in the form of points scored or encouraging feedback. Many of these games have a very simple aesthetic, such as the enormously popular Tetris™ where the focus is on the logic of the problem rather than the experience of play. However, these games can also be, on the surface, very complex games using intricate 3d graphics and involved storylines, such as first-person shooters. Yet when examined for the type of problems solved within them, they may require the same cognitive skills as something like Tetris™. In the first-person shooter style of game, the player sees the world through the eyes of a character in a three-dimensional environment while attempting to traverse the environment and usually shooting or otherwise overcoming the various obstacles or NPCs preventing such progress. Although, to the casual observer, this is a very different style of game than Tetris™, the types of problems the player solves are very much the same. Although people can play together in linear games by collaborating simultaneously to succeed or by comparing their levels of success, the difference between linear games and competitive games comes when there are other players, either real or computer-controlled, which are not only blocking the player’s attempts at completing the game but are simultaneously attempting to win the game themselves.

## *Competitive Games*

Competitive games, like linear games, often require well-developed fine-motor skills, require linear logic to solve the problems presented in them, and vary widely in their aesthetic features. However, whereas in linear games there may be NPCs that foil the player’s attempts at success, competitive games, as their name suggests, include other players that are also playing the same game either competitively or collaboratively. A player can be controlled by either a human being or the computer, using AI software that simulates the actions of a real player (Björk & Holopainen, 2003), or a combination of both. These players are known commonly as *bots*, short for “robots”. In some games, human players can adjust the ability levels of bots to fine-tune the difficulty level of the game. This can be a significant feature for adequately challenging students (Wang & Reeves, 2007). This genre includes games that simulate real-world sports, competitive versions of the first-person shooter games described above, and their ancestor, Pong™. A comparison between Pong™ and another early game, Breakout™, since these™, since these games were absolutely minimalist and similar in their design, serves as a pristine example of the difference between linear and competitive games. In Breakout™, the player moved a rectangle or “paddle” back and forth across the bottom of the screen in order to hit a ball (or rather, a small square) around the inside of a three-sided rectangle, knocking out bricks from the opposite side and keeping the ball from moving past the paddle. In Pong™, the player used a paddle on the side of the screen to hit the

ball, but attempted to hit the ball *past another player*. Although these games were very similar, the difference is telling: the addition of the opponent causes the players to move from solving a simple problem in dynamic plane geometry (in order to determine where the ball will travel so that it might be hit) to anticipating the movements of another player (and/or bot) and attempting to exploit those predictions. When a player moves between competing with players and working on their own within the same game, it can become unclear whether the game is a linear or competitive game. Although bots can act somewhat predictably depending on the sophistication of their AI software, human players are highly unpredictable and make very simple logic problems terribly difficult to solve, even when they are on the player's side. In fact, the attempt to predict the actions of other people in games has led to the development of one of the most complex fields of mathematics, known as *game theory* (Kuhn, 2003). The techniques of this field can often clarify how others will act in a competitive or collaborative situation, but its complexities are beyond the scope of this chapter. Of note, however, is game theory's ability to determine the possible actions of a player who may choose to work *either* in cooperatively or competitively with oneself. These situations and other factors separate competitive games from the next genre: strategic games.

## *Strategic Games*

Strategic games involve managing a complex system, often in the form of a city, a country, a business, or some other organization. The strategic aspect of these games is in the management of resources, cost/benefit ratios, return-on-investments, and military planning and anticipating the same strategies for any opposing players. In this genre, players learn domain-specific content knowledge, and begin to apply that knowledge to complex problem solving in an authentic context, adding value to the learning experience (Artino, 2008). Aspects of the linear and competitive genres come into play in these games, and so strategic games also require fine-motor skills. If the system being managed is not very complex, there can be some apparent overlap between this genre and the previous two. However, in this genre, fine-motor skills usually become much less critical for success. The player spends a great deal of time planning and organizing, either before taking action in the game or during game-play. These games often become highly complex, involving the simultaneous management of several sub-systems. Each individual game may be played with a random set of initial conditions, forcing players to use unique strategies with each game. For example, a game in which the player rules a country may involve the management of food production for a growing population, the building of a military force to protect that population, and defending against invasions from neighboring countries. Meanwhile, other players or bots control these neighboring countries, and so the most important strategy is to understand one's opponent well-enough to anticipate their actions and reactions. Thus, it is with strategic games that communication and socialization becomes a much more critical aspect of multiplayer games. Players may form alliances, and so need to collaborate on strategy, economics, and military movements. They may compete, and so need to negotiate, cajole, or misinform their opponents. Strategic games are much more involved than our previous two genres, and players may find themselves in the role of military general, CEO, or emperor. However, the role of the player in these games is straightforward: the player is in charge of the entire system, and their decisions about how to manage that system are the rule of law. Collaborations with other players are tenuous, as the length of play in any one game is usually no more than a few hours. However, as we shall see in our last genre, when the length of game play stretches to days, weeks, or years, the player's involvement, the role they play, and their socialization in the game become far more complex.

