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Standards for educational, edutainment, and developmentally beneficial computer games

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Abstract: The results of a comprehensive review of the body of research concerning the developmental and educational value of computer gaming for children is reported. Based on the review, design criteria are proposed for educational and edutainment computer games. In addition, a hierarchy of educational, edutainment, and entertainment game categories is introduced. It is argued that a standard educational labeling system is needed to assist parents and teachers with selecting computer games. A gap in the research is highlighted with regard to the affordances of computer games to facilitate the development of young children's higher-order thinking. It is recommended that further research be conducted to identify foundational educational theories for the design and assessment of games. And finally, it is argued that teachers need both training and encouragement to build the confidence required to guide computer game use.

Introduction

Digital media is so well incorporated into modern society that it appears almost natural, says Charlie Gere, author of *Digital Culture* (2002). We have begun to take it for granted, he says, ceasing to notice its presence and how it affects us. Desensitization to digital media is perhaps most profound for children who have no memory preceding the digital age. These, *digital natives*, "have spent their entire lives surrounded by and using computers, video games, digital music players, video cams, cell phones, and all the other toys and tools of the digital age" (Prensky, 2001b, p. 1). Many children and young adults are spending far more time watching television and playing computer games than reading or just about anything else (ESA, 2007; NPD Group, 2007, October; Prensky, 2001b; Rideout, Vandewater, & Wartella, 2003).

The immediate and long-term effects on child and adolescent development are still not fully understood, but during the past few years, there has been an increasing body of research that associates computer gaming with the development of higher-order cognitive processes (cf.(Amory, Naicker, Vincent, & Adams, 1999; Blumberg & Sokol, 2004; Buchanan, 2005; Jenkins & Hinrichs, 2003; Pillay, 2003; Pillay, Brownlee, & Wilss, 1999). It follows that researchers and policymakers have begun to call for digital literacy to be added to school curricula and even for new pedagogies that incorporate computer games[1] (Carrington & Marsh, 2005; Gee, 2003; Plowman & Stephen, 2005; Yelland, 2005). Many still question the leap from computer software to computer games in education, but "among all the forms of computer technology, there is one that touches people on a mass scale and, even more important, touches them during the formative years of childhood when cognitive development is taking place. This form of technology is the action video game" (Greenfield, DeWinstanley, Kilpatrick, & Kaye, 1994, p. 106).

This paper reports the results of a comprehensive review of the body of research concerning the developmental and educational value of computer games. It begins with a brief look at play in child development. This leads to a discussion of computer game play and children's cognitive development. Based on the discussion, design criteria are proposed for educational and edutainment computer games. In addition, a hierarchy of educational, edutainment, and entertainment computer game categories is introduced. It is argued that a standard educational labeling system is needed to assist parents and teachers with selecting educational and developmentally beneficial games. It is recommended that further research be conducted to identify foundational educational theories for the design and assessment of computer games. A gap in the research is highlighted with regard to the affordances of computer games to facilitate the development of young children's higher-order thinking. And finally, it is argued that teachers need both training and encouragement to build the confidence required to guide computer game use in educational settings.

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[1] The difference between the terms *computer game*, *arcade game*, *handheld video game*, and *console video game* generally identify the gaming platform on which a game is played. For the purpose of this paper, the term computer game refers to any electronic game played by manipulating images on a computer monitor, video display, or television.

Play is crucial to child development

The crucial role of play in children's development has been well documented in developmental psychology (Frost, Wortham, & Reifel, 2005; Henniger, 1994; Plowman & Stephen, 2005; Roussou, 2004; Verenikina, Lysaght, Harris, & Herrington, 2004). While freely engaging in play, children acquire the foundations of self-reflection and abstract thinking, develop complex communication and meta-communication skills, learn to manage their emotions, and explore the roles and rules of functioning in adult society (Bodrova & Leong, 1996; Verenikina et al., 2004; Vygotsky, 1967, 1978).

Computer play, however, is not well understood. It is "the first qualitatively different form of play that has been introduced in at least several hundred years," says Salonius-Pasternak and Gelfond (2005), and consequently, "it merits an especially careful examination of its role in the lives of children" (p. 6). Computer play is different in that the physical hardware is not interacted with in the traditional sense of play. Many forms of play involve interaction between the players and tangible media such as blocks, figurines, markers, balls, etc. With computer games, the computer hardware is not part of the game. It is only means for accessing the game.

