

Physical Health

Combining Physical Activity with Learning: An Interactive Approach

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Key Summary Points

1

This chapter introduces the potential of pairing physical activity with video game technology that has the potential to foster learning.

2

The chapter reviews the possible mediating factors that facilitate learning and outcomes through physical interactions with video game technology.

Key Terms

Exergaming

Activegaming

Active Learning

ActivLearning

Exercise

Physical gaming

Introduction

An educational tool that is engaging, enjoyable, improves educational outcomes, and increases physical activity levels would appear to be unlikely. Yet current advances in interactive technologies include three key components—physical activity, video gaming, and educational content—have the potential to be valuable complements to traditional forms of educational instruction (Shayne, Fogel, Miltenberger, & Koehler, 2012). The use of physical activity game-based learning or active learning games, which will be referred to as “Active Learning” throughout the chapter is characterized by the interplay of the three key components and has recently been used as a successful physical activity and e-learning

alternative (Fogel, Miltenberger, Graves, & Koehler, 2010; Mellecker, Witherspoon, & Watterson, 2013). Incorporating Active Learning into physical education lessons has shown to improve physical activity levels in inactive children and provides an active alternative that is enjoyable, improves skills that are necessary for physical movement, and increases physical activity levels (Fogel et al., 2010; Maeda & Randall, 2003). Using Active Learning inside the classroom has also resulted in promising learning outcomes, teacher acceptance, and student enjoyment (Mellecker et al., 2013).

Proponents of traditional physical education (PE) programs that focus primarily on sport and exercise regimes may be reluctant to embrace Active Learning into physical education lessons. Removed from many curriculums or cancelled due to increased focus on national and state mandated testing, physical education is slowly being eliminated from the school day (National Association for Sport and Physical Education & American Heart Association, 2012). Inclement weather conditions or lack of space also limit the amount and level of physical activity participation. For students beginning an exercise regime for the first time or for those students ridiculed due to their lack of skill or success in sport and exercise, Active Learning may prove to be an attractive alternate physical activity as most games are easy to play and can be individualized for a participants' skill level. Individualized and graded challenges (competence) and self-selected levels (autonomy) in video games allow the user to participate at a pace that suits one's skill-level and understanding, and this promotes engagement and sustainability in an activity (Sheldon & Filak, 2008). This is particularly relevant in active video gameplay, as it requires players to meet the cognitive demands, as well as the physical effort of each level in the game, but also allows players to determine the speed at which they perform a task or move to the next level. The "play at your own pace" feature in Active Learning could also instill the confidence needed to engage in physical activity. When addressing the lack of interest or unwillingness to participate in physical activity and when considering the positive attributes associated with Active Learning, there is a potential advantage to using Active Learning as a physical activity and learning alternative, which should be studied further.

Case Study One: *Learn-Pads*

Researchers at the Multimedia Communication Research Laboratory University of Ottawa designed *Learn-Pads*, a math Active Learning system. The team has piloted the program to determine whether children enjoyed their experience when playing with the *Learn-Pad* system as well as the social component of playing with others (Karime, Al Osman, Gueaieb, Aljaam, & El Saddik, 2011), both important variables for initiation and long-term adherence to learning programs and physical activity. When using the *Learn-Pads* children are given a mathematical equation, including multiplication, addition or both (e.g., $(8+3) \times 2$). To solve the math problem, children jump and jog over the *Learn-Pads* within a set time. When the children are moving over the *Learn-Pads*, verbal spelling of the number that has been reached and whether the child is reaching the correct answer accompany the movement pattern. The difficult level in the *Learn-Pads* system is customized to ensure the game is suitable for various cognitive abilities. In the first pilot study, children were asked to assess the difficulty of the math, enjoyment and whether they would recommend the *Learn-Pads* game to their friends. Subjective feedback from the children suggests that the children enjoyed playing the game. In addition, math difficulty level was determined by age and observation of the children indicates that *Learn-Pads* promote social interaction. Although it appears that the main objective of the *Learn-Pads* is to address learning math and social bonding, this first pilot study did not assess step counts or physical activity increases from stepping on the *Learn-Pads*. The authors report that this game will continue to revise the system to include more topics such as shapes, vocabulary, and letters as well as a heart rate monitor and vibrating pads. It also appears that physical activity was simply a condition for the learning to occur and for this reason it would be interesting for future research to address the benefits from the physical activity component used in the *Learn-Pad* system.