## *Role-playing Games*

In computer-based RPGs, players create unique characters at the start of the game comprised of *abilities*. Each of these abilities is a score or percentage, which indicates the level of that ability the character possesses. With character creation, there are only a certain number of points to distribute amongst the



various abilities. Thus, an increase in one ability usually means a reduction in another. During game play, a character will be more successful in situations that call upon their higher-level abilities. Once the player creates a character, the player must succeed at various challenges in order to improve their character's abilities and advance in the game. This can be done through allotment of points or, in some games, through in-game currency systems, in which players "buy" items to improve their abilities. Indeed, many players derive enjoyment primarily from investing in these virtual markets, or running virtual businesses within the game. Such play would fall more into the strategic genre, depending the level of commitment to these alternate activities. As the player improves certain abilities, they often become more highly specialized in their chosen role, and thus become even better suited for specific situations. Conversely, players may manage their character to balance abilities, allowing them to suit a variety of roles. If a situation requires abilities that are weak in that player's character, they can collaborate with players whose characters are strong in the required ability. Strategically formed groups of characters can adapt to a variety of situations, with each player fulfilling a particular role in the group, hence the name. Players become highly involved in the development and refinement of their characters in an environment that is persistent over weeks, months, and years (Steinkuehler, 2004). Players may also develop more than one character, changing roles as required by the situation.

This need for collaboration in RPGs significantly increases the level of socialization used in them. Players are in constant communication to manage groups, direct action, plan strategy, etc. They communicate through many forms of communication such as in-game text and voice chat, email, and discussion forums, extending the social sphere beyond the game itself (Schraeder, Lawless, and McCreery, 2009). These players engage voluntarily in highly collaborative, ill-structured problem solving, also known as *computer-supported collaborative learning* (Kapur & Kinzer, 2007). Additionally, the extended length of play and socialization results in players developing long-term relationships and, thus, more subtle interactions. In most RPGs, players form extended groups in the form of clubs, guilds or leagues. Players also assume leadership and management roles within these groups, assembling and scheduling smaller groups to tackle particular challenges. All of these interactions lead to players engaging in problem solving which imitates or even replicates that found in "real life".

## **EDUCATIONAL THEORIES IN THE TAXONOMY**

In progression through these genres, it seems apparent that not only does game play itself change, but the cognitive processes of the player change significantly as well. When considered in the light of current educational theory, a linking pattern appears between types of problem solving and educational affordances, and the levels of game genres described herein. First, Gagne and Briggs (1974) categorized five Categories of Learning Outcomes, organizing the various skills acquired through educational experience. These types of skills translate to the skills required for success in the several genres in the taxonomy. Bloom's Taxonomy of Educational Objectives (1956) describes increasingly advanced levels of cognitive skills that students develop. As the cognitive complexity of a game increases, so do the cognitive abilities exercised by the player. David Jonassen's Typology of Problem Solving (2000) delineates categories of problems according to, in part, how well they are structured. The genres in our taxonomy encompass increasingly ill-structured problem types as described by Jonassen. Designers of instructional activities involving games can exploit this linking pattern to make informed decisions about what type of game, or even what particular game, is most suitable for their objectives. Depending on the objective, designers may consider these theories and the taxonomy separately or in conjunction with each other. A better understanding of this pattern will aid educational policy makers, educational researchers, instructional designers, game designers, teachers, parents, and students to embrace games in curriculum and instruction.