Similarly, Verenikina et al. (2004) explain that one of the most important and powerful impacts of play on children's cognition is the development of mental images and symbolic representations. This development lays the foundation for children's abstract thinking. In other words, when children play a game with a stick, the stick may symbolically represent a wizard's wand. Verenikina et al. (2004) question whether computer games, or perhaps more specifically, computer-based virtual worlds, are capable of facilitating symbolic play among children. If so, in what ways might computer-facilitated symbolic play affect children's cognitive development? and what are the characteristics of computer games that facilitate opportunities for symbolic play?

Despite the potential advantages of computer games and child's play, many academics and policy makers are quick to reject them outright. de Aguilera & Mendiz (2003) rebut that the critics who denounce computer games across the board do not have experience playing the games. This may be true, but there are still many negative issues that have been attached to computer gaming. Some of the main issues are briefly discussed below.

But are all forms of play developmentally beneficial?

Summing up the last 30 years of research on education technology, Larry Cuban of Stanford University says that the only definite link between computers and children's learning is that drill-and-practice software appear to improve test scores (Alliance for Childhood, 2000). Regardless of the validity of Cuban's comment, computers and computer games have come a long way since the last decade. They have changed a great deal in just the last five years. It was not until late 90s, that modern-style computer games began to emerge, moving from simple 2D vertical- and side-scrolling games to complex strategy and role-playing games played in 3D worlds. Still, researchers and practitioners alike commonly perceive computer games as recreational or "toy" technology. "During the 1980s, researchers commonly held that, for children and adolescents, video games are colossal time-wasters" (de Aguilera & Mendiz, 2003, p. 7). In many cases, this belief may be well justified (Buchanan, 2005; de Aguilera & Mendiz, 2003; Rieber, 1996; Rieber & Noah, 1997).

On the other hand, there may be a significant underestimation of the potential developmental and educational value of recreational computer play (Dawes & Dumbleton, 2001; Gee, 2003; Greenfield et al., 1994; Jenkins & Hinrichs, 2003; Pillay, 2003; Pillay et al., 1999; Rouse & Ogden, 2001; Sandford & Williamson, 2005; Squire, 2005; Subrahmanyam & Greenfield, 1994; Subrahmanyam, Kraut, Greenfield, & Gross, 2000). One of the greatest misunderstandings among teachers is the belief that computer play does not require supervision because computer use is only a play activity or that computer games are programmed in such a way that adult mediation is not required. This could not be farther from the truth. Researchers consistently argue that adult mediation is required to reap educational benefits from computer software. This is true for educational games and especially recreational ones (Dawes & Dumbleton, 2001; Jenkins & Hinrichs, 2003; Ko, 2002; Let'sPlay!, 2000; Luckin, 2001; Nir-Gal & Klein, 2004; Plowman & Stephen, 2005; Rieber & Noah, 1997; Sandford & Williamson, 2005; Yelland, 2005).

One of the greatest concerns has been the addictive behavior that appears to be associated with computer gaming. Researchers have taken pains to calculate the amount of time children "waste" playing computer games and even to conduct studies with the aim of reducing such addictions (de Aguilera & Mendiz, 2003). Addictive gaming behavior seems to ground concerns "that once children start to use them, they will not want to experience traditional play materials and will only want to play computer games. In fact, the data shows that this is unwarranted" (Yelland, 2005, p. 203). Furthermore, evidence of the addictive nature of gaming provides substantial support for the intrinsic motivational nature of gaming and is a strong indication that further research needs to be conducted in the area of *edutainment* gaming—a cross between recreational gaming and educational software (Buckleitner, 1999; Games-to-Teach, 2001; Kirriemuir & McFarlane, 2003; Roussou, 2004; Shiratuddin & Landoni, 2003; Squire, 2002, 2003).

