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Review

Implications of exergaming for the physical education curriculum in the 21st century

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Abstract

Exergaming provides an initial situationally interesting environment in physical education (PE) that serves to motivate novice players to engage in PE or physical activity. Current research suggests, however, that as students persist in this activity their situational interest decreases as their ability to exercise consistently at moderate intensity levels increases. In this article I will briefly review the literature citing benefits of exergaming and the role of exergaming in contemporary PE curricula before turning to the question of the place of exergaming in a learning-oriented approach to PE. I will suggest that exergaming, when taught within a situated learning framework, can contribute to student understanding of the effects of exercise on their bodies and may produce meaningful lessons to assist students to create, monitor, and adapt a fitness plan to participate in life long exercise using a variety of physical activities.
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1. Introduction

Exergames create novel opportunities for teachers and students to expand the physical activity (PA) options in physical education (PE). Exergames typically are situationally interesting and motivational both to skilled and unskilled students[1] and have the potential to increase the intensity and duration of PA within lessons, while enhancing perceptual motor skills, strength, balance, motivation, interest, enjoyment, and engagement.[1–10] There is an increasing body of evidence to support exergaming as a situationally interesting activity for novice students from the upper elementary grades through high school. Students, however, can grow complacent with exergames, gradually reducing the situationally interesting advantages of exergaming over time.[10] Complacency, however, should not be mistaken for concomitant decreases in PA. Sun,[10] Gao,[3] and others have documented that, over time as situational interest wanes, students' ability to play exergames increases, resulting in higher levels of PA intensity.

The authors of the three papers in this exergaming section, Gao et al.,[4] Sheehan and Katz,[8] and Sun,[10] have provided an excellent foundation from which to view the contributions of exergaming. In my paper, I will first discuss several of these contributions, supplementing their findings with those from other PE related studies examining the benefits of exergaming. Next I will discuss ways in which exergaming might be integrated in contemporary approaches to PE curriculum. In the final sections, I will affirm the work of Young and his colleagues[11] viewing exergaming curriculum from a situated learning perspective. I will argue that viewing exergaming only as a motivator or a PA option, misses a prime opportunity to increase student learning, problem solving, and ability to

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transfer fitness (and self-regulation) concepts learned in exergaming to create, monitor, and adapt PA plans, facilitating life long participation.

2. Contributions of exergaming in PE/PA settings

Gao et al.'s,[4] Sheehan and Katz's[8] and Sun's[10] research provides substantial evidence to support the contributions of exergaming to PE. Although there are concerns, particularly with PA intensity levels, these researchers are quite optimistic that exergaming adds value to PE. Of critical importance is the research in this set of papers comparing exergaming with several other forms of PA. For example, Gao et al.[4] compare the amount of time students participate in Dance Dance Revolution (DDR), with the amount they spent in aerobic dance. Additionally, they also examined measures of self-efficacy, enjoyment, and other cognitive mediators that appear to impact students' willingness to engage in PAs and give effort. Similarly, Sheehan and Katz[8] compare exergaming activities using four different games, specifically designed to enhance agility, balance, coordination, reaction time, and rhythmic sense (iDance), strength, flexibility, balance, and dance (Wii-Fit Plus); balance (on a snowboard simulator, XR-Board); location and force, vertical movement, coordination, reaction time, speed, agility, balance and laterality (Lightspace) with a standard PE class. Sun's[10] research compares the level of class PA and situational interest across two semesters using eight different exergaming stations. This research, when combined with other relevant studies, makes it quite clear that exergaming can make contributions to PA, situational interest, motivation to participate in PE, and enjoyment.

2.1. PA

There is much to like about exergaming activities in PE. There is a growing body of evidence that suggests that exergaming can increase students' PA when compared with multi-activity, typically sport/game based PE.[5,6] This is likely to occur because, encouraged by the exergame, more students are active for longer durations when compared with periods of low intensity PA during game play, especially for low skilled, low effort students. However, concerns remain that novice exergamers may not be able to participate at moderate levels of PA.[3,7] In both the Gao et al.[3] and the Sun[9] research where exergaming was compared with fitness-oriented lessons (e.g., jump roping, running, jogging, pacer, and step aerobics), students' moderate-to-vigorous PA (MVPA) scores in exergaming activities were lower than in the fitness lessons.