### **Gagne's Five Categories of Learning Outcomes**

Robert M. Gagne, in his *Principles of Instructional Design* (1974), describes five outcome areas toward which educators can direct instruction: *intellectual skills*, *cognitive strategies*, *verbal information*, *motor skills*, and *attitudes* (Table 1). Intellectual skill is the ability to manipulate knowledge through cognitive operations. Cognitive strategies are akin to metacognitive abilities, monitoring a learner's behavior. Verbal information, although the name is misleading, is the ability to retain, recall, and communicate facts. Motor skills are abilities in physical control and expression. Attitudes, although also a cognitive ability, are the learner's ability to choose from among a group of options due to personal preference rather than logic. Instructional designers must decide, ahead of the design process, into which of these categories their learning objectives fall, and how to weight the focus of those categories. Most of the genres in our taxonomy can target all of these objectives in one way or another, but the focus on which of these skills is more engaged changes. With this in mind, the choice of an appropriate genre of educational game can be more obvious.

Linear games, even though they may often be difficult, as we shall see, use a very simple logic. Thus, the skills needed to succeed in them do not tend to engage higher order thinking skills. Under Gagne's outcomes, these games mostly teach the use of motor skills, verbal information, and intellectual skills. Players are required to move objects around the screen in response to stimuli, often very quickly and accurately. To understand the stimuli, they must acquire verbal information about the game's elements and be able to recall it at will. In doing so, they develop their intellectual skills as they learn the rules and patterns that govern the behavior of the game elements. These games can be highly complex as well, increasing the use of verbal information and intellectual skills and downplaying the need for acute motor skills. Although these games may seem to have limited use in education, their low learning curve and the ability to adopt them for many different curricular areas may make them the most prevalent genre as games become ubiquitous in the classroom.

The same learning objectives are obtainable through competitive games; however, the specific skills acquired can be much different. Since players are now trying to solve linear logic problems in spite of another player doing the same thing, the logic required can change rapidly. The verbal information the player must master includes not only the rules and features of the game elements, but also certain features of the opponent and their possible behavior. This type of information can be much more tenuous and difficult to grasp. Additionally, the intellectual skill needed to predict another player or bot's behavior is much more advanced than simply understanding the predictable actions of NPCs. Even the motor skills required by competitive games are more difficult to master since a player must track and counteract the movements of opponents. Although these games are primarily multiplayer extensions of linear games, there is an argument to be made that they may become more like strategic games if players develop more acute understanding of strategy and the ability to monitor their own learning of that strategy. In addition, players have choices about whether they play more offensively, defensively, and what strategies suit them outside of the strategy's efficacy. Thus, when players interact in these games, they may begin to develop the attitudes or preferences they have for the type of play in which they engage. However, players develop these last two skills more thoroughly as game play becomes more involved.

In strategic games, players begin to plan and organize much more than in the previous two genres. Although they use motor skills to execute actions, these skills are not critical in many strategic games. Additionally, students develop some attitudes in their game play about preferred methods and styles of play. However, Gagne's other three objectives are far more heavily engaged in these games. Strategic games often require knowledge of a great deal of information to determine how game elements act or interact, and this knowledge must be readily accessible to the player. If this knowledge is available, the player uses intellectual skill to plan and execute strategy. Here, cognitive strategies themselves come into play when the player monitors and adjusts their thinking and learning to be more successful. In strategic games, these skills work together continually to allow the player to adapt to the changing conditions of the game. However, in order for all of Gagne's objectives to be attainable through game play, the game

must engage the player in many different ways, motivating them to invest themselves more fully. The fourth genre, RPGs, satisfy this requirement, engaging players even when they are not avid game players (Smyth, 2007).

