

Review

# Operationalizing physical literacy: The potential of active video games

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## Abstract

The core idea of physical literacy is a mind-body integrated, holistic approach to physical activity. A physically literate individual is expected to be cognitively knowledgeable, physically competent, and mentally motivated for a physically active life throughout the lifespan. The advancement of technology in recent years, especially those in active video games (AVGs), seems to have allowed the mind-body integrated physical activity accessible to children at all ages. This article reviews findings from research and critique research on AVGs in light with the theoretical and pedagogical tenets of physical literacy and, on the basis of the review, elaborates the potential that AVGs could contribute to enhancing children's physical literacy.

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## 1. Introduction

The newly released U.S. National Standards for K-12 Physical Education stated that the goal of physical education (PE) is to develop physically literate individuals with the needed knowledge, skills, and confidence to enjoy a lifetime of healthful physical activity (PA).<sup>1</sup> A physically literate individual is expected to have the skills necessary to engage in a variety of PA, understand the implications and the benefits of PA participation, value PA and its contributions to a healthful lifestyle, participate regularly in PA, and be physically fit.<sup>1</sup> To help students achieve the National Standards for Physical Education, researchers and professionals in the field continue to explore new and creative ways for effective teaching in PE. Creatively using technology has emerged as an approach that can enhance teaching and learning in PE.<sup>2</sup>

By the time when children meet the age requirement for school entrance, they are accustomed to and familiar with technology as one of the primary tools for receiving information.<sup>2</sup> As a recent CNN report indicated, today's PE is not the

same that we remember from school.<sup>3</sup> Teachers are now facing a generation of digital natives and expected to have a deep understanding of how to use educational technologies to facilitate student learning. In some states (e.g., Texas), teachers are expected to have competence of using technologies such as heart rate monitors or personal digital assistant.<sup>4</sup>

Technology has been integrated in PE curriculum development, instructional design, and assessment of students' achievements. During the past two decades, a variety of tools, such as pedometers, heart rate monitors, accelerometers, global positioning system, online learning in PE, and active video games (AVGs) have been adopted by physical educators in their teaching practice. For example, Lazerte and Lathrop<sup>5</sup> designed a website for PE lessons guided by their school district curriculum of health and PE (Grades 1–8) and ideas suggested by students and teachers. The website had a homepage and other 13 online pages such as the “get moving, practice your skills!” page, the “active living, it's great!” page, the “talk to the teacher” page, and the “why do we have to have (PE)?” page. Results suggested that 76% of the students reported that they would at least “always” use the website. Students also indicated that the website provided them with more information and helped them think about and participate in sports. This study showed the potential to develop health

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and PE website to enrich elementary school students' experience in PE. But more evidence is needed to identify long-term effects on students learning in PE.

Web-based PE and others using advanced information technology requires knowledge and skills to navigate through the learning process in different ways. The different knowledge and skill sets may be known as digital literacy. The core idea of physical literacy is a mind-body integrated, holistic approach to PA.<sup>6</sup> A physically literate individual is cognitively knowledgeable, physically competent, and mentally motivated for a physically active life throughout the lifespan. The development of technology has provided a platform that not only makes the integrated, embodied experiences possible, but also affords the mover with instant cognitive, motivational information during all phases of PA.

Among a variety of technologies used in PE, AVGs or exergames have received substantive attention from researchers and practitioners. AVGs are a new generation of video games that requires children to put in high volume of body movement in association with the usual cognitive functioning tasks while playing.<sup>7</sup> Sheehan and Katz<sup>8</sup> argued that AVGs could support the development of physical literacy by making connections to the three learning domains in PE: cognitive, psychomotor, and affective. Although other technology applications such as web-based PE, adoption of pedometers and heart rate monitors in instruction have changed in-class learning behaviors, AVGs emerge as a curriculum modifier that may have an impact on PE programming in the future.<sup>9</sup> In this article, I will review and critique research on AVGs in light with the theoretical and pedagogical tenets of physical literacy and, on the basis of the review, elaborate the potential that AVGs could contribute to enhancing children physical literacy.

## 2. AVGs and motivation in PE

The essential characteristic of physical literacy is the desire to become knowledgeable, competent, and confident to engage in a variety of PAs, to persist with these activities, and to appreciate physical competence and performance.<sup>6</sup> Whitehead<sup>6</sup> described that a physically literate individual is a motivated individual who enjoys challenge, is prepared to take time and effort, has a positive attitude towards participation in PA, and involves in PAs regularly. AVGs have shown a strong potential to motivate children to become active players of the AVGs.<sup>7</sup> Using technology such as AVGs, therefore, might be feasible to motivate school-aged students to engage in PA.