The greatest concern with regard to computer games has been violence and adult content, and it has of late, been the largest area of research (Baldaro et al., 2004; Calvert & Richards, 2004; de Aguilera & Mendiz, 2003; Jansz, 2005; Salonius-Pasternak & Gelfond, 2005; Sternheimer, 2007; Williams & Skoric, 2005). More than two decades of research, however, has failed to shown a clear link between game content and aggressive or antisocial behavior (de Aguilera & Mendiz, 2003). It can be countered, however, that one of the same mechanisms that education researchers feel allows for the transfer of educational content to children may also transfer violent or antisocial content (Detterman & Sternberg, 1993, as cited in Squire, 2002; Pillay, 2003). Hence, the level of violence and adult content in games as well as the accessibility of such games to children, remains cause for concern. The Entertainment Software Rating Board (ESRB) was established in the mid 90s to help monitor the content of computer games. The Board labels all games using a rating system similar to those used for motion pictures. In 2006, 85% of all computer games sold were rated "E" for everyone, "T" for teen, or "E10+" for everyone 10 and older (ESA, 2007).[2]

Designing better games

Given the complexity of today's games, and the fact that most gamers are in their 30s (ESA, 2007), recent research has focused on the use of computer games for learning in secondary and higher education (Abrantes, 2007, November). One such project, Games to Teach, set out to design prototype games to support learning in advanced math, science, and engineering (Jenkins & Hinrichs, 2003). Another project looked at games for training surgeons (Rosser et al., 2007). Since the average game buyer is 40 years old (ESA, 2007), it is not surprising then that a significant amount of game content might be inappropriate for children. And with 30% of gamers being under the age of 18 (ESA, 2007), it follows that recent research on child and young adult gamers has focused on violence and adult content.

Nevertheless, children are still playing games. "In 1991, the home video game industry had $4.4 billion worth of sales (of which Nintendo had $3.5 million). The primary age range of Nintendo game players is 6 to 11 years, with 12- to 17-year-olds in second place" (Berkhemer Kline Golin / Harris Communications, 1992, as cited in Greenfield, 1994). The following review focuses on children aged 12 and under. While discussing the body of research, the review references design criteria for educational and developmentally beneficial computer games. A complete list of the criteria is presented in Table 1.

Computer game play, education, and children's cognitive development

Prior research on child development and computer play has focused primarily on cognitive learning-related aspects, physical and psychophysiological aspects, social aspects, and emotional aspects, e.g., self esteem (Verenikina, Herrington, Peterson, & Mantei, 2008, July). Much of the research literature dates to the late twentieth century, following the release of Pong and Space Invaders in the 70s; and Pac-Man, Super Mario Brothers, Tetris, and Sonic the Hedgehog in the 80s and early 90s. "Conducted during the age of Nintendo, these studies are few in number and somewhat outdated, given recent advancements in game theory and game design" (Squire, 2003, p. 1).

One study looked at decision making and logical reasoning in children aged 7 to 10 (Ko, 2002). "Results support the cognitive decision-making theory, according to which children represent the problem and calculate the outcomes of moves. The cognitive theory explains the children's game behavior better than the probability matching theory, in which children merely reflect the likelihoods of happenings" (p. 229). This study supports the design criterion for *reasonable solutions*.

Haugland (1992) and Haugland and Shade's (1988) research with 4 and 5 year olds led to an important distinction between developmental and non-developmental computer software. They proposed ten criteria for developmentally appropriate commercial software (Haugland & Shade, 1988). The *age appropriate, clear game-play instruction, child control, free exploration, trial and error, realistic world representation, expanding complexity*, and *visible transformations* design criteria are all supported by their findings.

Cordova and Lepper (1996) examined the effects of contextualization, personalization, and provision of choices for increasing *intrinsic motivation* in computer software with forth- and fifth-grade students. They found that all three strategies produced dramatic increases. Several researchers have linked the learning possibilities associated with gaming to motivation. One of the most cited works is by Malone and Lepper (1987), who argue that there are five intrinsic motivations related to game play: challenge, curiosity, control, fantasy, and socialization (Malone & Lepper, 1987, as cited in Roussou 2004). Since one of the key learning benefits of computer gaming

[2] The ratings used by the ESRB include EC, early childhood, E, everyone, E10+, everyone 10 and older, T, teen, M, mature, AO, adults only, and RP, rating pending. Some of the ESRB content descriptors include alcohol reference, animated blood, comic mischief, crude humor, fantasy violence, intense violence, language, and sexual themes (ESRB, 2007).

appears to be intrinsic motivation, the five motivations form the basis for the first three categories of design criteria in Table 1. *Real-world contextualization*, *personalization*, and *provision of choices* are listed as design criteria.