RPGs are highly complex. They include the development of unique character identities, a diverse in-game social structure, a wide variety of obstacles and NPCs, engrossing competition, active virtual economies, and strategic planning and organization, both on large and small scales and over the short and long term. This complexity creates the possibility to engage players in a wide range of educational experiences, such that educators can address all of Gagne's learning objectives. The complex organization in these games can require comprehensive knowledge of verbal information and the intellectual skill to manipulate that information. When players become highly engaged in this complex play, they must activate cognitive strategies to improve their application and understanding of that manipulation. The investment in their character increases their investment in success in the game, and they invest more time learning and developing their own ability to improve (Yee, 2006). This investment in the metacognition of learning is one of the most difficult learning objectives to achieve, and the most valuable. When students are engaged in improvement, learning follows. It is up to the instructional designer to harness that engagement such that all students can achieve that outcome.

## Bloom's Taxonomy of Educational Objectives

Bloom's well-known and widely used Taxonomy of Educational Objectives (Table 1) (Bloom, 1956) is descriptive of the increasingly complex content learning which occurs through the four genres in our taxonomy. Bloom described three domains of objectives: *psychomotor*, *affective*, and *cognitive*. Most educational games exercise all of these domains in some way. The psychomotor domain is always engaged in playing digital games, to a greater or lesser extent depending on the game's design. Educational games also engage the affective domain, but to a greater extent at the higher levels of our taxonomy. However, our focus in the description of the educational games taxonomy is on Bloom's cognitive domain and the subcategories therein. The focus in most good instructional design is within this domain (Gagne & Briggs, 1974), and cognitive development is the area where games have the most potential for educational application. Educators can use all types of games to teach at the knowledge level, through engaging exposure to content. Players also practice comprehension in any of the genres, as games allow for authentic use of facts and concepts to enhance understanding. At the levels of application and analysis, we start to see where linear, competition, and role-playing games become more useful for authentically teaching content knowledge, as games may simulate authentic situations where players may apply and analyze knowledge. At the highest two levels of the genre, where players begin using more complex problem solving skills, there comes the ability to exercise the synthesis of knowledge to form unique solutions to problems. Finally, only in the RPG genre are students usually able to practice evaluation by forming unique opinions about the value and meaning of content knowledge. It is the unique nature of each genre that denotes its applicability to Bloom's Taxonomy.

### *Knowledge and Comprehension*

Games at all levels of the taxonomy suit the teaching of content at the levels of knowledge and comprehension as long as they are engaging. Indeed, the high motivation games induce can make learning at these levels much more enjoyable. Linear games, as with most classroom instruction, present students with clear, logical steps to perform in recalling and understanding knowledge. Competitive games, if played against real people instead of bots, make learning a social event, and thus more engaging (Cole & Griffiths, 2007). In strategic games, often many factors change simultaneously, so there is often a dramatic increase in the need to recall significant amounts of detailed information in order to manage systems in the game. RPGs magnify this aspect, as not only do players manage many systems, but also they are often changing from system to system, or managing many systems simultaneously. RPGs may

address the knowledge and comprehension levels of facts most readily: in some RPGs, players have developed searchable online databases full of information about game elements such as obstacles, NPCs, and rewards (Gee, 2003). In an information-rich society, students must often learn to manage large amounts of data, and RPGs have begun to give them an engaging way to practice that skill. However, the value of games comes when students need to use knowledge authentically.

### *Application*

In Bloom's Taxonomy, the application level of learning requires making use of knowledge in contexts unlike those in which the learner acquires the knowledge. Linear and competitive games can require the application of knowledge, but they tend to be limited in the variety of novel situations that they produce. Their repetitive nature allows for ample practice of knowledge application, but players quickly master the limited use of knowledge required to play them. Thus, when the objective is for students to apply knowledge with practiced aptitude, linear or competitive games may provide the most suitable format for honing those skills. In strategic games and RPGs, however, there is a significant increase in the need for players to apply knowledge in novel situations. These games present a multitude of unique challenges, and often require players to have considerable content knowledge to be successful. Players must also manage this significant amount of data, such as the specific capacities of game elements, geographical and mapping data, and the hierarchical structure of organizations. Although these games are usually themed around fictional contexts, instructional designers can construct games at these levels to reflect the desired educational content domain. Thus, the variety of situational contexts these games create would allow for extensive novel application of the content knowledge. For example, in a strategic war game, a player may apply knowledge of European geography to plan various military offensives. In a fantasy RPG, the knowledge of a healer's (one who assists other characters) weakness in combat is applied to compensate with the strength of a warrior (who can protect the healer) or avoid dangerous situations. If students must demonstrate the application of knowledge in a great variety of contexts, strategic or role-playing games may create a more suitably authentic environment. The games in these two genres are also the most suitable for the highest levels of Bloom's Taxonomy.