Key Frameworks

Active Learning includes physical activity and video game technology, with the added value of knowledge transfer capabilities. This is a novel and innovative approach to learning that has yet to be assigned a specific framework. Recent suggestions to create a framework for active video games that incorporates theories of play and fun include the Design, Play, and Experience (DPE) Framework (Mellecker, Lyons, & Baranowski, 2013). The expanded Design, Play and Experience (DPE) Framework suggest that bodily movements consistent when children are engaged in active video gaming evoke a sense of play. The embedded “play” in video game technology is a key component of the DPE Framework and is influenced by the learning subcomponent. The learning subcomponent in the DPE Framework drives content and pedagogy design, as well as the type of teaching that may lead to self-directed learning. This self-directed approach is also prevalent in play scenarios as children readily engage in free play and learn as a result of independently directed play. Although not specifically designed or expanded to include Active Learning, the DPE Framework includes the constructs of play as well as the subcomponents of physical activity, teaching, and learning, and therefore may help to further advance Active Learning as a tool for use in the classroom.

Key Findings

The educational benefits of combining physical activity with video games appear to be abundant. Both video gaming and physical activity increase blood flow to the brain. This response triggers numerous physiological responses, such as a catecholamine release (Koepp et al., 1998). These responses have been linked to emotions that are important for learning. Enjoyment is an important component for initiating and adhering to educational activities, as well as physical activity.

Evidence indicating positive learning outcomes from playing video games have emerged highlighting increased physical benefits (Barnett, Hinkley, Okely, Hesketh, & Salmon, 2012; Vernadkis, Gioftsidou, Antoniou, Ioannidis, & Giannous, 2012) cognitive outcomes (Chuang & Chen, 2009) and social interactions (Chou & Tsai, 2007). Functional motor skill proficiency, including object control skill, has been achieved with games designed to engage individuals in physically active gameplay (Barnett et al., 2012). Video game technology has also been useful in improving analytical skills and recall processing (Chuang & Chen, 2009). Student reports suggest that gameplay may influence relationships with friends and promote social interaction (Chou & Tsai, 2007).

To educators and parents already focused on student performance, standardized tests, and the recently added Common Core Standards (CSS), incorporating video games and more physical activity into the curriculum may seem time-consuming and counterintuitive. In reality, if physical activity is incorporated into the learning experience using a holistic approach, the potential to accomplish specific learning outcomes could surpass expectations using traditional teaching strategies (Prensky, 2001). Improvements in cognitive development and academic achievement have been reported as a result of regular participation in physical activity (Tomprowsk, Davis, Miller, & Naglieri, 2008). Physically active children have higher executive functioning (e.g., cerebral processing involved in goal directed behavior) and when compared with sedentary peers perform better academically (Best, 2010; Davis et al., 2011). When children are physically active during the school day, on-task behavior improves (Mahar et al., 2006) and emerging evidence indicates that physical activity improves behavior and cognitive performance in children with ADHD (Gapin, Labban, & Etnier, 2011). Moreover, children who engage in regular physical activity are more likely to live healthier lives, avoiding the diseases associated with an inactive lifestyle (LeMasurier & Corbin, 2006). In addition to the known physical health benefits, regular participation in physical activity also results in social competence or a willingness to interact with peers (Centers for Disease Control and Prevention, 2010) as well as positive psychological well-being, such as improved self-esteem (Nieman, 2002). Fusing physical activity into educational content and video gameplay has considerable potential in obtaining learning outcomes. Learning benefits may be possible with even short bursts of activity that are synonymous with child activity patterns (Bailey et al., 1995).

