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Computers and Play in Early Childhood: Affordances and Limitations

IRINA VERENIKINA
University of Wollongong, Australia
irina_verenikina@uow.edu.au

JAN HERRINGTON
Murdoch University, Australia
j.herrington@murdoch.edu.au

ROB PETERSON AND JESSICA MANTEI
University of Wollongong, Australia
rob_peterson@uow.edu.au
jessica_mantei@uow.edu.au

The widespread proliferation of computer games for children as young as six months of age, merits a reexamination of their manner of use and a review of their facility to provide opportunities for developmental play. This article describes a research study conducted to explore the use of computer games by young children, specifically to investigate the affordances and limitations of such games and the features of children's traditional play that can be supported and further enhanced by different kinds of computer play. Computer games were classified and selected according to game characteristics that support higher order thinking. Children aged 5 and 7 were observed playing the games, and findings are given, together with suggestions for further research.

COMPUTERS AND PLAY

With the use of computers rapidly becoming a reality in early childhood settings and homes, many computer software applications are being produced with a very young audience in mind. To ensure that the software is suitable and appealing to young children, designers aim to present content in a play oriented manner. Such software ranges from commercial arcade games, produced for recreational purpose only, to different kinds of educational software, presented in a form of play designed to attract and sustain children's attention in what otherwise might be quite a boring enterprise.

However, the play component of children's software should not be seen as appropriate solely for recreational or fun purposes. Some authors urge instructional designers to seriously consider play and treat it as a powerful mediator for learning throughout a person's life (Rieber, 1996). During the past few years, there has been an increasing body of research that associates computer play with the development of higher order cognitive processes (Amory, Naicker, Vincent, & Adams, 1999; Buchanan, 2005; Pillay, 2003). What is surprising though, is that this research deals mainly with the computer play of adults or adolescents. Little research has been done with regard to the developmental value of computer play for young children (Ko, 2002; Plowman & Stephen, 2005).

The crucial role of play in children's development in the early childhood years has been well documented in developmental psychology. Association for Childhood Education International affirms that play is "an essential and integral part of all children's healthy growth, development and learning" (Isenberg & Quisenberry, 2002). Theories of play have identified many ways in which children's traditional play may advance their cognitive and socio-emotional development (summarized in Verenikina, Lysaght, Harris, & Herrington, 2004). A number of characteristics that distinguish child's play from other forms of their activity have been identified (Piaget, 1952, Garvey, 1977; Bruner, 1976; Singer & Singer, 1990). Play has been characterized as a spontaneous, self-initiated, and self-regulated activity of young children, which is not necessarily goal-oriented.

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. Sociocultural theorists have drawn attention to the overarching role of play in child development and view it as the most significant, "leading" activity of the early childhood years (Bodrova & Leong, 2007; Vygotsky, 1967). Classical research found "the most complex cognitive operations in the realm of fantasy play" (Bronfenbrenner, 1981, p.52). Acting in an imaginary situation of make believe play constitutes the basis for the child's awareness of the world around them and raises their cognition of reality to a more complex and generalized level. This, argued Vygotsky, sees the beginning of higher mental functioning and abstract thought (Vygotsky, 1978). Recently it has been argued that "children's play, especially in its make-believe or pretending game forms, is a critical precursor to a major feature of our adult narrative consciousness" (Singer & Singer, 2006, pp. 97-98).

Given the time and opportunities that young children of today have for engaging with computers, it is important that software designers understand the richness of children's traditional play and use its developmental advantages in their products. It is also essential that early childhood educators and parents are able to make an informed decision on the purchase of such products on the basis of educational or developmental value, rather than the often exaggerated claims of commercial advertising. As pointed out by Rieber (1996), "the time has come to couple the ever increasing processing capabilities of computers with the advantages of play" (p. 43). However, more than a decade on, there is still a significant gap in understanding the ways that children's spontaneous play can be related to computer games to enrich the developmental value of both.

This article describes a research study conducted to explore the use of computer games by young children, specifically to investigate the affordances and limitations of such games and the features of children's traditional play that can be supported and further enhanced by different kinds of computer play. The study was guided by the following research questions:

- What are the critical characteristics of computer games that facilitate opportunities for symbolic play? What are the criteria for their assessment?
- To what extent do computer games provide opportunities for developmental play activities and higher order thinking among early childhood learners?
- How do early childhood learners respond to computer games offering varying opportunities for play?