### *Analysis and Synthesis*

Linear and competitive games rarely require much thinking at this level. Any in-depth analysis of the structure of these games does not prove valuable when the player cannot affect that structure. Also, if the acquired knowledge can be synthesized to create new knowledge, there are rarely opportunities to apply that new knowledge, since the player is usually already provided with the knowledge needed to solve the game's problems. In strategic games and RPGs, players must not only master their command of the applicable factual knowledge in the game's content domain. They must also clearly understand the rules and variables of the game, and use that knowledge to adapt to changes. Thus, their command of knowledge must be at the analysis level to separate the component elements of their knowledge so that they can understand the relationships between these elements, and thus the systems the game requires them to manage. Additionally, as the player begins to command more and more complex systems, interact with other players in more complex ways, and, in RPGs, develop a more complex profile, they are required to synthesize their knowledge to develop original thinking about their game play. To become very successful in these games, players must thoroughly understand the organization of the knowledge they have developed through the game, and express their understanding of that knowledge in a way that is understandable to other players. In RPGs, they may even develop critiques of their own and other players' understanding.

### *Evaluation*

RPGs provide the most authentic environments for simulating real world, ill-structured problem solving (Steinkuehler & Chmiel, 2006). Based on subtle probabilities, they provide players with endless variations and outcomes to which they must constantly adapt. Additionally, the rules, the objectives, and the criteria for success are not always clear. The inclusion of hundreds or even thousands of players and the development of complex communication networks make them highly social “third spaces” and thus even more authentic environments (Steinkuehler & Williams, 2006). With this social engagement and authenticity comes a responsibility for the players to develop much of the structure of the game, and to maintain a cohesive, functioning social system. Thus, players in these games often engage in heated debates, both in game and in message forums, about their own and each other’s actions, behavior, beliefs, policies, and procedures (Steinkuehler & Chmiel, 2006). This demonstration of the evaluation level of Bloom’s Taxonomy is possibly the most valuable feature of RPGs, as it creates an opportunity for social cognition. By giving players an environment in which they can engage socially while simultaneously working together to solve problems, RPGs foster natural curiosity and intellectual engagement.

Bloom’s Taxonomy has provided, for many years, a solid foundation for instructional designers to outline the knowledge-centered objectives of curriculum, instruction, and assessment. However, in recent years, there has been a movement away from the focus on the understanding of content knowledge, as described by Bloom, and toward the development of the cognitive skills necessary for real world problem solving (Fernandes & Simon, 1999). The play of games is based on the solving of problems. Thus, although games provide many ways in which students may be engaged in their development of knowledge, in the next section we shall see they are far more valuable in their ability to develop students’ problem solving skills.

## Jonassen’s Typology of Problem Solving

David H. Jonassen, in his 2004 *Typology of Problem Solving*, outlined specific problem types that fit into the linking pattern of the educational games taxonomy. In his typology, Jonassen describes many facets of problems, including their *abstractness*, *dynamicity*, *complexity*, and *structuredness*. Of particular concern for the taxonomy is the structuredness of problems. Briefly, however, there are connections with Jonassen’s other facets as well. Abstractness (also referred to as domain, or context, specificity) is the degree to which a problem is situated in the context in which it is being solved. One of the advantages of digital games is the ability to create and control the domain in which problems occur. This ability has led, in the higher levels of the taxonomy, to the creation of games in what Gee (2003) describes as *semiotic domains*. These domains embody the authentic types of problems that engage higher order problem solving skills. Dynamicity refers to the problem’s tendency to change even as one solves it, and can contribute to a problem’s difficulty. The problem solver’s ability to adapt to these changes can be one of the most difficult aspects of problem solving to assess (Schacter, Herl, Chung, Dennis, & O’Neil, 1999), but digital games may provide a way of monitoring a player’s adaptations. Complexity contains a number of aspects of the problem:

Problem complexity is determined by the number of issues, functions, or variables involved in the problem; the degree of connectivity among those variables; the type of functional relationships among those properties; and the stability among the properties of the problem over time (Funke, as cited in Jonassen, 2004, pp. 67-68).