Research also has suggested that exergaming is correlated to reductions in waist circumference[6] and other health-related parameters, such as body mass index and percent body fat, in addition to increases in MVPA.[5] Likewise, Sheehan and Katz[8] made a strong case that certain exergames can increase balance and postural stability over agility-oriented non-gaming programs. There is additional evidence to suggest there may be cumulative PA effects associated with increased experience in exergaming. Sell et al.[7] compared experienced and inexperienced exergamers and found that experienced exergamers regularly and consistently played at the highest difficulty level and were able to work consistently at moderate to vigorous intensity levels for 30-min sessions. Conversely, inexperienced gamers achieved only light intensity activity. Although this difference could be attributed to higher preexisting levels of conditioning and/or higher motivational levels in the experienced players, it is unclear from the Sell et al.[7] research whether there was a "learning" effect associated with exergaming. Sun[10] also documented that students participating in exergaming for a second unit within a 12-month period were able to increase their level of intensity. Because the school's summer break interrupted exergaming between the spring and fall semesters during Sun's studies,[9,10] it is less likely that a conditioning effect confounded the results. Sun[10] also compared levels of situational interest between the two time periods (spring and fall) finding that situational interest decreased as PA intensity increased.

2.2. Balance

Sheehan and Katz[8] have contributed to exergaming claims by providing initial evidence that a 6-week exergaming unit can contribute to student balance. The balance-oriented exergaming curriculum designed by the researchers enjoyed a 5-day/week format and was compared in this research with both an instructor-taught PE lessons also focused on agility, balance, and coordination, and a "typical" PE program. Students experiencing the exergaming curriculum increased their scores on postural stability measures more than in lesson taught in either the instructor-led balance program or the standard program. This, too, is very good news for exergaming advocates and gamers because it confirms a second significantly important exergaming contribution.

2.3. Situational interest

It is easy to imagine students' feelings of excitement when they enter a gymnasium equipped with exergaming stations! Sun's[9,10] and Gao's[3,4] research has documented that opportunity to participate in a variety of self and group challenge exergames can be situationally interesting, increasing students' motivation to participate. Interestingly, researchers are finding that, like other initially novel, challenging experiences, the levels of situational interest for exergaming decreases with repeated experiences over a long time period.[11] Novelty is fleeting. It is not surprising that students became comfortable in the exergaming environment and came to play the exergames more effectively. They exhibited both decreased situational interest and increased PA intensity as their experience levels increased.[10]

2.4. Motivation toward PA/PE

In research by Hawkins[1] and Souter,[12] exergaming participants were more likely to be motivated to participate in PA and to have positive feelings toward PA. In Souter's[12] study, unskilled students who were reluctant to participate in sport-based traditional programs were comfortable playing Wii with groups of skilled and unskilled students. Likewise, findings from Hawkins'[1] research indicated that children enjoyed the challenge of moving continually to "power" the exergame. Children reported that they wanted to continue exercising to keep the games from pausing and that this challenge reduced exercise boredom.

In other research[2] examining motivational levels of overweight and non-overweight students using DDR, researchers found that students were motivated to play DDR with the dance pad because of the socially interactive nature of this format. The researchers did not find significant difference by gender or weight status.[2] Thus, exergames appear to attract students who may be reluctant to participate in sport-based, recreational PE. Attracting these students to PA is the first step in encouraging them to participate willingly after school and without adult urging.[13]

2.5. Enjoyment

Increasing student enjoyment of PE and activity is central to creating a more meaningful experience.[14] Sell et al.[7] in research comparing expert and novice gamers found that both groups experienced higher levels of enjoyment when playing DDR when compared to more traditional forms of exercise. Increased enjoyment may make it easier for players to maintain consistent and regular daily exercise. Gao's[3] research confirmed that experienced eighth and ninth grade players demonstrated increased intrinsic motivation during exergaming, although they exercised at low levels of physical intensity. Certainly, enjoyment appears a key to continued engagement in PE and future PA participation. Although the goals of enjoyment, PA, and engagement are central to many PE programs, often instructional time and resource constraints limit students' opportunities to experience these benefits in contemporary PE.