COMPUTER GAMES AND IMAGINATIVE PLAY

In the early childhood literature, there is a concern that the push for early academic achievements, such as teaching preschoolers to read and learn mathematics and computer skills, is rapidly replacing imaginative play in young children's lives (Elkind, 2001; Cordes & Miller, n.d.). A similar situation appears to dominate the increasing market of computer software for young children: there is a strong commercial push in educational software designed to enhance basic skills of literacy and numeracy. To make the educational content of these software packages more attractive to children, designers use a play oriented approach, often equating play with fun only, thereby diminishing the potential developmental value of such software in enhancing children's generic higher order cognitive skills.

By the same token, there may be significant underestimation of the potential developmental value of computer play designed for the purposes of children's recreation and entertainment. Educators might perceive recreational games as not suitable for educational purposes based on the range of existing arcade games "which are generally narrow, violent, and fantastical" (Buchanan, 2003, p.10). Negative reaction to such games together with the prevalence of criticism of gaming in the literature (Carrington & Marsh, 2005) might stop educators from thinking of positive aspects of other kinds of computer play. There is a concern that "most of the research on computer and video games has focused on possible negative influences and the evaluation of policy designed to minimize risk to children and adolescents" (Salonius-Pasternak & Gelfond, 2005, p. 6).

If computer play in its different forms is to become a significant part of young children's lives, an examination of its developmental value is required from the same perspective that is taken when considering the significance of traditional forms of play in child development. Relatively little is known about the development of young children's thinking within the context of a computer game, or how to investigate and research it (Ko, 2002). Theories of play can provide significant assistance in understanding this process, as it is in a child's natural play that the foundations for further development of higher mental functions are formed.

One of the most important and powerful impacts of play on young children's cognition is the development of mental images and symbolic representations which lay the foundation for the development of children's imagination and abstract thinking. The pretend situation of a child's play creates an imaginative dimension in which he or she uses symbols and signs to substitute for objects and acts. Separation of the meaning from the object promotes the development of abstract ideas and abstract, verbal thinking. In actions such as riding a broomstick as if it were a horse, a child separates the literal meaning of the object from its imagined meaning, and the stick becomes "a pivot between the real and the imagined" (Bruner, 1976, p. 49) . By pretending to be a mother, the child may explore and advance his or her understanding of the norms and rules of family functioning (Vygotsky, 1978).

Since most software programs provide meticulously detailed and realistic representations of objects and landscapes, imaginative substitution of things and actions is generally neither encouraged nor possible for young players. A significant lack of such developmental opportunities in most software may undermine the wisdom of allowing very young children to spend many hours on computers in the belief that such activity facilitates cognitive development.

Computer programs are often produced atheoretically for cosmetic appeal using animations, color, sound, surprise and vibrancy as the basis of their design, rather than pedagogical principles or developmental theories of play (Papert, 1998). The research described in this article contributes to the theoretical basis for computer play design by researching and applying theories of play (established in conventional play settings) to children's use of computer games, and by investigating whether aspects of computer play provide unique affordances for children's development that are simply not possible in natural play.

APPROACH AND METHODOLOGY

The data gathering and analysis was based in the traditional techniques of child's play observation: the children's speech samples and behavioral episodes were noted, in particular those that indicated their engagement in imaginary play (e.g., undertaking the roles of others, variations in labeling the situations and objects, interactions with peers and the adult about situations of pretend). The study was conducted in several stages.

Stage1: Literature review. A comprehensive literature search and analysis was undertaken to explore current research and theory on the affordances offered by different kinds of computer play in assisting children's and young adults' cognitive development (a more complete discussion of the findings of this stage is presented in Peterson, Verenikina, & Herrington, 2008). Features of different kinds of play software that are associated with the development of higher order thinking were identified. Both theoretical and empirical research sources were analyzed. On the basis of the literature analysis, a preliminary list of criteria was developed for assessing the affordances of computer play.