Table 1: Design criteria for educational, edutainment, and developmentally beneficial computer games

	CURIOSITY, FANTASY AND PLAYER CONTROL	
Intrinsic motivation, enjoyable to play:	❑	Engages player's curiosity, encourages fantasy, challenges the player, and puts the player in control of the gaming world. The design of the game itself provides motivation to play.
Educational content intrinsic to game play:	❑	There is an integral and continuing relationship between educational content and fantasy or play aspects of the game.
Child control:	❑	Puts children in a position to lead the game and set their own pace.
Free exploration:	❑	Encourages curiosity, allowing for independent free-exploration of the game world and encouraging hidden secrets to be discovered.
Periodic saving of game state:	❑	Allows players to save as desired or at regular intervals.
Multiple paths:	❑	Provides more than one path through the game. Games should be non linear, allowing for multiple ways to win or solve problems.
Trial and error:	❑	Encourages trial and error as one way to solve problems.
Reasonable solutions:	❑	Reasonable solutions solve the problems presented. Winning is based on knowledge, not chance.
Incremental tasks:	❑	Large tasks are accomplished in steps.
Realistic world representation:	❑	The world is realistically simulated.
Real-world contextualization:	❑	Learning content is contextualized within real-world situations.
Personalization:	❑	Allows users to personalize game characters and customize graphs, backgrounds, and objects.
Provision of choices:	❑	Provides choices among various game modes and learning themes.
Avoid repetition:	❑	Avoids repetition. Avoids drill and practice.
Random elements:	❑	Provides random elements of surprise.
No loss of points:	❑	Points are not lost for wrong answers or failures.
	CHALLENGE	
Performance criteria:	❑	Performance criteria are clearly defined.
Constant challenge:	❑	Difficulty consistently and appropriately exceeds the player's level of understanding.
Expanding complexity:	❑	Expands in complexity as skills are mastered. Provides game levels for a wide range of abilities.
Monitor performance:	❑	Monitors player's performance, increasing and reducing difficulty to provide continuous challenge.
Display progress:	❑	Clearly indicates progress. Players are able to evaluate their progress at any time.
Real-time hints and instruction:	❑	Provides hints and real-time instruction as needed to scaffold the player.
Induce flow state:	❑	Helps players find their flow state, the point at which challenge and ability to overcome the challenge are perfectly matched.
	SOCIALIZATION	
Collaboration:	❑	Provides opportunity for collaborative play.
Competition:	❑	Provides opportunity for competition among players.
Multiple winners:	❑	Allows multiple players to reach the highest level.
	PEDAGOGY	
Age appropriate:	❑	Clearly states the target age group and is designed appropriately for that group.
Learning activities:	❑	Recommends learning activities to conduct in conjunction with the game.
Learning objectives:	❑	Clearly states educational objectives and educational philosophy.
Opportunity for adult mediation:	❑	Incorporates provisions for adult mediation. Acknowledges the role of a teacher or parent.
Clear game-play instruction:	❑	Provides clear direction, enabling players to focus on content rather than the rules governing game play.
Tutorial levels:	❑	Offers tutorial levels that allow players to learn by doing rather than reading the manual.
	TECHNOLOGY	
Mainstream technologies:	❑	Runs on technologies available and affordable to schools and the general public.
Licensing:	❑	Provides attractive licensing agreements for schools.
Usability:	❑	Provides an intuitive user interface.
	YOUNG CHILDREN, SPECIAL-NEEDS CHILDREN	
Spoken directions:	❑	Provides spoken directions. Written directions may accompany spoken directions.
Uncluttered design:	❑	Graphics and gaming screens are not overly cluttered.
Play for the sake of play:	❑	Playing the game is in itself a meaningful activity.
Visible transformations:	❑	Child actions impact the software, changing objects and colors and producing sound effects through their interaction.
Simple input/output:	❑	Intricate keyboard or mouse control is not required. Even banging on the keyboard or aimless movements of the mouse produce visible transformations.
Sequential increase in challenge:	❑	As the child learns, the game becomes more challenging. Sequential steps may be necessary to progress where only one button push was previously required.
Familiarity and repetition:	❑	Game activities are enjoyable to repeat. Aspects of the game are memorable, such as main characters, theme songs, and catch phrases.
Relate to daily life:	❑	Objects and sounds are taken from daily life. They are things that children can easily recognize.
After play:	❑	Inspires children's play after the game, i.e., even when the computer game is off.