Recently, educators have implemented physically active video gaming or active video gaming in physical education classes, increasing the opportunity for students to engage in physical activity while participating in an enjoyable activity (Maloney, Stempel, Wood, Patraitis, & Beaudoin, 2012).

Although newly introduced, active video gaming has been shown to increase motor skills (Barnett et al., 2012), balance (Sheehan & Katz, 2013), executive function skills (Staiano, Abraham, & Calvert, 2012), and knowledge about healthy nutritional habits (Mellecker et al., 2013). Considerable evidence is mounting on the benefits of using technology in educational settings and video games offer the type of experience that students have come to expect in their classrooms. Combining the two components, physical activity and video gaming (Active Learning) will provide the educational tool educators can use as they look to improve learning environments and connect with the students in their classrooms.

In the classroom?

Children confined to a classroom environment for long periods during the day lose concentration, which is counterproductive to learning and may ultimately result in an ineffective learning environment (Pellgrini & Davis, 1993). The use of alternatives activities to alter undesirable behavior is of increasing interest to policymakers eager to improve school based physical activity and academic performance (Centers for Disease Control and Prevention, 2010). Adjusting to a curriculum that appears to be stretched and ridden with time constraints has left teachers searching for physical activity alternatives to address these constraints (Ward et al., 2006). Improvements in academic performance and behavior are being realized from participation in physical activity, dispelling the belief that physical activity reduces the amount of time for academic related activities and is counterproductive to learning (Bartholomew & Jowers, 2011; Trost & van der Mars, 2010). To address this issue and to promote physical activity participation, physical activity programs have been introduced into the classroom environment to promote learning (Bartholomew & Jowers, 2011; Mahar et al., 2006). Physically active academic lessons incorporated into classroom lessons improve on task-behavior (Mahar et al., 2006) and are showing promising learning outcomes (Bartholomew & Jowers, 2011). Teachers engaging children in physical activity in the classroom environment are able to increase their productivity and subsequently spend more time engaging children in learning activities (Maeda & Randall, 2003).

Changes in learning and behavior typically require children to participate in physical activity for as little as five to ten minutes (Centers for Disease Control and Prevention, 2010). Increased concentration (Caterino & Polak, 1999), as well as improvements in on-task behavior is suggested to occur when using short duration physically active “brain breaks” (short breaks between lessons that include body movements) led by teachers in the classroom (Mahar et al., 2006). The learning effects occur in response to the brain derived neurotropic factor (BDNF), a protein responsible for growth and development of neurons and connections in the brain and has been associated with improvements in learning following short bouts of activity (Winter et al., 2007). This approach to learning has also resulted in increased daily in-school physical activity levels that are synonymous with public health guidelines (Bartholomew & Jowers, 2011; Mahar et al., 2006).

Case Study Two: Active Learning in Schools

George Velarde at Siesta Vista Junior High School in California has created a physical education program by including Active Learning as a valuable aspect in the physical education program. Mr. Velarde's program includes technology for learning such as *HopSports*, *Nintendo Wii*, virtual bikes, and *Dance Dance Revolution*. The "new" Physical Education (PE) program is based on teaching fitness, health and wellness rather than traditional team sports and skills that has been the focus of traditional physical education. Sierra Vista transformed their PE program into a personalized physical education curriculum that utilizes technology to engage children in physical activity and maintain interest throughout junior high school. Students are engaged in enjoyable and challenging activities that enable them to learn knowledge, attitudes, and behaviors related to functional motor skills, physiological responses to exercise, and even core vocabulary words printed on the backs of the PE uniforms. During PE lessons, use heart rate monitors to track their workout intensity and to learn about the cardiovascular efforts associated with physical activity. The *Polar Cardio GX* heart rate monitoring system allows the students to view their heart rate in real-time on a screen while they are exercising thus providing a valuable feedback and learning tool. Other physiological parameters, such as heart rate, step counts, and calories burned, are also tracked in some of the game based technology systems that are used in the program. Physical education lessons are all encompassing and interdisciplinary. One of the more interesting components of the program includes lessons that incorporate traditional exercise with game based technology. Physical education at Sierra Vista has moved into the classrooms with "brain breaks" during classroom time. Children are encouraged to get out of their seats and exercise during a five-minute break and are often asked to lead the activity breaks. The students are also given the opportunity to use the *Gamebikes* in math classes. Once a month the school opens its doors to the community and invites parents and children to come to the school to experience the joy of using the active game-based technology and learn how exercise impacts learning as well as health and fitness. Mr. Velarde's PE program is well received by the students, parents, and fellow teachers and was recently recognized by Michelle Obama's *Lets Move!* Active Schools program as a model "Active School." This program is a testament to the possibilities afforded by Active Learning alternatives in school PE programs.