Stage 2: Software review and selection. Computer software designed for children aged 4-8 years was located, analyzed, and classified to select different types of software for further exploration in Stage 3 (for further discussion of this process see Peterson et al., 2008). The computer games were selected in accordance with the criteria identified in the previous stage, or the closest match to the criteria.

Stage 3: Observation and analysis. In Stage 3, observation and analysis of children's engagement with different kinds of software identified in Stage 2, was conducted. The sessions were videotaped for later analysis, and the mother of the two children who were observed in the study was also interviewed.

Stage 1: Reviewing the Affordances of Computer Play

The Literature Review: There have been a number of studies that have demonstrated the influence of children's computer play on their cognitive and socio-emotional development (Amory et al., 1999; de Aguilera & Mendiz, 2003; Flintoff, 2002; Cassell & Ryokai, 2001; Ko, 2002; Pillay, 2003 and others). Many studies examined the value of computer play for learning (de Aguilera & Mendiz). Computer games can be useful in enhancing memory capacity (Haugland, 1992; Amory et al., 1999; Flintoff, 2002), attention span (Green & Bavelier, 2003), and the problem-solving strategies of children (de Aguilera & Mendiz, 2003; Doolittle, 1995), each of which can, in turn, affect their academic achievements (Flintoff, 2002).

Research indicates that there is similarity between mental skills used in computer based educational tasks and those used in recreational games (Pillay, 2003; Ko, 2002). Pillay explored the transfer of cognitive and metacognitive skills developed in recreational computer games to high school children's subsequent performance on computer-based educational tasks. Skills such as generating alternative solutions, information organization, and computer screen navigation were consistent between the two types of computer activity. Similar results were obtained in the research of Ko (2002), which identified a number of logical thinking strategies that were used in recreational computer games. Cassell and Ryokai (2001) described a computer-based environment, StoryMat, which can enhance developmentally advanced forms of children's collaborative storytelling, develop fantasy and imagination that provide a bridge to written literacy.

Yelland (2005) provided an overview of numerous studies that examined the use of computers in early childhood education. Even though the early childhood curriculum is traditionally based in play (Van Hoorn, Noujrot, Scales, & Alward, 2003), the majority of considered studies are focused on the use of computers to enhance learning in a particular curriculum area. It was demonstrated that the use of technologies can raise the level of early childhood curriculum so that "young children can not only experience concepts that were previously well beyond that expected of them but that they could deploy sophisticated strategies and work collaboratively with others in new and dynamic ways in technological environments" (Yelland, p. 224). In particular, computer software can provide advantages for teaching abstract mathematical concepts such as shapes, which challenges the idea that the early childhood curriculum has to be predominantly based on the use of concrete materials. Research demonstrated pedagogical benefits in using the computer-based manipulatives for advancing children's ability in abstract thought (Clements as cited in Yelland, 2005). In regards to children's play it was concluded that "the manipulation of symbols and images on the computer screen represents a new form of symbolic play, in which children treat the screen images as concretely as they do the manipulation of any alternative blocks and small-world toys" (Brooker as cited in Yelland, 2005, p. 221). This study indicated that there is potential for further exploration of the affordances of computer play in the development of children's ability for higher order thinking. Similarly, Salonius-Pasternak and Gelfond (2005) argued that computer play is perhaps "the first qualitatively different form of play that has been introduced in at least several hundred years," and "it merits an especially careful examination of its role in the lives of children" (p. 6).

Early childhood educators talk about developmentally appropriate use of computer technologies (National Association for the Education of Young Children [NAEYC], 1996). They suggested that to be effective, computer software should be designed in a pedagogical manner suitable for young children, that is, create an environment where children can play, explore, investigate, solve problems, and do puzzles and other activities which promote communication, interaction, discovery and problem solving (NAEYC, 1996; Downes, Arthur, & Beecher, 2001). The use of technologies in early years needs to be informed by modern pedagogies. It was demonstrated that in Reggio Emilia preschools, for example, long-term projects enhanced by a variety of computer technologies, promoted significant growth in childrenís thinking and social development (Trepanier-Street, Hong, & Bauer, 2001).