3. Exergaming in contemporary PE curricula

Exergaming has potential to contribute to PE programs by supplementing the current activity options and increasing student enjoyment for PE/PA, contributing to PA goals (at least for experienced gamers), and providing a relational learning environment in which students work with others in complex contexts to solve meaningful problems. Currently, these goals are central to K-12 PE programs described as recreational, public health-oriented, and educational.[15]

3.1. Recreational approaches to PE

Those of us who frequent PE classes are most likely to find a recreational approach to PE. I expect this is the "traditional" PE program that Gao et al.[4] used as a comparison condition for their interactive dance activity. "Typical" or "traditional" physical can take several forms and reflect programs that typically focus on many different sport activities.[15] Students often begin the lesson by participating in modest stretching and strengthening warm-up exercises with some jogging before spending the remaining instructional time in game play. This curriculum is characterized by limited skill and tactical development with a few skilled students highly motivated to participate in moderate intensity activities while most students engage in light activity. Because indoor sport space and facilities often are limited, students must take turns, rotating into activity at 5−10 min intervals. Situational interest and motivation to give effort varies with student skillfulness. Unfortunately, low skilled and reluctant students rarely increase their skills, enjoyment, or motivation to participate in a physically active lifestyle in recreational environments.

Exergaming activities certainly fit easily into recreational PE programs. They provide additional opportunities for students to be exposed to another PA option and to have fun and engage in PA. Sun[10] emphasized that a situationally interesting environment contributes to students' willingness to engage in a setting that is novel, moderately challenging, enjoyable, demands attention, and provides opportunities for exploration.[16,17] Her research suggests that even as the levels of situational interest decline over time, students' ability to perform the exergames increases, leading to increasing levels of MVPA.

3.2. Public health-oriented PE

While currently most PE programs focus on recreational goals, some programs are adopting a "public health" approach in which the primary focus of the lesson is PA. The primary goal is for students to be physically active within their target heart rate zone for the majority of the instructional period. Students participate in aerobic sports for part of the lessons and may engage in structured strength and endurance exercises and cardiovascular fitness for the class time. Students who are skilled and enjoy PA may find satisfaction in challenging themselves to reach teacher or self-defined goals, while low skilled and low energy students often benefit from external motivators to encourage them to be active at target heart rate. These PE programs are based on MVPA and structured so that children and adolescents meet MVPA guidelines when instructional time permits.

Developers, teachers, and epidemiologists have held high hopes for exergaming to provide a central activity in public health-oriented PE curricula. Several exergaming studies have documented that, as students received multiple opportunities to participate in exergaming, they increase their ability to play effectively, permitting them to exercise at a higher intensity for longer durations.[10] Additionally, the fast paced, frequently changing environments appear to provide the perfect context to decrease boredom often found in some MVPA-oriented PE programs. In fact, the multi-exergame environments described in both Sheehan and Katz's[8] and Sun's[10] papers provided a host of different experiences that were exciting, novel, and appropriately challenging.[16] However, the jury is still out as to whether exergaming will meet the intensity and motivational goals required in public health-oriented PE. Interestingly, while multi-exergaming formats appear to fight boredom,[1] Sun[9,10] found that even in these highly stimulating environment, students' levels of interest declined over the 12-month period monitored in her research.

3.3. Educational PE

A third category of PE programs focuses on increasing student learning associated with physical (skill, sport, fitness, *etc.*), cognitive (skillfulness, sport performance, fitness principles), and affective (cooperation, leadership, goal-setting, and intrinsic motivation) outcomes.[15] Although most educationally-oriented programs include goals found in recreational (participation and enjoyment) and public health (increased MVPA) programs, educationally-oriented physical educators are not satisfied until students attain a third element, student learning. Although participation, enjoyment, and increased MVPA are necessary, they are insufficient goals for an educational PE program.[13]