Research findings are consistent that AVGs can provide more interesting and enjoyable experiences than activities in the traditional PE<sup>10–12</sup> and sedentary video games.<sup>7</sup> For example, Sun<sup>11,13</sup> examined the difference of students' perceived situational interest in an exergaming unit and a cardiovascular fitness-education unit. She suggested that students perceived significantly higher level of situational interest in the exergaming unit than they did in the fitness-education unit. In other words, results indicated that exergaming

activities provided a unique opportunity for novel and innovative experiences, demanded high attention throughout the game play, led to explorations of different game situations, challenged student both cognitively and physically, and elicited a high level of instant enjoyment.

In PE, situational interest has been assumed to have practical meaning with respect to curriculum and task design. Unlike individual interest, situational interest can be controlled and manipulated by teachers.<sup>14</sup> Situational interest is embedded in tasks and learning environments. In a study examining the effects of different cognitive and physical demands of learning tasks on situational interest, Chen and Darst<sup>15</sup> found that cognitive demand in a PA determines the level of situational interest. The middle school students in the sample ( $n = 242$ ) considered the tasks with high cognitive demand as highly situationally interesting, regardless of the physical demands. Tasks with low cognitive and low physical demands were evaluated particularly low in situational interest. A PE learning task consists of, in large part, a physical movement component and, often neglected, a cognitive component.<sup>16</sup> How much cognitive information is integrated in a PA task may offer different situational interest in PE. Therefore, for a task to become a motivation source, it should be designed carefully to become situationally interesting to the learner.<sup>14,17</sup>

In addition to interest and enjoyment, AVGs were found to foster higher level of self-efficacy than traditional PAs. For instance, Gao et al.<sup>10</sup> compared fourth graders' experiences of dance-exergaming (Dance Dance Revolution, DDR) and aerobic dance in PE using a repeated measures design. Students ( $n = 53$ ) who experienced both DDR and aerobic dance activities reported significantly higher self-efficacy toward DDR than they did toward aerobic dance activity. Gao et al.<sup>10</sup> asserted that AVGs such as DDR might provide unique experiences that contribute to the sources of self-efficacy. Particularly, in PE class children learned how to play DDR gradually for mastery by mimicking the dance movements of the dance figures in the screen. They received simultaneous feedback from the AVG system and timely comments from their teachers and peers. They played DDR at their individual expertise levels for optimal challenge. All these experiences provide a positive learning environment for developing their self-efficacy.

One salient characteristic of AVGs or exergames is social interaction, which can influence or enhance motivation.<sup>11,18</sup> In Staiano et al. study,<sup>18</sup> 31 adolescents (15–19 years old) were randomly assigned to a competitive condition where players competed individually against a peer, or a cooperative condition where players played with a peer. Motivation was measured through questionnaire and interview at the end of the intervention. The result showed that cooperative condition produced higher intrinsic motivation than competitive situation. Also, the intrinsic motivation was positively correlated with energy expenditure during game play. The researchers speculated that the motivation stemmed from perceived control/choice opportunities due to the design of the exergame.

Chin A Paw et al.<sup>19</sup> observed that interactive competition and cooperation with other players could enhance enjoyment and motivation for AVG players. In their study, children between 9 and 12 years old ( $n = 27$ ) were randomly assigned to a group playing an individual AVG environment (home) and a group environment (multiplayer classes). The children in both conditions played the same game. Motivation to play was measured on self-reported playing time and dropout rate. Children in the group environment reported approximately twice as many playing minutes as children in the home environment and at a significantly lower dropout rate. These findings suggest that the social interaction experiences in playing cooperative exergames can increase and sustain children's motivation in playing AVGs. More importantly, physical educators could use cooperative AVGs to foster a feeling of group cohesion for positive perception of AVG play, increased motivation, and sustained PA.<sup>18</sup>

Although the motivational effect of AVGs has been evident in previous studies, the sustainability of this effect is still questionable. Sun<sup>11,13</sup> reported a dramatic drop of situational interest motivation in playing AVGs overtime. More importantly, challenge and exploration were the two components of situational interest that were decreasing at a sharper or faster rate than other components. Research on situation interest has suggested the critical role of cognitive demand (e.g., challenge and exploration) of a learning task in eliciting situational interest.<sup>13</sup> For AVGs, "Challenge is an essential element of any successful video games. A key to the task design is to keep challenge at an optimal level for the players. Progressive levels of increased difficulty provide the user with periodic accomplishment and setback."<sup>8</sup> Staiano et al.<sup>18</sup> found certain aspects of the exergames such as the virtual obstacle course, if too long and too challenging, may result in frustration and demotivation. On the other hand, Staiano et al.<sup>18</sup> speculated that when the AVGs do not provide enough challenges, players would perceive the game as boring, which also leads to demotivation. Sun,<sup>13</sup> therefore, suggested that exergames should provide players ample opportunities for multiple levels of challenges in order to help sustain high level of motivation.