Characteristics of Computer Games That Promote Higher-Order Learning Through Play

As a result of the literature review and analysis of research into play and computer games, characteristics were extracted and used to guide the choice of computer games for the study and to inform the analysis of the data. It was proposed that a computer game or program exhibiting the following characteristics would have the best chance of enabling and promoting higher order thinking and developmental play. Table 1 groups the elements by factors, giving characteristics of the game itself and the manifestation of each characteristic in play, together with supporting literature.

Table 1
Characteristics of Computer Games That Promote Young Children's Development

Factor	The computer game:	Play effects:	References
Motivation	is intrinsically fun and is not limited in scope to "teaching" particular skills	fun, state of flow, intrinsic motivation	Kirriemuir, & McFarlane, 2004; Squire, 2003; Malone & Lepper, 1987; Bowman, 1982
	allows play for the sake of play—reaching goals is less important	no visible goal, possibly unintentional play	Let'sPlay!, 2000
Context	relates to daily life—sounds and objects from daily life, and other things that the child can recognize	uses familiar objects consistently throughout the program	Ellis & Blashki, 2004; Haughland & Shade, 1988; Cordova & Lepper, 1996; Let'sPlay!, 2000
	can be incorporated into children's imaginative play	engaging in pretend, make-believe play	Siraj-Blatchford & Whitebread, 2003; Cole, 1996
Path	is discovery-oriented	children explore situations in an open-ended, nonlinear manner; free exploration	Haughland & Shade, 1988; Rouse & Ogden, 2001; Bredekamp & Copple, 1997; Gredler, 1996
	allows children choices in selection and timing of activities	children in control of selection, timing and pace	Downes et al., 2001; Siraj-Blatchford & Whitebread, 2003; Cordova & Lepper, 1996; Dawes & Dumbleton, 2001
	allows the manipulation of symbols and images on the computer screen	symbolization by children, engage in make-believe and situations of pretend;	Brooker as cited in Yelland, 2005
	provides the facility to engage collaboratively with the program rather than exclusively single player	discuss, talk, children seek collaboration	Downes et al., 2001; Brooker as cited in Yelland, 2005; Rouse & Ogden, 2001; Lindstrand, 2001; Dawes & Dumbleton, 2001
	provides visible transformations	children's actions impact the program; their decisions and choices have consequences	Siraj-Blatchford & Whitebread, 2003; Haughland & Shade, 1988; Let'sPlay!, 2000
	enables increasing complexity	children move to more complex levels of the program	Haughland & Shade, 1988; Let'sPlay!, 2000

Access	provides spoken directions (as children may not be old enough to read), or provides advice when children need assistance from more experienced players	children listen and follow directions, or children seem to be "stuck" and cannot move forward without further assistance	Let'sPlay!, 2000
	employs an uncluttered screen design with simple background, coloring, and graphics	children seem to respond well to the interface and are not distracted by meaningless features	Let'sPlay!, 2000

For use in Stage 2 of the study, games were chosen that best matched the characteristics listed in Column 2 of Table 1. In Stage 3, the study involved two children, (siblings, a girl aged 7 and a boy aged 5) who were systematically observed as they engaged with the computer games. The ability of the games to offer developmental opportunities to deal with symbolic representations and abstractions of different kinds was then assessed. The choice of siblings allowed the children to engage in comfortable and familiar communication, stimulating a higher level of engagement in free pretend play (Crawford, 2002). The data gathering involved observing and videotaping the children as they played with nine different computer games, in three different locations and over varying amounts of time. The schedule of observations is provided in Table 2.

The children were observed playing on separate adjacent computers or together on the one computer in different sessions. The children's mother and a teenage helper who knew some of the software, together with the researchers, were available to help the children with the games, in different configurations throughout the research. Three locations were chosen iteratively to enhance the quality and nature of the play experience for the children. The first location was a classroom at the university, chosen because it was the home centre for a specialized primary preservice teacher classroom. It was very cheerfully decorated with displays of children's work on the walls, and it had small-sized furniture. Two sessions were conducted in this room, but as it was foreign to the children, the engagement with the games was not naturalistic. Two sessions were also conducted in a usability laboratory to enable the children to play the games without the researchers being in the same room. While this facilitated data gathering, it did not lead to the children participating in the games through free choice, or as they might in their own home environment. The third location used for the remainder of the sessions was the children's home. The children's mother monitored the children's use of the computer games and videotaped their play.