Complexity also contributes to the difficulty of a problem. All of the types of problems Jonassen describes can vary in complexity, depending on the above conditions. Similarly, games in any of the genres in the taxonomy can and do vary in their complexity. Although the different genres engage different functions of cognition, games within each genre can be more or less difficult depending on the complexity of the problems the player is solving. Thus, linear games may follow a very straightforward logic, but have many variables and require careful thinking to solve. Conversely, RPGs may be very

simple and easy to play, while using the same probabilities and organization of their more difficult counterparts. Educational game designers may manipulate dynamicity and complexity as a way to customize a game for a particular subject area or grade level. However, of Jonassen's facets of the various problem types, the most critical to educational games is a problem's structuredness. This facet follows most clearly the linking pattern in the taxonomy.

Structuredness refers to whether a problem is more "well-structured," having a clear set of "rules and principles" for solution, or more "ill-structured", having more "uncertainty about which concepts, rules, and principles are necessary for the solution" (Jonassen, 2000). Jonassen's problem types separate roughly into two groups based on their structuredness, with some variability (Table 1). Additionally, there is a drop-off in structuredness between the two lower and the two higher genres. This change in structuredness links these problem types closely with the genres in the taxonomy, with the problem types encountered in the higher genres decreasing in structuredness. Thus, the taxonomy can provide instructional designers with a plan for integrating games by examination of the problem types encountered in the curriculum.

### *Problem Solving in Linear Games*

The games in the linear genre, with their clear logic problems, only lend themselves to some of the well-structured problem types in Jonassen's typology. Although very often the actions required by these games test fine-motor skills, success requires the straightforward thinking of logical, algorithmic and story problems. In fact, the spatial representation in these games, whether two-dimensional or three-dimensional, is also usually linear, requiring a player to follow a more or less straight line, hence the term "linear". These spaces are often maze-like, with one point of entry and one exit point. The players may spend a great deal of time exploring the various areas of the maze, but, ultimately, success will depend on whether they can follow the route to the exit. There are only obstacles and NPCs to deal with in these games, which require one of a few possible actions (run from the monster, fight it, or hide) and there is always one best answer in any given situation (if the monster is too big, run or hide; if it's small enough, fight). However, these games can present somewhat more complex problem types. Rule-using problems can arise as players are required to recall and comprehend larger sets of more complex rules, and to apply those rules to situations appropriately (what type of monster is attacking determines what type of weapon to use). Additionally, some more complex linear games include decision-making problems, as players have more options for action and must weigh those options and test them in trials (if the fire sword does not kill the dragon, try the ice sword). Thus, these games are excellent tools for students to practice curricular objectives such as mathematics, grammar rules, and simple cause and effect relationships. However, these well-structured problem types become more authentic when someone (or something) is trying to stop you from solving them.

### *Problem Solving in Competitive Games*

Competitive games are closely related to linear games, and so many of the same problem types occur in them. Problems encountered in these games, although involving opponents, are still very straightforward, and much of the discussion about linear games above applies to competitive games. Indeed, the competition aspect of these games is often less in trying to stop one's opponent from solving the game's problems and more in trying to solve the problems first. However, particularly when the opponents are humans rather than bots, the nature of rule-using and decision-making problems in these games can change dramatically. The rules involved in competing with other people can be very straightforward (stop them from winning a race, kill the dragon first), but the dynamicity of these rules can be extremely high. Humans, and even bots, are very unpredictable, and so players are required to change which rules apply as situations change quickly and dramatically. With decision-making problems, players must consider not only possible actions, but must test theories about those actions and then adapt those theories based on

outcomes. When solving these problems in real-time, combined with the unpredictability of the opponent, they become strategic performance problems. As the number of opponents increases and players begin working in teams, competitive games can involve very complex strategies and tactics. Those strategies may be clear, but whether or not teammates will agree with them or apply them can vary. Additionally, teams usually include members who take on somewhat different roles, i.e. offensive positions, defensive positions, assignments to specific areas, or varying leadership roles. At this point, the more ill-structured nature of strategic performance problems becomes significant. This lends these games to instructional objectives such as history and politics. However, although the leaders of such groups may begin to grapple with the trouble-shooting and diagnosis-solution problems common to managing systems, their lack of control over teams in this genre precludes them from truly encountering those types of problems. When players can effect more control over systems, these types of problems become prevalent.