Key references: Dawes and Dumbleton (2001); Gredler (2004); Habgood, Ainsworth, and Benford (2005); Haugland and Shade (1988); Kirriemuir and McFarlane (2003); Let'sPlay! (2000); Malone and Lepper (1987); Rouse and Ogden (2001)

Habgood et al. (2005) explored the concepts of extrinsic and *intrinsic fantasy* with regard to computer game creation and play by children aged 7 to 11. They report that results are inconclusive with regard to the value of intrinsic fantasy in educational computer games. What is implied, however, is that when fantasy aspects of a game are not intimately related to the educational content, children may avoid educational content all together. Habgood et al. (2005) illustrate this point with a game called DARTS. In DARTS, three balloons appear on a number line and players guess the position of the balloons on the line. After each guess, an arrow flies across the screen to the guessed position. If the arrow hits a balloon, it pops, otherwise the arrow remains on the line with the incorrect guess written next to it. This was the same game used by Malone (1981) to demonstrate an educational computer game with intrinsic fantasy, whereby the balloons and arrows fantasy is intrinsically related to determining the value of fractions on a number line.

Habgood et al. (2005) created eight new versions of the DARTS game, altering the graphics, feedback, scoring and other aspects from the first version and progressively adding each aspect back in later versions. The final version directly corresponded to Malone's original game. The extrinsic fantasy versions of the game removed the balloons from the number line and displayed them as a separate scoring method. They found that users played the extrinsic fantasy game more than the intrinsic fantasy game. Hence, it can be inferred that players avoided educational aspects of the game altogether when given the opportunity.

Regardless of the value of intrinsic fantasy in educational computer games, the results from Habgood et al. (2005) support the design criterion originally derived from Malone (1981), *educational content intrinsic to game play*. The findings of Cordova and Lepper (1996) also support this criterion. They say that "as in previous studies, students for whom the abstract learning activities had been embedded in meaningful and appealing fantasy contexts generally showed substantially greater motivation, involvement, and learning than those for whom the activities had not been so contextualized" (Cordova & Lepper, 1996, p. 727).

Funk, Pasold, and Baumgardner (2003) researched psychological absorption and the *flow state* with fourth- and sixth-grade students. Being in the flow state has been associated with enhanced learning with regard to computer games (Bowman, 1982, as cited in Squire, 2003; Malone, 1980). "In the flow state, the challenges presented and your ability to solve them are almost perfectly matched, and you often accomplish things that you didn't think you could, along with a great deal of pleasure" (Prensky, 2001a, p. 124, as cited in Kirriemuir & McFarlane, 2003). Results from the Funk et al. study (2003) indicate that children can reach the flow state when playing computer games. The corresponding design criterion, *induce flow state*, is supported by the literature, but more research may be required to determine how and to what extent the flow state is educationally and developmentally beneficial with regard to gaming. The *performance criteria, continuous challenge, expanding complexity, monitor performance, display progress,* and *hints* design criteria all help to induce a flow state.

Luckin (2001) considered Vygotsky's zone of proximal development as a design foundation for computer games. The study reviewed computer software designed to teach children aged 10 and 11 about ecology. Three variations of the game were tested with children: Vygotskian social collaboration, Woodsian scaffolding, and non-theory based. Results support the *tutorial levels*, *hints*, *monitor performance*, and *induce flow state* design criteria.