Assessment Considerations

Determining the outcomes from Active Learning introduces a degree of complexity. As mentioned throughout the chapter, activity game-based learning is inclusive of three diverse components (physical activity, educational content and video gaming) and therefore is capable of producing numerous outcomes. To add to the complexity, existing literature on assessment of learning outcomes when using activity Active Learning is scant. Furthermore, numerous devices are used to measure physical activity preventing comparisons across video games and studies. The two most popular forms of technology driven physical activity assessment tools, the pedometer and accelerometer have been introduced into mobile devices and more recently been developed with video game technology. Pedometers are used to track number of steps while the accelerometer is used to assess velocity of movement. The

pedometer is an inexpensive tool and can be used to assess physical activity patterns of large groups of people whereas the accelerometer is more expensive but has a much higher degree of accuracy than the pedometer. *Zamzee*, a social networking game-based activity monitor has recently introduced an inexpensive triaxial accelerometer that has proven to be useful with young children by providing a reward system for being physical active. Accelerometers are now common in mobile devices and can be used with mobile-based apps to assess physical activity. Both of these devices are also used in research to understand the amount and intensity of physical activity when children play physically active technology driven games.

Future Needs

Technological changes occur at speeds unseen in any other form of learning application. For these reasons, there is an urgent need to learn more about how these systems can be used in the academic classroom and other environments that promote learning. Establishing and implementing best practice evidenced-based models will be crucial if we are to maximize the full potential of Active Learning technology in the academic or the physical education classroom. With this in mind, there is a need to understand long-term sustainability and attempt to understand the correlates that produce interest and engagement to achieve best practice approaches to implementing successful game based e-learning physical activity programs. It would also be interesting to learn how Active Learning approaches differ from traditional forms of teaching and which form of teaching students prefer.

The key to the success of Active Learning is based on the educators and the educational system. Many teachers currently in the classroom are digital immigrants and lack the confidence to embark on a new teaching regime especially when it includes technology-based learning. An understanding of teacher attitudes and experiences when implementing Active Learning into the classroom environment is necessary for successful implementation. In addition, adequate training and continued professional development will be required to encourage and develop physically active educational tools.

Furthermore, continuous assessment is needed to ensure that learning goals are being achieved and physical activity guidelines are being met when children engage in Active Learning. Similar to other forms of assessment, test anxiety will surely be apparent if children are aware of pending assessments. Embedding relevant content and assessing any changes to student attitudes, behaviors, or knowledge using Active Learning is one of the benefits of using technology (Shute, 2011). Little is known about this seemingly valuable attribute or whether embedded assessment can be used with success when implementing Active Learning. Finally, establishing specific guidelines, safety precautions and privacy policies for school-aged students will be necessary prior to implementing these technologies.