Table 2
Schedule of Observed Computer Game Play Sessions

Session	Software category	Name of software	Software characteristics	Duration of session	Location
1	Simulation/ puzzle	Thinkin' Things 1 Thinkin' Things 3	Open-ended problem solving	50 mins	Classroom
2	Simulation/ puzzle	Sammy's Science House	Closed problem solving	60 mins	Classroom
	Adventure/ action	Pajama Sam	Closed problem solving, linear play		
3	Simulation	Dogz	Open-ended problem solving	55 mins	Usability lab
	Puzzle/ action	Jump Start	Closed problem solving		
4	Simulation	Dogz	Open-ended problem solving	60 mins	Home
5	Simulation	Dogz	Open-ended problem solving	75 mins	Home
	Adventure/ action	Spy Fox	Closed problem solving, linear play		
6	Simulation/ puzzle	At the Vet's At the Cafe	Closed problem solving	30 mins	Home
7	Simulation/ puzzle	At the Vet's At the Doctor's	Closed problem solving	30 mins	Home
8, 9, 11, 12	Simulation	Sim City	Open-ended problem solving	130, 20, 45, 55 mins	Home

Data Capture

The test setup in the classroom included four MiniDV camcorders on tripods. Two laptops were also attached to monitors, allowing the computer software to be viewed simultaneously on both the laptop screens and peripheral monitors. One camera was set up directly in front of each of the two peripheral monitors. To capture facial expressions, the other two cameras were set up just to the front and a little off to the side of each participant. To reduce flickering, the peripheral monitors were set to the fastest frequency possible that is still divisible by the camcorder's frequency (the refresh rate of consumer MiniDV camcorders is generally about 50 Hertz). For this study, the peripheral monitors were set at a resolution of 800 by 600 pixels and 100 Hertz refresh frequency (50 Hertz x 2 = 100 Hertz). The main challenge with the classroom setup was the synchronization of recordings. To achieve this, recordings were started with each camera and then a clap of hands, within view of all of the cameras, enabled sound and vision to be synchronized. This method is not perfect, but for the purposes of this study, it was sufficient.

The test setup in the usability lab was more effective at synchronizing multiple audiovisual inputs. The setup included two video cameras, two desktop computers, and a VCR. Screen-capture software was loaded on the computers. One camera was angled to capture facial expressions and the other to capture keyboard and mouse use as well as general activity around the computers. The microphone on one camera was switched on to capture audio. A four-port audiovisual switch captured input from the two cameras as well as the two computers, allowing for synchronized recording of both audio and video onto one VHS cassette. The VHS recorder was attached to a portable digital video recorder for conversion to digital format for easy playback on a computer.

The data capture in the home was achieved using a MiniDV camcorder angled to capture images from both screen events and facial expressions. The same camcorder also recorded audio of the game and the conversation between the children. Field notes were taken throughout observations while the children interacted with the software. A preliminary analysis of videos was conducted by time code with the researchers noting behavior and talk of interest together with notes on initial interpretations. The data was analyzed using a process of data reduction, data display, conclusion drawing, and verification (Miles & Huberman, 1994).

AFFORDANCES AND LIMITATIONS OF COMPUTER PROGRAMS FOR DEVELOPMENTAL PLAY

The analysis used the literature based criteria listed in Table 1 as an observation checklist. Three games and the children's responses are discussed next.

Pajama Sam. Pajama Sam, No Need to Hide When It's Dark Outside, by Humongous Entertainment, is designed for children aged 5 to 8. It is a mystery adventure game in which the main character, Pajama Sam, must conquer his fear of the dark to reclaim his lost possessions. Game play is set in the land of darkness, an imaginary world located in Sam's closet. To navigate through the land of darkness, Sam must complete a series of problem-solving tasks with the help of an array of animated objects such as Otto, the boat.

