Using Interactive Fitness and Exergames to Develop Physical Literacy

By Dwayne Sheehan and Larry Katz

Introduction

Children today see screen technologies as integral to their daily lives (Cappella, 2000; Prensky, 2001) thereby influencing how they spend their spare time and affecting time spent engaging in physical activity. Excessive sedentary screen time has contributed to an increase in childhood obesity, higher incidences of disease, and difficulties learning in school (Hancox & Poulton, 2005; Robinson, 2001; Summerford, 2001; Vandewater, Bickham, & Lee, 2006; Vandewater, et al., 2005). With sedentary screen time at an all-time high, research has shown that a new movement in interactive games technologies, known as interactive fitness or exergames, is motivating children to be more active in an environment comfortable to them; one based in technology and gaming (Lieberman, 1997, 2001, 2006; Prensky, 2001, 2003). The pedagogical applications of retail exergaming technology as an educational tool to help achieve physical literacy could have a significant impact in the fight against childhood inactivity.

At the heart of fighting inactivity is the development of fundamental movement skills upon which more difficult motor tasks are built. Balance is one such fundamental skill which can be further dissected to include postural stability. The potential for a beneficial change in postural stability, and other basic motor abilities, as a result of using exergames may, in the end, affect children's perceptions of physical activity by engaging them in activities that they enjoy.

Context

Various studies across Canada have found startling information regarding the sedentary lifestyles of Canadian youth. The annual 2009 Active Healthy Kids Canada Report gave Canadian children a grade of "F" in the screen time category (Active Healthy Kids Canada, 2009). National data shows that only 10% of children are meeting the recommended limit of two screen time hours (a proxy for sedentary behaviour) per day; many children are logging on average six hours per day (Active Healthy Kids Canada, 2009). Canadian children also received a grade of "F" in physical activity, where only 13% are participating in 90 minutes of recommended physical activity per day. In 2005, the Government of Alberta responded to decreased childhood physical activity by introducing mandatory daily physical activity (DPA) for all elementary-aged school children (Alberta Education, 2006). Since then, other provinces have initiated school-based physical activity requirements. However, follow up and accountability must be improved if these initiatives are to be taken seriously and ultimately proven worthwhile (Chorney, 2009). Unfortunately, the traditional physical education model does not always fit with today's students (Morey & Karp, 1998; Prensky, 2001).

Evidence shows that one reason many students dread traditional physical education programs is because those students lack the movement foundation, have poor physical fitness, or are often just not interested (Morey & Karp, 1998). Missing out on the vital building blocks for participation could stifle the opportunity for young people to develop confidence and competence during crucial

Dwayne Sheehan is an Assistant Professor in the Department of Physical Education and Recreation Studies at Mount Royal University in Calgary, Canada. He taught physical education from K-12 during his 19 years in public education. He is a past president of both the Health and Physical Education Council (HPEC) of Alberta and the Alberta Schools Athletic Association (ASAA). He is currently a Ph.D. student at the University of Calgary in the Faculty of Kinesiology.

Dr Larry Katz is a Professor at the University of Calgary in the Faculty of Kinesiology. He is the Director of the Sport Technology Research Laboratory and an award-winning developer of interactive multimedia applications. He is an Educational Psychologist interested in how people learn, and how to improve human performance through the use of technology.

physical skill development stages. Examples of these fundamental movement skills are running, hopping, catching, and throwing. These skills are often preceded by the acquisition of agility, balance, coordination and laterality. Children who have not developed these abilities face difficulties later in situations that require a more difficult skill set (Canada Sport for Life, 2009). Being unable to participate fully in daily school activities can then lead to feelings of exclusion, which can affect a child's self-esteem and their academic performance (Tremblay, Inman, & Willms, 2000). This negative cycle must be improved through creative quality physical education and unique extracurricular programs (Canadian Paediatric Society, 2002).

The intrinsic motivation of interactive fitness and exergaming

Hinson (1995) has identified five components that are essential for intrinsically motivating children to participate in physical activity: **control**, **challenge, curiosity**, **creativity**, **and constant feedback**. Without an inherent desire to participate in physical activity, some children will continue to "slip through the cracks" toward a lifetime of obesity-related health issues. A physical education program that can inspire children to take responsibility for their health by being physically active may look very different for some students. Today's youth may be motivated to partake in fitness activities that are interactive, technologically driven, and ultimately more rewarding than traditional physical education models (Cappella, 2000; Prensky, 2001, 2003).