Case Study Three: Two Research Laboratories

Two labs are directed by Lisa Witherspoon, an Assistant Professor at the University of South Florida (USF) and focus on Active Learning, which the labs call “ActivLearning.” One lab is located in an elementary school and the second lab is located in the Physical Education and Exercise Science building on the USF campus. The university aims to understand the effects of ActivLearning products when children engage in physical education. The “living” laboratory located in the elementary school is used for physical education programs that are implemented into the PE curriculum. Research studies are used to determine the efficacy and to provide an evidence base for physical education. Specific emphasis is placed on learning objectives that are based on evidenced based research and best practices approaches to learning. Whereas the research laboratory located in the USF Campus focuses specifically on research. Learning more about how different populations appreciate the games as well as learn through the games is the main focus. The labs house fully functioning active gaming rooms equipped with numerous ActivLearning products. The labs focus on understanding the effects of active gaming on various populations (specifically children) including behavior, academic performance, product preference assessment, skill development, physiological performance and physical education outcomes. A recent program introduced by the USF active gaming research labs discovered that ActivLearning activities provide children with a cognitive benefit related to nutrition and science academic content. The students involved in these pilot studies were asked to play online video games involving nutrition and science principles whilst stepping on Footgaming pads and the *Gamercize* stepper, respectively. Students in these pilot studies achieved academic success, elevated heart rates and reported high levels of enjoyment. ActivLearning research is ongoing at USF as the topic is insufficiently researched and may provide educators important information on effective and efficient methods for teaching and implementing ActivLearning programs. Currently, USF is investigating the use of “brain breaks” throughout the school day to understand the consistency of physical activity breaks and effects of “brain breaks” on behavior and learning. Additionally, researchers are exploring the use of a multiplayer system by Konami, *DanceDanceRevolution-Classroom Edition (DDR-CE)*, to learn about the physiological and cognitive effects of the product on middle school students.

Best Practices

Some key factors are emphasized to realize the full learning potential of Active Learning in the classroom:

1. To ensure that skill levels are appropriately set and to avoid frustration for the children the Active Learning games should be age and topic appropriate. Allowing or including students to choose games and or levels can empower them, give them greater feelings of autonomy, increased enjoyment and perhaps motivate them to continue playing.

2. The learning outcomes and physical activity objectives should be combined into the playing of the games. By blending the physical activity and learning content into a game the teacher has an opportunity to assess students with less test anxiety.
3. The games should be set at a level that provides physical and cognitive challenges but does not overwhelm the student. Teachers and or the games/technology should provide meaningful and appropriate constructive feedback to their students to further enhance feelings of competence and self-efficacy. Teachers should also be able to adapt or change games according to student skill levels. This scaffolding approach may lead to a more appropriate (and less frustrating) experience.
4. The intensity level of the activity should be kept within a range that corresponds to physical activity guidelines or health outcomes. Current physical activity recommendations suggest that children should be participating in 60 minutes of physical activity that makes them sweat and breath hard referred to as moderate to vigorous intensity physical activity. Students performing activities below these thresholds may still improve skills, increase their confidence and receive health benefits; and should be encouraged to continue participating at their skill and fitness level.
5. Learning and health benefits may occur within a short duration of activity and this type of activity is consistent with activity patterns during childhood. Implementing Active Learning in the classroom in short intermittent bouts offers children an activity they enjoy and provides the teacher with a transition activity that has proven to be beneficial for students.
6. Teachers should be well acquainted with the Active Learning games and should be trained to use the system prior to implementing programs into the classroom or learning environments. Many schools also have student leaders within each class that are able to assist teachers (especially substitute teachers) in using the equipment and teaching others (including parents during an open house or parent/teacher conference). These opportunities should be seized upon as these helping hands can be well-versed in technology and a valuable resource for students and teachers.

Educators are instrumental in facilitating and implementing activity game-based learning into the educational environment. Determining the most suitable system, platform, and game requires the educator to consider the user, the physical activity, and learning outcomes. Currently, there are a number of popular commercially available active game-based learning systems that can be used to promote physical activity and learning (e.g., functional motor skills), including *Dance Dance Revolution (DDR)*, *Microsoft Kinect*, *Nintendo Wii*, and *XaviX* (see Table 1 for more details). Similar to other teaching applications, it is essential for the teacher to not just provide the game, but to pair the lesson plan with the technology and desired learning outcomes. To assist teachers and to provide possible Active Learning alternatives specific game platforms and software, targeted learning outcomes, and the body movements required to play each of the games are highlighted in Table 1.

Resources

Table 1.