The research findings seem to indicate that there is a strong potential to nurture children and adolescent's motivation for physical literacy through the use of AVGs. The games with opportunities for players to cooperate, meet optimal challenges, and extend their mental capacities to explore physical movements stand for a greater chance to motivate them. The challenge, however, remains for researchers primarily in uncovering the game—person interaction features that help not only elicit but also sustain the motivation.

### 3. Learning with AVGs in PE

Adopting physical literacy as the goal of learning in PE requires a strong learning orientation in activities offered in class. AVGs appear to be able to elicit strong motivation in children. For AVGs to contribute to the goal of physical literacy, it has to assist children in learning important knowledge

and skills of physical movement. In other words, it has to help children develop meaningful competence needed for a physically active life. Ennis<sup>9</sup> suggested that AVGs could supplement the current activity options in PE to enrich the recreational and public health-oriented programming. She elaborated that AVGs fit easily into recreational PE programs in that they provide additional opportunities for students to experience fun PA. Similarly in a public health-oriented PE, AVGs may provide continuous opportunities for children to be active at a moderate physical intensity level to receive health benefits. However, despite its potential to enhance participation, enjoyment, desired MVPA levels in PE, AVGs have to yet establish their potential to develop student learning (physical literacy) as demonstrated in their skills, knowledge, positive attitudes, values, and health.<sup>9</sup>

Although scarce, limited research evidence did show that educational AVGs might have positive impact on student science knowledge learning.<sup>7</sup> In the randomized controlled study, Sun and Gao<sup>7</sup> assigned students ( $n = 53$ ) to either an active educational video game (experimental group) or a traditional sedentary educational video game condition (control group). Students in both groups played the same educational video game called "Earth, Moon, and Sun—an interactive learning experiences". The only difference was that the game for the experimental group was attached to a set of steppers. The players need to continue exercising to keep the game going throughout the entire gameplay period. The results show that students in the experimental condition gained as much knowledge about the solar system as their peers in the control condition. But they did it with higher level of physical intensity. The findings suggest that educational AVGs can be used to enhance student science knowledge learning and clearly warrant a need for future research to identify potential effects of AVGs on student cognitive learning in PE.

Similarly, Gao et al.<sup>20</sup> employed a repeated-measures crossover design to identify the impact of DDR on Latino children's physical fitness and academic achievement. Children in the intervention group participated in a 30-min, structured DDR-based exercise program three times per week at school. It was found that over time the children in the intervention condition displayed greater improvement on math test scores than children in the comparison group. Taken together, these studies have displayed an important potential of AVGs to develop cognitive knowledge. Although the knowledge domains were not PE in these studies, the findings provide useful evidence for physical educators to consider using AVGs to facilitate students' learning of movement concepts, principles, or strategies.

Demonstrating competency in a variety of motor skills and movement patterns has been an important aspect of a physically literate individual.<sup>1</sup> Research has shown that adolescents' PA participation and perceived sports competence are predicted by their childhood's movement skill competence.<sup>21,22</sup> Using AVGs to enhance children's fundamental movement skill competence has been proposed by scholars and researchers.<sup>23,24</sup> Anecdotal evidence has suggested that *Virtual Gym* (an instructional tool for movement skill practice through

interactive computer software) can be an innovative approach to motivate children to increase PA levels and has the potential to improve motor skill competence and understanding of movement principles.<sup>25</sup> A review of research findings<sup>24</sup> further suggests that virtual reality games could be effective in the acquisition of a motor skill only when the players intentionally used the game for learning purposes and the game allowed players to sense the execution of the skill.

Barnett et al.<sup>23</sup> investigated associations between use of AVGs or traditional video games and object control and locomotor skills in preschool children ( $n = 76$ ). The results showed a statistically significant association between children's time in AVGs player and their object control skill. The findings suggested that playing AVGs might help children to develop game related skills such as underhand rolling, overhand throwing, and eye—hand coordination.

A latest intervention study also indicated a positive impact of AVGs on object control skills in elementary school students.<sup>12</sup> In the study, 66 elementary students were randomly assigned to an exergame-based group, a traditional object control group, and a control group. Students' object control skills were assessed at pre-, post-, and 1 month after the intervention. The students in both experimental groups practiced a specifically designed object control training program with skills of throwing, catching, dribbling, kicking, rolling, and striking in two 30-min sessions per week for 8 weeks. The students in the control group did not receive any structured object control skills training program. Results indicated that the students in both experimental groups did a superior performance over those in the control group in both post-test and 1-month retention test.