The children were observed playing this game for one session in the study. When observed against the criteria described in Table 1, most of the elements appeared to be present albeit in varying degrees. The children were both familiar with the game, as it was one of their personal favorites. They took turns playing the game, first Joshua (pseudonyms used) with the support and assistance of Bronte, then Bronte by herself. In terms of motivation factors, the children were clearly absorbed and having fun with the game, but perhaps because of the brevity of the observed session and the unfamiliar surroundings they did not appear to reach a state of deep flow (Csikszentmihalyi, 1992). Both children appeared to play for the sake of play, and were happy to explore the virtual world at leisure. This lack of goal orientation was confirmed by the children's mother who noted that, unlike their older sister Lizzy (11 years old), the younger children were never intent upon finishing the game—they were happy exploring. For example, there are odd socks in various places throughout the game that can be collected and taken back to the laundry for sorting. While the younger children enjoyed this diversion from the goal of the game, playing it many times just for the fun of it, Lizzy only tried this once.

In terms of the path, the game generally allowed free and nonlinear pathways, although at times this was limited. For example, there may be a choice of two options, but both need to be completed before advancing in the game. There were subtle but obvious hints as to the timing expected at certain points in the game. For example, Pajama Sam would cross his arms and tap his foot if the child took longer than expected to make a decision.

While there was little opportunity for children to manipulate the objects on the screen in unintended or make believe ways, Joshua in particular, carried the character of Pajama Sam into his everyday play. Sam's hair and dress style were mimicked by Joshua, he arranged his room to look like Pajama Sam's room and he modeled many of the character's behaviors, such as running and jumping off stairs, and using a torch in dark spaces. When playing together, the children collaborated to the extent of making recommendations about what to click and where to go, but only one child controlled the mouse, so in this sense the game was not truly collaborative.

In terms of access factors, the game is not one where more simple levels must be completed before moving to advanced stages. Children simply move through the stages of the game. The feedback and impact of the children's actions clearly directed the character's progress, and there was immediate feedback in this sense. Clear verbal instructions were given to enable children to begin easily and to understand the aim of the game.

Dogz. Ubisoft's computer game Dogz is a simulation game designed to provide players (children and/or adults) with an opportunity to create and take care of their own virtual pet dog. The player is responsible for feeding, cleaning, playing and training the pet. The game was chosen as it had most of the characteristics presented in Table 1 and it appeared to have strong potential to stimulate children's make-believe play.

The game was initially introduced to the children in a Usability Lab where Joshua and Bronte were observed and taped during 55 minutes of computer play. Both the children were highly motivated to play Dogz as at that time their family was about the get a real dog. As the game didn't allow for two simultaneous players, Bronte and Joshua had to alternate. Bronte was the first to play and she needed support to get started and to move forward. The objects and situations were obviously familiar to her, but the ways of dealing with them were not always intuitive. For example, she could not give the dog food by putting it in front of him, but she needed to bring it right to his mouth; and she could not get food directly from the fridge, but she needed to open a briefcase for that. Joshua also needed plenty of assistance to get him started. Once he created the dog, he started exploring the possibilities. His way of exploring was different than that of his sister, and was often just a repetitive practice of single features. For example, Joshua appeared to be very interested in stroking the dog and looking at the red hearts that appeared on screen as an indication of the dog receiving loving care. He came back again and again to this during the observed session.

This is an interesting example of the affordances of computer play compared to traditional forms of play. In traditional play, when a child repeatedly strokes a toy dog, such actions are usually classified as significant but yet "immature play" (Bodrova & Leong, 2007, p.145). In computer play, however, this "simple act of pretend" is extended by providing, in a symbolic form, a visual support to the idea of "loving care," thus taking play to a new level of abstraction. This finding supports the importance of, and reveals further potential in, the design principle: *Provides visible transformations, children's actions impact the program; their decisions and choices have consequences* (see Table 1).

In the previous example, the program not only allowed children to see the consequences of "their decisions and choices" but provided them with a visualization of an underlying, abstract idea of "care"—the appearance of red hearts linked to the child patting the dog. It can be argued that such visualization might assist the child's internalization of this complex abstract idea, as it is through play that the child achieves a "functional definition of the concept or object" (Vygotsky, 1978, p. 99).