Exergames and interactive fitness are videogames with an interface that requires active involvement and the exertion of physical force by its participants. The trend toward this type of videogame has provided an active alternative to traditional sedentary video gaming (Graf, Pratt, Hester, & Short, 2009). Although studies have produced some encouraging results regarding the energy expenditure involved in playing active games, exergaming is no substitute for real sports and activities (Daley, 2009). Being active helps children to naturally develop essential motor skills, but not every child develops movement fundamentals at the same pace or in the same way. Exergaming and interactive fitness activities could provide the stimulus for engagement to those students who have started to lose interest in more traditional forms of physical activity. The graduated levels of contemporary exergaming allow children to progress at a pace that is individualized to their physiological and psychological readiness. The excitement of advancing to a higher and more difficult level can be a powerful motivational tool and the virtual world of

Exergames are a fun, social, and inclusive way for children to be active and hold promise as tools for the development of fundamental movement skills. Development of physical literacy requires connections to each of the learning domains (e.g., locomotive, non-locomotive, and manipulative skill improvement). Exergames are videogames with an interface that requires active involvement and the exertion of physical force by its participants. In this paper, the interface between exergaming and physical literacy is addressed. In addition, six attributes applicable to exergaming are identified as essential for intrinsically motivating children to be active. The paper introduces both the Exergaming Experience Rating System (EERS), a wiki-based "living document" used to assess the applicability of games to physical literacy outcomes, and the Canadian Exergaming Research Centre studying the impact of active video gaming on the acquisition of fundamental movement skills. Discussion centres on the role of blending technology, physical activity, and motivation..

Les jeux-exercices Exergames offrent un moyen amusant, social et inclusif d'aider les enfants à devenir plus actifs physiquement et constituent des outils prometteurs qui pourraient s'avérer fort utiles au développement d'habiletés motrices fondamentales. L'acquisition du savoir-faire physique exige qu'on établisse des liens avec chaque domaine d'apprentissage (p. ex., amélioration des habiletés locomotrices et non locomotrices, ainsi que des habiletés de manipulation). Il s'agit de jeux vidéo avec une interface exigeant une participation active et une démonstration de force physique de la part des participants. Cet article s'intéresse aux interfaces entre les jeux-exercices et le savoir-faire physique. Il identifie également six attributs applicables aux jeux-exercices, les jugeant essentiels pour arriver à motiver intrinsèquement les enfants à être actifs. L'article présente un système pour coter l'expérience avec les jeux-exercices (Exergaming Experience Rating System), soit un « document vivant » sur wiki qui permet d'évaluer l'applicabilité des jeux en fonction des résultats du savoir-faire physique, ainsi que le Canadian Exergaming Research Centre qui étudie l'impact des jeux vidéo actifs sur l'acquisition d'habiletés motrices fondamentales. La discussion tourne autour du rôle des amalgames de technologie, d'activité physique et de motivation.

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active gaming can provide users with a safe yet exciting version of reality. Beck and Wade (2004) state that the attraction to the gaming world is due to the simplicity of the games, the customized reward system, and the highly stimulating entertainment experience that allows players to escape from boredom. With 86.2 percent of children stating that fun is the most important part of growing up (Lindstrom & Seybold, 2003), activities that do not include a healthy degree of excitement are quickly left behind. If the high "fun factor" is attracting children to try new games, exergames such as Wii Fit, Dance Dance Revolution (DDR), XR Board, and Lightspace could be used to encourage physical activity and assist in the acquisition of fundamental movement skills. Wii Fit is an exercise video game that utilizes a peripheral balance board for players to participate in activities. DDR is a dance video game that utilizes a platform for players to synchronize their steps to the music and visual cues. XR Board is a balancing video game that requires a player to stand on a modified skateboard and use their body as the human joystick to virtually snowboard or surf. Lightspace is an interactive surface of colourful lights and sound that requires a player to move quickly from one lit panel to another. Not surprisingly, the components of intrinsic motivation identified by Hinson (1995) are readily apparent in active video games:

Control is evident in the individualized manner in which a child participates in the game. They are free to pause, restart, and end a game at will. There is control in the selection of the game, its level, and when they want to play. This independence is a strong influence on younger children who are so desperately seeking self-sufficiency and an opportunity to make their own choices.