### *Problem Solving in Strategic Games*

Strategic games can seem to be very well-structured forms of games. Indeed, much of the problem solving required by them is at the lower levels of Jonassen's typology, but in much more complex form. Managing systems such as businesses or countries involves large numbers of variables that players must organize into finite problems to solve. In fact, it is typical of strategic games that they often involve very simple logic problems to perform routine maintenance and repair of the system (which are often, in more poorly designed games, somewhat tedious). However, success in these games requires much higher-level cognition. These logic problems interconnect, with the outcome of one affecting the variables of another. The player frequently must solve rule-using and decision-making problems, managing large numbers of variables and needing to consider many possible courses of action. The complexity of the systems under control (and the length of time usually required to play these games) brings into play trouble-shooting and diagnosis-solution problems, when players must develop the system, observe its operation, find faults in it, and work to correct those faults. This genre also presents very ill-structured problems. Especially when playing competitively, players must manage a system in an environment and against an opponent, all of which are in constant flux. Strategic performance problems, as one might expect, describe the primary type of problem solving in these games. Players must integrate many objectives at once, and must balance the needs of these objectives evenly to attain success. These games, less frequently, can present design problems, when the system involved is intended to produce a particular product, such as with manufacturing simulation games. With the inclusion of these problem types, these games become suitable for simulations in domains such as the natural and physical sciences, business, and politics. Although strategic games can replicate much of the problem solving of real-world systems management, they fail to engage players in forms of problem solving which, although the most ill-structured and vexing, are also the most authentic.

### *Problem Solving in Role-playing Games*

Role-playing games, particularly the more complex of them, have emerged with some of the most engaging and rich game play experiences to date. By creating experiences in which players can take on unique identities they develop over time, RPGs allow players to invest themselves in ways unseen in other game types (Smyth, 2007). Since many of these games involve huge numbers of players, complex social networks develop within them, creating the opportunity for computer-supported collaborative learning, discussed above. RPGs are not only ill-structured problem solving games; many are virtual gaming environments in which players may encounter individual problems of many types, often working to solve them simultaneously. As a player begins to develop and enhance the role of their character, they become involved in sub-games of all three previous genres. Individual sessions of play may involve overcoming obstacles or NPCs to obtain a reward, such as in linear games. Indeed, often the most common actions of players in RPGs are linear sub-games. In these linear sub-games, they may also compete against other players alone or in teams, organizing and planning tactics. Individual players may

strategically manage systems such as in-game businesses using the currency system, in which they gather resources to produce items for other players, bartering or dealing to maximize profits. They may also form larger groups of players, or “guilds” in which they lead, manage and schedule the play of other players. Design problems become highly prevalent in RPGs, as players develop or “design” their characters throughout the course of the game. The design of a character involves the consideration of a number of factors, such as the weighting of abilities for different situations, the management of resources, and the role the character must play in conjunction with other characters. Thus, this integration of the lower genres within RPGs includes the problem solving types found in those games. However, the value of the RPG as an environment rather than a singular game is in the way players must learn to cope with unknown elements when solving problems.

The two final problem types RPGs may engage are not possible within the other genres, namely case analysis problems and dilemmas. Case analysis problems typically occur in the real world in various business and educational environments in which specific hypothetical situations are analyzed to understand various possible courses of action. In RPGs, players often engage in case analysis either casually when trying to plan ahead, or in discussion with other players in-game or in discussion forums (Steinkuehler & Chmiel, 2006). This type of problem solving is highly ill-structured, with no clear reasoning that should be followed, no obvious steps that should be taken, and even no assurance that there is a solution (Jonassen, 2004). These problems, like the complex environments of RPGs, often involve multiple domains of knowledge and are approached using a variety of techniques, none of which is clearly the best. Case analysis problems have traditionally been used mostly in higher education settings, and professional ones at that (Artino, 2008). The ability to present case analysis problems to students in secondary or, even, elementary settings through engaging digital games may open up new avenues for instructional design. However, RPGs also have the ability to extend problem solving to less discrete educational domains, such as social, moral, and ethical development.