To advance his game Joshua needed assistance either from an adult or from his sister. For example, Bronte's question about what he bought for his pet, prompted him to go "shopping" for the dog as well as complete a simple training session. Once the children mastered the main elements of the game and were able to engage in it at their own pace in a comfortable home environment, Joshua, Bronte, and their older sister Lizzy created a make believe environment, best described as a "community of dog owners": each of the children had their own pet-dog, which they named and looked after. They appeared to engage in make-believe episodes on a regular basis, coming back to it in everyday conversations with each other. For example, Joshua began a conversation with Bronte by asking, "Do you have a suit of armour for your dog?" to which, Bronte replied, "No, I got the big hat instead because I am going outside to the backyard." Later on they included in this on-going make-believe play, characters that they created in the Nintendo version of Dogz, thus owning a number of dogs each. They "looked after" each other's dogs, taking them for walks and giving them treats. They were also observed using each other's dogs during sibling disagreements, making comments such as "I will take Ruby [the sibling's virtual dog] for a walk until she is tired and hungry and then I won't give her any food!"

Some frustrating features of the game were time restriction and repetitive music during the dog show, which were annoying for the children. Interestingly, when the children were given the game At the Vet's to play, Bronte, who wants to be a vet, was really disappointed when the restriction of the game did not allow her to become the character herself, and she could participate only vicariously. For example, Bronte wanted to select her own course of treatment for the sick cat that had a sore foot. The restrictive setup of the game, however, would not afford her such opportunities; she was expected to give an injection and some medicine followed by the bill. Quite disgruntled, Bronte exclaimed, "I don't want to give him a needle because it won't fix his sore foot!" Obviously, Bronte was frustrated by not being able to play out the role of a veterinarian properly, as she knew it from real visits to a doctor or vet. This is consistent with observations of traditional play, where young children were found to be sensitive to following the rules of their character correctly according to the rules learned from real-life situations (Leontiev, 1981).

Playing out the roles of real people or fictional characters that they observe, children acquire and internalize the rules and norms of functioning in society. Undertaking the role of a doctor, mother, or salesperson in a grocery store, they need to follow the rules of real behavior appropriate for the role (Vygotsky, 1967). Children borrow the rules from real life but to acquire them they have to put them at the centre of their attention. "What passes unnoticed by the child in real life becomes a rule of behavior in play" (Vygotsky, 1967, p. 9). The design of a computer game, which represents such rules in an inaccurate way, is most likely to be restrictive for children's spontaneous engagement in developmental play. Our literature review identified a design principle which suggests that software for young children should represent *objects from daily life, and other things that the child can recognize* (Table 1). This needs to be extended to the actions of game characters and the rules of their behavior, which should be relevant to the context of children's real lives.

Sim City. Sim City is a simulation game by Maxis that allows users to build cities and inhabited environments. The open-ended "designer" nature of this game suggested it could be a most appropriate vehicle for developmental play. Most Sim games are rated M, so the lowest rated game was chosen, in this case a PG rating.

Initially, the rules of the game were quite challenging for the children to understand, and the large number of options available to them meant that they found it quite confronting to begin with. There were no verbal directions on how to get started with the game, and while both children could read, the text on screen was very small and difficult for them to read. However, both children were highly absorbed after a few sessions of play. The game has an initial "God" mode, where players create the worlds they wish to inhabit, and both children spent a great deal of time creating and recreating these worlds. The object of the game was not apparent to them, so there was no intention to achieve a goal in a short time, and the enjoyment and creativity involved in creating the worlds was in itself rewarding to both children.

While the objects themselves that children could create (such as landscapes, animals, and buildings) were realistic and life-like to the children, the manner of making the features was not. They were not familiar with the toolbar and its symbols, and trial and error was used to learn the functions. Both children were able to freely explore the worlds they created, although at certain points the game itself controlled the action, such as, if the child created an airport, a plane would appear.