Challenge is an essential element of any successful video game. Progressive levels of increased difficulty provide the user with periodic accomplishment and setback. The ability for a child to accept defeat and persevere is a strong life lesson not unlike that gained through sports. The capacity to cope with these challenges and eventually succeed is evident when children are actively playing for prolonged periods of time.

Curiosity and ambiguity about the next activity helps keep a child engaged and motivated. Many video games are designed for a child to achieve objectives in a number of different ways. Children will often search for a faster or more efficient way to progress through the level. Hidden clues and "gems" cultivate the player's curiosity.

Creativity is related to curiosity in that how a child chooses to plays the game can often be an expression of their personality. The virtual environment of age-appropriate exergaming provides children with the ability to take risk-free chances and think "outside the box". Experimentation and problem solving are the foundation of any elementary school experience and can be achieved while being active during exergaming.

Constant feedback is evident throughout an active gaming experience. A player is often bombarded with details about his or her progress, the details of which only the most serious players can absorb. Yet children thrive on this personalized information and can adjust their strategy to improve their results. Knowing how they are doing at all times will inevitably keep children engaged and focused.

A sixth intrinsically motivating component could be added to the "5C's" (Hinson, 2001) listed above. **Competition** is an underlying premise of most games, whether it occurs on a playground, ice rink, or in front of a television monitor. Children have the ability to choose their level of opposition to ensure their competitive experience is both rewarding and demanding. Success results in

Table 1: Connections between interactive video games and the learning domains

Learning Domain	Level	Examples While Participating in Active Gaming
Cognitive (Bloom, 1956)	Knowledge	Remembering sequences and patterns
	Comprehension	Interpreting challenges and predicting outcomes
	Application	Applying previous knowledge to more difficult tasks
	Analysis	Breaking down challenges to manageable pieces
	Synthesis	Creating a player that moves about in a virtual world
	Evaluation	Judging the value of games to personal health
		Evaluating one's performance in a game and identifying ways to improve performance
Affective (Krathwohl, D. R., Bloom, B. S., & Masia, B. B., 1973).	Receiving	Instructional awareness
	Responding	Knowing the safety rules and practicing them
	Valuing	Respect for equipment and others
	Organization	Balancing game play with authentic life experiences
	Internalizing	Developing a value system that reflective of how you play and live your life. Predictable behavior consistent with the characteristics of the learner
Psychomotor (Simpson, 1972)	Perception	Responding to visual cues
	Set	Readiness to participate
	Guided response	Trial and error that occurs during game play. Imitating others and practicing to improve.
	Mechanism	Confidently performing movements with proficiency
	Complex overt response	Moving with efficiency in a quick, accurate, and highly coordinated way through complex movement patterns
	Adaptation	Modifying movement patterns to respond to unexpected stimuli
	Origination	Creating new movement patterns to fit a particular situation

confidence which may be one of the reasons certain children excel in school, music, and sports. Exergaming could provide an opportunity for those children who are not progressing at the same rate to develop fundamental movement skills and become confident enough in their abilities to pursue physical activity outside a virtual environment.

Linking physical literacy to interactive fitness and exergaming

The proposed definition of physical literacy for Canadian physical educators is intended to bridge the gap between sports and physical education. The abbreviated definition is: "Individuals who are physically literate move with competence in a wide variety of physical activities that benefit the development of the whole person" (Mandigo, Francis, Lodewyk, & Lopez, 2009). The flexibility intended in this description allows for personalized proficiency during the process of skill acquisition. It also addresses the development of the whole child from the perspective of the physical, cognitive, social, and affective domains (Mandigo et al., 2009). Other definitions of physical literacy (Kentel & Dobson, 2007; Killingbeck, Bowler, Golding, & Gammon, 2007; UK Sports, 2002) are narrower and may not address the breadth of the concept as it was originally intended (Whitehead, 2001).