Cross (2005) studied communication among 10-year-old boys after engaging with a computer-based storytelling game. Cross found that "computer use intensified children's experience of multilinear and multimodal genres of play" (2005, p. 350). Cross found that though computer software stimulated play, the virtual computer world limited play space to a specific number of options. In contrast, options and goals can be continually negotiated in play that occurs after engaging with the computer. Cross's study is a good example of how to conduct learning activities in conjunction with a computer. Even for younger children, Ellis and Blashki's work with 1- and 2-year-old children indicates that "technology can be a meaningful learning tool alongside/in conjunction with, the more traditional play such as the sand pit, water, reading, coloring, and so forth" (2004, p. 94). Ko (2002) argues that educators must select games carefully. Ko says that educators should look at what concepts are taught and prepare activities that children can complete in conjunction with computer games. These findings support the *learning activities* and *learning objectives* design criteria.

Plowman and Stephen's (2005) study of computer use in preschools, found that there were very few examples of adults guiding children's interaction with computers. They believe that this was due mainly to a lack of practitioner confidence with computers. It is surprising given that scaffolding and *guided interaction* is common practice in other curricular areas. When guided interaction with computers was observed, Plowman and Stephen report highly positive outcomes. This finding supports the *opportunity for adult mediation* design criterion. Examples of guided interaction include "explaining how to use the software; placing a hand over a child's hand they move the mouse; suggesting alternative actions; demonstrating how to use tools: moving children to an appropriate level of difficulty; offering remedial help when errors occur; providing positive feedback on completed tasks; sharing pleasure in features such as animation; and intervening in turn-taking (Plowman & Stephen, 2005, p. 152). A study by Nir-Gal and Klein (2004) with children aged 5 and 6 supports these findings. They argue that the role of the adult mediator should be to focus, affect, expand, encourage, and regulate learning in conjunction with computers. Even so, guided interaction can be very time-consuming and is often unnecessary for children once they are comfortable with the software. Thus, guided interaction coupled with *reactive supervision*, is often the best approach. In other words, show children how to use the software and then be available as needed. More extensive adult mediation may be required for complex software or children who are less comfortable with computers.

Another study addressed children's selective attention when computer gaming. Blumberg (1998; 2000) found that children aged 8 to 12 were more adept at paying attention to the information most relevant to succeeding at a game than children aged 7 to 10. Study results support the design criterion that young children *play for the sake of play*, without the need of reaching specific goals.

Lindstrand (2001) looked at children ages 3 and up that used computer play centers (CPCs) in Sweden. Lindstrand reports that "The CPCs have shown to be of great importance for families of children with disabilities" (2001, p. 50). Parents surveyed by the study reported that computers supported child development within the following areas: language, concentration, coordination, understanding of colors and forms, new words and concepts, communication, specific skills, and social communication. A report published by the Let'sPlay! project (2000) says that although software is generally designed for all children, babies, toddlers, and children with disabilities may find additional benefits. Findings by Yelland (2005) concur.

One category of design criteria listed in Table 1 is specific to young children and those with disabilities. The Let'sPlay! report says that in contrast to older children, young children enjoy *familiarity and repetition* and that they *play for the sake of play*, meaning that a game's goals are less important. For children aged 9 months to 2 years, it is important that parents "point out objects and talk about what is happening on the screen" as well as incorporate real objects with computer activities (Let'sPlay!, 2000, p. 6). As an example, the Let'sPlay! report mentions software that comes with toy characters that are also featured in the game. Their discussion provides support for the *real-world contextualization* and *realistic world representation* design criteria.

For younger children and children with disabilities, game controls should be simplified, e.g., a large red button to press instead of a mouse. The Let'sPlay! (2000) report also recommends the following for this group of children: spoken directions, uncluttered gaming worlds and graphics, and content related to daily life. These recommendations support the *simple input/output*, *uncluttered design*, *spoken directions*, and *relate to daily life* design criteria (Haugland & Shade, 1988; Let'sPlay!, 2000). The findings from an ethnographic study of 1- and 2-year-old children's behavioral interaction with computers also support that content should be linked to daily life. The researchers report that "the provision of a teddy on the screen when the program starts instantly engages the children" (Ellis & Blashki, 2004, p. 94). Ellis and Blashki believe that the teddy bear aided in learning from the computer software because it is a familiar, happy, and easily recognizable object.