The creation of different objects and the consequences of the actions meant that Joshua was able to manipulate and use objects symbolically. For example, he would try to use lightning bolts as weapons to shoot robots (a function not supported in the game). He also created and used trains more like racing cars than a vehicle for mass transit, resulting in many train crashes. Joshua's attempts to use objects in ways other than intended by the game designers indicates a desire to engage in imaginative play. However, the game software does not allow for a multifunctional use of the objects, which is somewhat restrictive for a child's imagination and can be considered as a limitation of the design. Symbolic play—the use of objects to substitute for other things in play—is a common and important developmental feature of traditional pretend play. It allows for the development of imagination and contributes to later developments in children's abstract thinking (Vygotsky, 1978). Thus, it might be worthwhile investigating how this can be used in the design of computer games.

The make-believe play that the children engaged in after playing the game was very strong. For example, the children's mother observed multiple instances of talk involving the game, such as asking each other about what they had created "when they were God." They did not engage in make-believe role playing, that is, they did not pretend to be any of the characters they invented. The children did not seek to collaborate on the creation of a common world (each had their own separate world), but they did collaborate and support each other to discover features of the game and to consolidate their understanding. The children found the game to be challenging and engaging over multiple sessions of play. In many respects, the SimCity game was above the children's age, however, it was chosen for research because they already had it at home and engaged in playing it together with their older sister.

FINDINGS AND CONCLUSION

This study has proposed that a computer game or program that supports higher order thinking and facilitates developmental play has characteristics such as:

Motivation factors

• is intrinsically fun and not limited in scope to "teaching" particular skills

• allows play for the sake of play—reaching goals is less important

Context

• relates to daily life—sounds and objects from daily life, and other things that the child can recognize; the actions of the characters and the rules of their behavior are relevant to the context of children's real life

• can be incorporated into children's imaginative play

Path

• is discovery-oriented

• allows children choices in the selection and timing of activities; allows for multi-functional use of the objects represented on the screen

• allows the manipulation of symbols and images on the computer screen

• provides the facility to engage collaboratively with the program rather than exclusively in single player mode

• provides visible transformations on screen

• enables increasing complexity

Access

• provides spoken directions (as children may not be old enough to read), or provides advice that children need assistance from more experienced players

• employs an uncluttered screen design with simple background, coloring, and graphics.

These principles, which have emerged from the literature review (summarized and referenced in Table 1) and the data, could usefully guide designers in creating games that facilitate developmental play. To maximize engagement in make-believe and to avoid restricting and frustrating children, game design and activities need to be realistic in their depiction of real life. For example, the Dogz game could have allowed a variety of more realistic possibilities for feeding the dog, not just putting the food in his mouth, but putting it in front of him on the floor, or feeding him outside at his kennel rather than anywhere and anytime.

It appeared from data analysis that there is at least rudimentary evidence that significant opportunities for engagement and developmental play exist in the playing of computer games. In all three games described here, ample opportunities were presented for young children to explore the environments in imaginative and make-believe ways, both within the games and beyond to a child's everyday play.

The data also suggest that make-believe is at its best when children play as a group. An individual young child can engage in simple acts of symbolic play but needs communication with others to create complex scenarios. The use of objects within the games in imaginative and symbolic ways (such as lightning being used as a weapon) was a very strong indicator that computer games do not necessarily constrain children's play to movements predetermined by game designers. While it is possible that some games do inhibit imaginative play, the games chosen for the study appeared to enable developmental play in often unintended ways, at least to some extent.

In terms of the research methodology and data collection locations, the research indicated quite strongly that observations need to be made in a natural setting such as a home environment. Indeed some of the confirming data would have been lost to the researchers except for the observations of the children's mother in home play settings far removed from the laboratory. Make-believe needs to be observed both "on and off screen" (Carrington & Marsh, 2005, p. 282) as children extend their play into real life situations.

If we are to believe Salonius-Pasternak and Gelfond's (2005) contention that computer play is, perhaps, "the first qualitatively different form of play that has been introduced in at least several hundred years" (p. 6), then we must also accept their challenge to examine it carefully in the context of its role in the lives of children. This research has accepted this challenge, by investigating and classifying types of computer games, researching and interrogating the literature for existing knowledge and principles on the use of computer games with young children, extracting salient principles from these works for both the design of computer games and their visible effects, and observing and researching the use of the games with two children in three different data collection contexts. Our study suggests that there is still a great deal of research to be done in identifying the conditions under which computer games best facilitate developmental play and higher order thinking in very young children.

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