Interactive fitness and exergaming activities can support the development of physical literacy by making connections to each of the learning domains (See Table 1). The proposed Canadian definition of physical literacy for physical educators (Mandigo et al., 2009) describes many of the specific characteristics that are related to the process of becoming physically literate such as motivation, diversity of movement, confidence, competence, creativity, strategy, and making healthy active choices. Although the opportunity exists to develop many of these traits in a video gaming environment, that does not imply that the virtual world of physical activity (e.g., virtual skiing) is the same as real world activities (e.g., downhill skiing on the mountain). Nevertheless, there are quantifiable benefits to the acquisition of basic movement abilities while participating in active gaming.

Exergaming should never replace any child's opportunity to participate in physical activity. Interactive video games have the ability to increase energy expenditure and provide an experience that simulates actual game play. However, cycling on a virtual race course or pretending to snowboard through the trees is not the same as being in the mountains or on a secondary highway cruising at 25 kilometres per hour, regardless of the quality of the videogame graphics. Interacting with the outdoor environment and all of its uncertainties is an invaluable experience that cannot be fully duplicated with technology.

The development of virtues and character traits is a significant component of most quality physical education programs. Cooperation, fair play, sportsmanship, respect, and social skills are just a few examples. While exergaming has many unique advantages, it is also limited in its ability to offer an experience that is rich with opportunities to engage with other children. Playing an active game against someone else online may not be as advantageous as being able to communicate in person or to come in contact as part of an

Table 2: Alignment of interactive video games and a partial list of fundamental movement skills

	Balance	Agility	Coordination	Laterality	Locomotion (walk, run, skip, gallop)	Jump	Throw	Strike	Kick	Catching and Trapping	Other
Dance Games (DDR, iDance etc)	X	X	X		Run/walk In place	X					Eye-foot
Wii Fit/Plus	X	X	X		Run/walk In place						
Wii Sport/Resort		X	X		Run/walk In place			X			
XRBoard	X										
Lightspace (Wall)	X	X	X	X	Side to side	X	X	X	X	X	Reaction time
Lightspace (Floor)	X	X	X	X	Multi-directional	X					Eye-foot
3 Kick	X	X	X	X	Multi-directional	X		X	X		
Xavix (J-Mat)	X	X	X		X	X					
Bike Games (Expresso, Game Bike)			X								Cycling
Treadwall			X	X	Upward						Climb
Trazer	X	X	X			X					

Table modified from personal communication provided by Andrea Oh, iTech Fitness (2009)

actual game. Exergames like DDR have multiplayer capabilities but too often children are so focused on the screen that they forget that they are surrounded by friends. A sense of rhythm and balance may be developing while the benefit of a real social opportunity is being overlooked. Advocates of exergaming may argue that a child who develops confidence and success in DDR will be more likely to seek out social dancing opportunities in the future. The same logic is used when active video games simulate sports or other leisure activities. Children may be more inclined to attempt playing an actual sport if they have experienced the activity in the relatively safe environment of exergaming. Young people may have the confidence to try snowboarding if they have experienced success in the virtual simulation regardless of how different it is once they get out on that mountain. Exposing children to a variety of "real life" activities that they have played electronically may be an unintended but welcome benefit to active gaming.

The psychomotor domain is emphasized in the "Parental Guide for Developing Physical Literacy" created by Canadian Sport for Life as part of the nation's long-term athlete development plan (LTAD) (Higgs et al., 2008). The LTAD places a heavy emphasis on the acquisition of fundamental movement skills during the optimal years of readiness prior to puberty (Balyi, Way, Cardinal, Norris, & Higgs, 2008). There are many interpretations of fundamental movement skills and what they are exactly (Fisher et al., 2005; Hands, 2002; Hart, 2005; Knowles, 2000). Agility, balance, laterality, and coordination are arguably at the core of all movement and are considered by many as the undisputed necessities. Beyond those essentials one might suggest that running, jumping, and throwing are the priorities on which there should be a focus. Physical and Health Education Canada (PHE Canada) spotlights twelve activities in its training resource of fundamental movement skills: dodge, hop, skip, log roll, stork stand, jump, kick, dribble, throw, catch, run, and strike (Bell, Gibbons, & Temple, 2008). Regardless of the specific skills, basic movement education is generally divided into three categories: locomotive, non-locomotive