The last problem type includes social, moral, ethical, and many other types of dilemmas. These problems are the most complex and ill-structured in Jonassen’s typology, affecting many people in critical ways but with no solution that can “...meet the needs of the majority of the people or escape the prospects of catastrophe” (Jonassen, 2000). In RPGs, players face mostly less complex dilemmas when they weigh the advantages and disadvantages of social interactions and involvement, such as who to befriend in-game or thinking about their own motivation for playing (Cole & Griffiths, 2007). But the environment of RPGs can create more complex dilemmas, especially as players become more heavily invested in the game, and they must make choices about what direction they want to develop their skills and how best to spend their time playing or in game-related activity. RPGs have the potential for instructional design that simulates complex, real-world dilemmas. Dilemmas are highly context-dependent (Jonassen, 2004), and so the development of games for practice in grappling with dilemmas can align with real-world domains. As RPGs become even more complex and include larger numbers of variables, larger numbers of players, and simulate more real-world problems, they may become invaluable in teaching problem solving at this level.

## **FUTURE RESEARCH DIRECTIONS**

Research on educational games has taken a turn away from merely attempting to show the possibility of using games in the classroom and toward the specific steps necessary to integrate them effectively into curricula. With the development of this taxonomy, we hope to assist both the research of this research and the integration process by educators working in the field. The future of instructional design hinges on the development of well-established theory in order to focus design on the intended outcomes of instruction rather than a desired classroom activity. Since using games in the classroom has been seen in recent years as a desirable activity from the standpoint of researchers and educators, it is our hope that a connection can be made between instructional outcomes and the educational games that best suit them. Additionally,



educational research in the area of games and problem solving has been sparse, and by laying the groundwork for research in the joint study of these domains we may further the understanding of their intersection.

We have developed our taxonomy with the intent to tease out the linking pattern between the genres of games we describe and established educational theory. This taxonomy should allow instructional designers who intend to use games in the classroom better to understand which types of games are suitable for which educational objectives. If the objective is to teach pure factual content, linear games may be most suitable. However, as is usually the case, students more readily understand content in a social, interactive context, and thus competitive games may be more suitable. As the objectives move from content knowledge to the application of content in novel situations, instructional designers may use strategic games to create dynamic environments. Finally, when the learning objectives entail authentic, complex, ill-structured problem solving, role-playing games in complex, social, online environments allow students to replicate much of the authenticity of real-world problems. It is our intent that further research, review, and development of this taxonomy will more clearly refine the relationships in this pattern. We expect there may be additional theories to incorporate or exchange for those we have included. In addition, there may be games that do not fit in any of these genres, and that require further examination of their educational affordances for inclusion and expansion of this taxonomy.

## CONCLUSION

This chapter discussed the need for a comprehensive organization of educational games. Previous research has focused either on individual games for classroom use, or has been focused on classifying games for their features rather than for their applicability to education. We established that revealing connections between games and established educational theory would allow instructional designers and educational researchers to choose games for their educational affordances, and to understand the nature of games. We described the taxonomy of four genres, categorized according to their educational affordances. If instructional designers consider the discussed theories and the linking pattern with the genres in the taxonomy, this may lead to a more logical and effective design process. This, in turn, can lead to incorporating games in the classroom with specific intent and with greater success.

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## **KEY TERMS & DEFINITIONS**

Abstractness: The dependency of the problem on the nature of its domain

Competitive games: Success requires linear logic, plus the anticipation of an opponent's actions

Complexity: The number variables and the level of detail in their relationships

Dynamicity: The degree to which a problem changes over time

Linear games: Success requires linear logic and movement from a starting point to an ending point

Non-player characters: Entities that react to a player's actions

Role-playing games: Success requires developing and maintaining a profile of probabilities within a complex environment

Semiotic domains: Complex, interdisciplinary domains capable of engaging higher-order thinking skills

Strategic games: Success requires strategic planning and management of a complex system

Structuredness: The amount of structure the problem contains as presented