In addition to locomotor and object manipulation skills, recent studies started to show that AVGs might also help improve non-locomotor skills for elementary school students, such as balance.<sup>26,27</sup> In a pre-post controlled comparison study, postural stability was the outcome measure of a 6-week daily exergaming curriculum in PE. Students ( $n = 64$ ) were assigned into the following three groups: an exergaming condition designed for improving postural stability, a conventional PE focused on agility, balance, and coordination condition, and a typical PE condition (control group). Results showed a significant improvement in postural stability in both exergaming (29% improvement) and the agility, balance, and coordination (28% improvement) groups while the control group had no significant difference.

The development of fundamental movement skills (FMS) is at the heart of promoting physical literacy.<sup>26</sup> FMS cannot be developed naturally or through free play; these skills need to be learned, practiced, and reinforced.<sup>28,29</sup> A meta-analysis further indicated that motor skill interventions consist of planned movement activities that are developmentally and instructionally appropriate are effective in improving FMS in children including both object control ( $d = 0.41$ ,  $p < 0.001$ ) and locomotor skills ( $d = 0.45$ ,  $p < 0.001$ ).<sup>30</sup> The diversity of stimuli and spatial structures of AVGs allows children to use a diverse range of manipulative motor skills, which might foster FMS development.<sup>12</sup> Nonetheless, empirical studies focusing

on whether AVGs have the potential to increase children's movement skill development are still rather limited and findings have not been conclusive.<sup>31</sup> More research is needed on the feasibility of physical educators to successfully implement AVGs-based intervention programs in promoting children and adolescents' motor skill development.

#### 4. AVGs and PA level

An important fundamental theoretical tenet of physical literacy is the embodiment of PA (the monist perspective). The mind and the body act as a whole in a person in pursuing the optimal experience of PA for the purpose of his/her choosing.<sup>6</sup> With this in mind, the component of PA in any physical movement environment is crucial in determine whether physical literacy is achieved. One important environment in PE is created for health-enhancing PA. Research of AVGs has provided limited but useful evidence to suggest a need to design AVGs to create an environment in which not only the mind is involved in the "playing" phase, but also the body can be involved at a beneficial level for health enhancement.

A recent two-stage study<sup>11,13</sup> investigated AVGs effect on children motivation and PA levels in comparison with PA levels in the conventional PE. Using a counter-balanced design, Sun<sup>11</sup> assigned 74 fourth graders into a sequence to experience both an AVGs curriculum and a conventional fitness activity curriculum. The results showed that PA in the AVGs curriculum was lower in intensity (mean METs = 2.14) than that in the conventional fitness curriculum (mean METs = 4.1), although the children demonstrated higher motivation in the AVGs. In the follow-up study,<sup>13</sup> the children in the exergaming curriculum did post higher MET readings (mean METs = 2.92), significantly higher than that they posted in their first round of experiences with the AVG curriculum. Sun<sup>11</sup> attributed the increase to the mastery of the skills required to play the exergames proficiently.

The findings, however, are not unexpected, though. Previous studies have shown that using AVGs in PE is not equivalent to playing the games at home or other free-play settings.<sup>32,33</sup> Using AVGs in PE to provide health-enhancing PAs may require special considerations for game designs to prevent pre-mature slippage of PA levels often observed in both structured and free-play settings.<sup>34</sup> These issues emerged from research on AVGs call for continued effort to further determine the role of AVGs in promoting health-enhancing PA in the PE environment.

#### 5. Conclusion

As stated in the book,<sup>6</sup> a physically literate individual should be able to demonstrate the following attributes when engaged in PA: motivation, skillfulness and efficiency, intelligence about the environment, confidence, sensitivity to social context, and knowledge about functions (e.g., health) of the physical movement. The above review of the literature seems to affirm AVGs' contributing role in developing physical literacy in children and adolescents in PE. AVGs are motivating;

they provide a variety of opportunities to develop or reinforce basic motor skills; most importantly they provide ample opportunities for children to enjoy many forms of PA and movements.

Needless to say, however, AVGs have limitations in a few critical aspects of developing a physically literate person. Its motivation effect is largely built on its ability to elicit situational interest which, if not internalized, can stop functioning as a motivator as quickly as it motivates. Currently, AVGs offer little structured knowledge of exercise (e.g., principles of practices, principles of exercise, exercise benefits and risks), which is an inseparable part of the physical literacy identity. Lastly, it is still in question whether AVGs can deliver enough PA at the appropriate level of physical intensity for children to receive sufficient health benefits in PE classes. These and other potential related issues must be studied carefully. One thing, though, may have become certain: like any technologies in the 21st century, AVGs and its application in schools may have a place in the curriculum to enhance student learning.

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