Table 3: The Exergaming Experience Rating System (IFEW, 2010)

Requirements	Comment	Grading
Game Play	The overall quality and "fun" factor of the game. Are the challenges in the game balanced, well designed and engaging?	1 = Min, 7 = Max
Game Interface	Does the game's interface(s), allow an immersive, seamless and accurate response between the user and the game - Wiimotes, balance board, camera, interactive screen, exercise equipment etc?	1 = Min, 7 = Max
Exercise and Exertion	How much physical energy is required to complete the challenges or mini-games (approximate average result)?	1 = Min, 7 = Max
Customization	Can "game play" aspects be altered and reorganised to suit the player's preferences (e.g., can you customize your avatar, can you choose which exercises to combine)?	1 = Min, 7 = Max
Skill Scale	Does the game allow for a player of any skill level to take part, and does the game scale in difficulty with the players increasing skills and abilities?	1 = Min, 7 = Max
Age Scale	How successful is the game at scaling to suit young to elderly players or how well does the game function for its designed and rated age group?	1 = Min, 7 = Max
Biometric Feedback	Is the player able to view, store and retrieve fitness, health and competition data from the game (e.g. the players score, their BMI, skill level graphs, etc)?	1 = Min, 7 = Max
Intervention Capacity	Does the game promote interest in pursuing conventional exercise or activity as a result of participation in the exergaming experience (e.g., Does Wii Tennis encourage the player to try real tennis)?	1 = Min, 7 = Max
Socialization	Does the game offer local and online multiplayer or cooperative play, which offers support & socialization between players?	1 = Min, 7 = Max
Sustainability	Does the overall exercise and gaming experience lead the user to desire repetition of the experience? This factor is the ability gain health benefits through prolonged use.	1 = Min, 7 = Max
SAFETY	A genuine effort to outline how to safely utilize the product/service that is understood by any and all participants, and is the product robust and reliable to suit its purpose	1 = Min, 7 = Max

(stability), and manipulative skills. Each of these categories is sufficiently addressed in a variety of interactive video games (See Table 2).

An interactive fitness and exergaming rating system

The industry of active gaming is relatively new and is developing very quickly. Enthusiastic players, academics, and game developers have come together online to create several informal groups that are currently establishing guidelines and principles for exergaming. The Interactive Fitness and Exergaming Network (IFEW) has developed a code of practice, definitions, and an exergaming mission statement (Interactive fitness and exergaming, 2010). The IFEW wiki has recently embarked on the Exergaming Experience Rating System (EERS) which is a living document that incorporates a diverse collection of research, definitions, and opinion. The holistic evaluation method of the EERS takes into account a number of factors when determining the final rating, including safety which is a required component (See Table 3).

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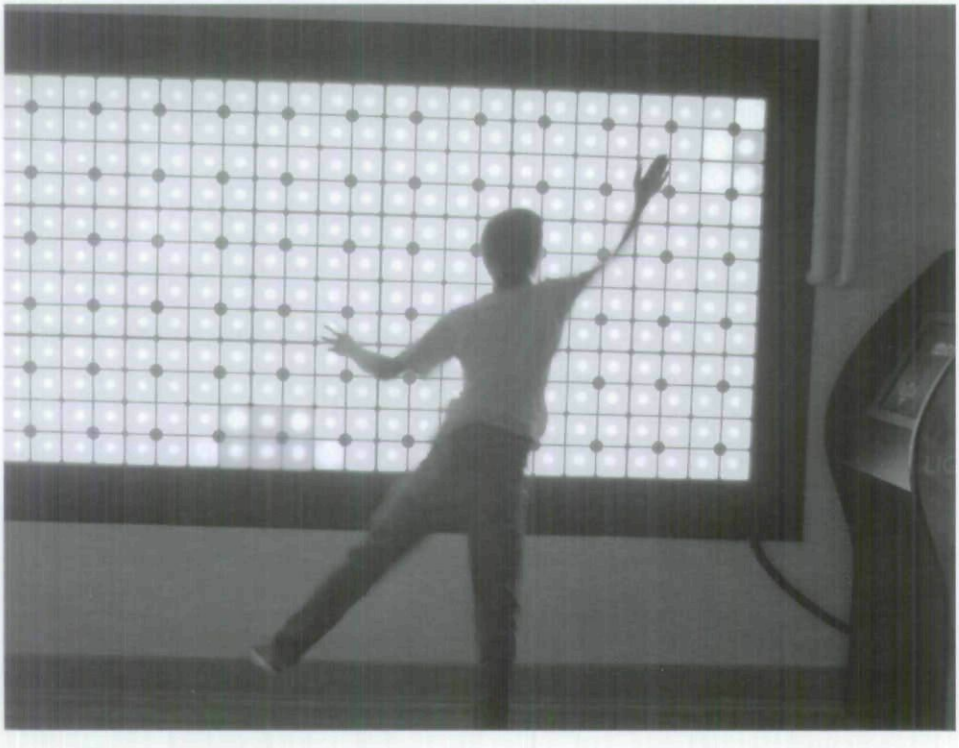
An effective rating system could provide parents and educators with an opportunity to determine the applicability of various types of games to their desired outcomes. A sample of current rating from the author's experience is provided in Table 4. The maximum score attainable is 77.