Comparisons of Active Learning systems and games, targeted learning outcomes, and body movement required for gameplay

Categories	Games	Targeted learning outcomes	Physical activity
Rhythmic Dance			
<i>DDR Classroom Edition</i> <i>iDance</i> <i>Nintendo Wii</i> <i>XBOX Kinect</i>	<i>Pump it Up, iDance,</i> <i>Just Dance Kids,</i> <i>Dance Central</i>	Math: pattern recognition Physical: motor skills, rhythm, timing, syncopation	Stepping, jumping, dancing, twisting
Sensor-Based			
<i>Microsoft Kinect</i> <i>Nyoyrn</i> <i>Wild Planet</i> <i>XaviX</i> <i>Vtech Vmotion</i> <i>Zippity</i> <i>Swinxs</i>	<i>Animal Scramble,</i> <i>Brain and Body,</i> <i>Sesame Street:</i> <i>Once Upon a</i> <i>Monster, Nebula/</i> <i>Strip, Soundsteps,</i> <i>Animal Scramble,</i> <i>Hyper Jump, Ask,</i> <i>Listen, Learn: Kids</i> <i>and Alcohol Don't</i> <i>Mix™, Jackie Chan</i> <i>Challenge</i>	Math skills: logic, executive control, numbers & counting, spatial awareness, sequencing, pattern and object recognition Physical: eye-hand coordination, agility, balance Science: Science: species recognition, ecosystem, food chain energy cycle, mapping skills, animal behavior Social responsibility: caring for the environment, recycling, caring for others Spelling Other: recognizing musical notes and color, sound and visual recognition, health nutrition behaviors	Stepping, jumping, kicking, waving, rolling, running, sliding, touching, sweeping, standing up, hand and arm gesturing
Virtual Bikes			
<i>BrainBike</i> <i>Fisher-Price Smart</i> <i>Cycle Racer</i> <i>Espresso HD</i> <i>Youth Exercise Bike</i>	<i>Neuroactive, Math</i> <i>Mountain, Shape</i> <i>Lake, Number</i> <i>Fields, Letter Creek</i>	Math: logic, pattern recognition, visual acuity, alphabet, shapes Physical: eye-hand coordination, motor skills,	Bicycling: steering, pedaling

Books and Articles

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Action Based learning (<http://abllab.com/>)
ActiveLearning Blog (<http://activlearninggames.blogspot.com/>)
Machine Dance Report (iDANCE in Norway) (<http://www.positivegaming.com/benefits/machine-dance-research-projects/stokke-machine-dance-project-report>)
Microsoft Kinect School Activity Plans
(<http://www.microsoft.com/education/en-us/products/Pages/kinect.aspx#3>)
Exergames Unlocked (<http://exergamesunlocked.org/>)
PE Central (<http://www.pecentral.org>)

Researchers

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Barbara Chamberlain, Ph.D. (<http://aces.nmsu.edu/mediaproductions/>)
Ann Maloney, M.D. (<http://www.umassmed.edu/Content.aspx?id=92224>)
Floyd Mueller, Ph.D. (<http://exertiongameslab.org/>)
Adam Noah, Ph.D. (http://mediaartslui.com/faculty_top.html)
Amanda Staiano, Ph.D. (<http://www.pbrc.edu/research-and-faculty/postdocs/>)
Josh Trout, Ph.D. (http://www.csuchico.edu/kine/faculty_staff/index.shtml)
Lisa Witherspoon, Ph.D. (<http://www.coedu.usf.edu/main/index.html>)
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Labs and Projects

Canadian Exergaming Research Center (www.ucalgary.ca/exergaming)
Exercise4Learning (<http://www.exercise4learning.com/>)
Exergame Lab (www.exergamelab.org)
Gateway Unified School District (Matt Diskin) (<http://www.californiaprojectlean.org/doc.asp?id=249>)
Learning Readiness PE, Naperville, IL (<http://learningreadinesspe.com/>)
Sierra Vista Jr. High PE (George Velarde) (<http://www.hartdistrict.org/sierra/pe/>)
Active Gaming Research Laboratory University of South Florida
(<http://www.coedu.usf.edu/main/departments/physed/labs/xrkLab.html>)

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