Design criteria

A comprehensive literature review led to the list of design criteria presented in Table 1. The list is not definitive, nor is it proposed that educational games should be designed to exhibit all of the criteria. It is hoped that subsequent research and discussion will lead to the establishment of an educational and developmentally beneficial games labeling system to help parents and teachers select computer software. Such a system might be similar to the ESRB's ratings and content descriptions for violence and adult content. In the same way, the establishment of an Educational Software Rating Board (EdSRB) might be required. Given the potential for additional sales due to an EdSRB label, companies might not need to be required to apply.

Computer game genres

At present, there is no standardized naming scheme for genres of computer games. Standard categories would be useful for communicating the results of scientific research as well as the establishment of a labeling system. The challenge is that modern computer games tend to blur across categories or are best described using two or more categories in combination. Kirriemuir and McFarlane (2003), for example, explain how football games that allow team management as well as game play arguably fit into sports, strategy, and simulation categories. Some games even offer games within the game. Nintendo has termed these *minigames*, and they are present in the popular Mario Party game series. Pajama Sam, by Humongous Entertainment, is an adventure game but also features a side-scrolling action game as a bonus to the consumer.

Of the scholarly works, the Herz (1997) system may still be one of the best attempts at categorizing games. On the Internet, one of the most complete and inclusive taxonomies can be found at Wikipedia.com under the topic, video game genres. Based on an analysis of the Herz (1997) and Wikipedia systems, and in terms of educational value, a hierarchy of game categories is proposed in Figure 1. The figure is designed to illustrate that some games may be designed purely for educational purposes, some for entertainment, and others for something in between. It is the in-between games, the *edutainment* games, that may be of most interest to future educational researchers because of the potential for crossover with some of the exceptionally popular entertainment gaming titles. Current research suggests that adventure (Amory et al., 1999; Dawes & Dumbleton, 2001; Pillay, 2003; Sandford & Williamson, 2005) and simulation (de Aguilera & Mendiz, 2003; Gredler, 1996, 2004; Kirriemuir & McFarlane, 2003; Sandford & Williamson, 2005; Squire, 2002) games may offer the most promise for education.

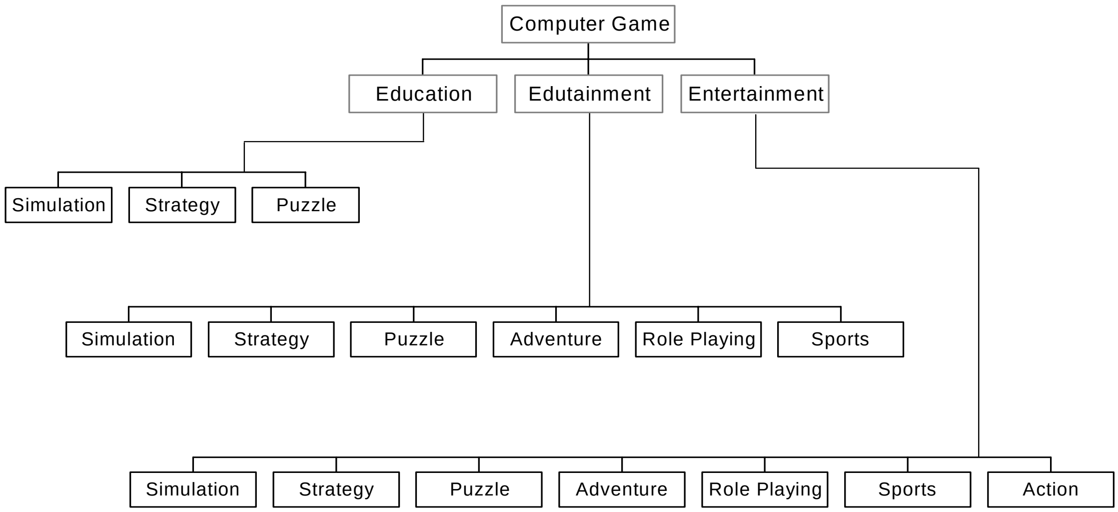

Figure 1: Hierarchy of educational, edutainment, and entertainment computer games

In addition to game categories, there is a growing body of game descriptors that prove useful for identifying subcategories. For strategy games, descriptors include the terms *real-time* and *turn-based*. With real-time strategy games, action is non-stop. With turn-based strategy games, as with traditional board games, a player completes their turn and then waits for the next player. Some of the action game descriptors include *side-scroller*, *platform climbing*, *fighting*, *first-person shooter*, and *third-person shooter*[3]. A good example of a side-scroller is Super Mario Brothers. Donkey Kong is a platform-climbing game. Fighting games, such as Street Fighter and Tekken, generally take the form of one-on-one martial arts contests. The perspective presented by first-person shooters, such as Doom and Wolfenstein, helps players to imagine that they are the character in the game. Players see only the character's hands, the same thing that they might see if actually inside the game world and viewing straight ahead. In third-person shooters, players see the game character's entire body.