The Canadian Exergaming Research Centre

The Canadian Exergaming Research Centre (CERC) has been designed to study the impact of active video gaming on the acquisition of fundamental movement skills in children. Located in Calgary Alberta, the CERC (www.ucalgary.ca/exergaming) is situated in an elementary school with children who are at an age of optimal readiness with respect to acquiring fundamental movement skills (Higgs et al., 2008). Direct connections to the

Table 4: A sample of EERS rating for popular exergames

Requirements	iDance	Wii Fit (Plus)	Wii Sport/ Resort	XR Board	Lightspace Floor	Lightspace Wall	3 Kick	Comments
Game Play	6	7	7	6	4	5	3	
Game Interface	5	7	7	5	6	6	5	
Exercise and Exertion	7	4	5	6	6	6	6	Wii Sports exertion depends on technique used
Customization	6	6	6	5	4	4	4	
Skill Scale	6	7	7	5	6	6	4	Children must be able to read directions in Wii
Age Scale	6	7	7	5	6	6	4	Lightspace Wall must be mounted lower for children
Biometric Feedback	4	7	5	2	3	3	2	BMI feedback in Wii Fit is questionable for children
Intervention Capacity	6	7	7	5	3	3	4	
Socialization	7	7	7	6	4	4	3	
Sustainability	7	7	7	7	5	5	4	
Safety	6	6	6	4	4	4	4	
TOTAL / 77	**66**	**72**	**71**	**56**	**51**	**52**	**43**	



Alberta Physical Education Program of Studies are made to ensure that the outcomes of exergaming activities align with the relevant standards of physical education. The CERC has selected age-appropriate equipment that will help children develop balance and improve agility, coordination, and laterality. A pilot study (N=75 grade 4 students) was conducted to validate the measurement tools and equipment used in the exergaming centre. In addition to using the exergaming system during physical education class, exergaming is being introduced into the intramural program. Self-selection in participating in these activities will be quantified and measured against the overall physical activity participation rates of the students.

Current research (N=140, grade 3 & 4 students) is underway to investigate whether postural stability can be improved by the use of active gaming equipment. Student physiological performance is being measured with an HUR BT4 portable balance platform (which HUR Labs developed in Tampere, Finland) and through self-monitoring using commercially-available heart rate monitors and accelerometers. Intra-rater reliability and the reliability of student self-monitoring was established during pilot testing.

Teachers will be encouraged to use the student-generated data in math and science classes to demonstrate that exercise and fitness are not just something for the physical education class. Incorporation of personal data could improve the level of interest in math and science since the children will be working with information that is relevant to them (Prince, 2004).

Conclusion

Given the popularity of video games with young people, the concept of blending technology and physical activity will likely continue to build momentum. Exergaming and interactive fitness is a fun, social, and inclusive way for children to be active and also holds promise as a tool for the development of fundamental movement skills and the pursuit of physical literacy. ■

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