Conclusions and recommendations

Given the popularity of computer games among both children and adults, there is no question that they are here to stay. Further, given the crucial role of computers in today's society, computers will remain an important part of every child's education. Since play is crucial to the development of children, it becomes clear that computer games will continue to play a role in the lives of modern children.

Fortunately, research has shown that computer games can actually help to educate children. Some of the abilities that computer games have been shown to help children acquire include goal setting and strategic thinking; metacognition; problem solving, logic skills; critical thinking; psychomotor coordination; attention and concentration; stimulating motivation; organization; memory; creativity; trial and error; exploration and free discovery; information and communication technology skills; collaboration and communication skills; and group decision-making skills. Computer games have also been shown to help relieve stress, build self-esteem, and in the construction of gender and self. Extensive literature reviews by de Aguilera and Mendiz (2003), Kirriemuir and McFarlane (2003), and Yelland (2005) confirm these conclusions. Despite the large list of skills that computers have been shown to help children develop, there are still many gaps in the research, especially with regard to the cognitive development of young children (Ko, 2002; Lindstrand, 2001; Plowman & Stephen, 2005; Salonius-Pasternak & Gelfond, 2005).

[3] Some might assume that there is no educational value in fighting and shooting games, but the military has taken great interest in them because of their potential to train and recruit new soldiers. They demand a closer look by researchers to determine to what extent they have been effective for military training and why. The official US Army game, America's Army, is rated "T" for teen (US Army, 2007).

It is important that future studies employ games and gaming platforms that children are actually playing. This means that entertainment games must be looked at for their developmental and educational value. Among children, handheld gaming platforms, such as the Nintendo DS and PlayStation Portable, are exceptionally popular. Children are playing them in the car, with friends during and after school, on the way home, and off and on throughout the evening. Handheld computer games help to keep children wired throughout the day and, along with personal computers and gaming consoles, throughout the night. They keep kids busy and quiet, but what are the developmental effects of concentrated long-term computer play by young children?

In addition, further research is required to support the application of educational theory to gaming. Gee's (2003) learning principles are a starting place because of their specificity to computer gaming, but need further grounding in traditional foundations of educational theory. Some of the theories that might apply well to computer gaming include activity theory, anchored instruction, situated learning, experiential learning, information processing, constructivist theory, and social learning theory. The design criteria for educational and developmentally beneficial computer games must be scrutinized against widely-accepted education theories. It is through this process that new theories for educational computer games may be defined. Moreover, scrutiny of the design criteria may lead to the establishment of a labeling system for the educational value of games. Labels would go a long way toward helping teachers and parents select the most appropriate computer games for children.

Beyond game selection, teachers will need instruction about how to teach with computer games. The inclusion of example learning activities with games, if only in the interest of increased sales, would help, but is only the starting point. In many cases, teachers do not feel confident enough with computers to provide any guidance about how to use them. Further effort will have to be put into educating teachers about how to teach with computers and encouraging them to try their hand at using something to teach that was formerly considered only for entertainment purposes. Perhaps some of the best advice will come from the practitioners already with years of success using computer games in classrooms, teachers such as the United Kingdom's Tim Rylands.

> "Fifteen children between the ages of 9 and 11 are staring at the computer screen, mesmerized, as the adventure game Myst III: Exile is played. In the middle of the group sits Tim Rylands, the most popular teacher at the small elementary school." Rylands' award-winning teaching incorporates the "Myst games to support literacy and communication skills." … "At key moments the action is paused and students are asked for a line of description or analysis." … The overall results of Rylands' "virtual excursions have been reflected in dramatic improvement in his classes' literacy assessments. If you don't have fun, then what are you going to learn?" (Rylands, 2007).

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