Learning is an elusive goal. Whether we use the behavioral definition of "learning" as a permanent change in behavior,[18] or choose a cognitive definition of learning as "a change in the way a person thinks, reasons, believes, and processes information in part by expanding or altering the individual's existing knowledge base",[19] it is clear that learning is an expectation for educational PE programs. Facilitating student learning in PE requires carefully planned lessons that synthesize a number of management, skill, and fitness based best practices, using instructional time effectively to reach measurable outcomes. Regardless of the theoretical perspective, learning objectives often encompass cognitive, physical, social, and affective goals so that students acquire the skills, knowledge, and attitudes they need to be physically active on their own, when the teacher is no longer present to cajole and reward activity or punish inactivity.[13]

When compared to research examining exergaming enjoyment/interest and MVPA outcomes in recreational and public health oriented approaches to PE, much less research is available investigating the learning possibilities presented by exergaming. With the exception of the Sheehan and Katz[8] article documenting exergaming activities that increased students' balance, it appears that exergaming has not been examined in educational PE programs where the goal is content mastery. There is little evidence currently to suggest that exergaming can be used as a viable context to teach the highly valued educational goals of problem solving and decision-making. Exergaming activities, however, appear to have potential to reach these goals. For example, as students monitor steps and heart rates during exergaming, what concept-based lessons can they learn as their bodies respond to exercise intensity? What lessons are waiting to be taught with learning goals associated with caloric balance and energy expenditure?

Although these lessons can be associated with any MVPA activity, the engaging activities embedded in exergaming environments may be the perfect site to integrate the physical, affective, AND cognitive outcomes central to educational PE. Additionally, these learning-oriented lessons can extend the immediate benefits of MVPA participation to include long-term, lifetime contributions as well. What's more, after the immediate physiological benefits of PA have subsided, cognitive principles associated with frequency, intensity, time, and type (FITT) principle, overload, specificity, and progression, to name a few, continue to be remembered, enduring long after the DDR system has been sent back to the vendor for repair. If exergaming were to be conceptualized within an educational PE environment what learning frameworks would be most likely to guide the development of the exergaming curriculum?

4. Situated learning as a theoretical framework for educational exergaming

Most contemporary learning theories emphasize the role of the learner as central to the learning process. Constructivism in PE[20] is framed around active learners engaged in mediating experience as they monitor their bodily responses, consider alternatives for increasing or decreasing MVPA, and set and reach reasonable goals as they construct meaning from their experience. Young and his colleagues,[11] for example, focus on serious gaming as a situated learning experience in which the player, game, and social environment interact to create an educational gaming experience that includes but is not limited to MVPA or situational interest/motivation. Situated learning experiences are complex, relational, authentic, and community oriented,[21] providing an educational context for exergaming learning goals.

4.1. Characteristics of situated exergames

Situated cognition encompasses the environmental dynamics of exergaming with a greater focus on the individual as a learner within a social and cultural world of exergaming.[22,23] Individual gamers do not experience the game alone on their gaming pads.[10] Instead, these students are interacting constantly both with the game and with their peers and teachers. Because each game contains highly defined affordances that permit players to adjust the type, difficulty, and intensity within each game, they individually define the relational game-player-environment conditions uniquely for their goals, interests, and abilities. Thus, "different players play the same game with different goals, intentions and definitions of achievement which can lead to different, even opposite, academic outcomes".[11] These highly complex environments are a potential authentic source of relational learning.

4.1.1. Complexity

Exergaming is an outstanding example of a situated learning environment, reflecting the characteristics described by Rovegno.[21] The gamer is immersed in a complex context, interacting within the game and, in PE, with others in the educational environment. For example, in the Sheehan and Katz[8] article, agility and balance become part of the learning environment because of the types of games selected. The content of the game includes not only the skills of the game itself, but also the physical and cognitive challenges that must be mastered to move to the next exergame level.

4.1.2. Relational gaming

Further, Rovegno[21] argues the interactive nature of the situated learning environment meets the "relational" criteria within the relational culture of the game, between the gamer and the game, and among gamers laughing, talking, and at time, taunting within the game environment. And while exergames consist of affordances and constraints consistent with other situated learning environments, the exergaming relational environment takes affordances to a more complex level by permitting the learner to select the game and the level of difficulty. Young and his colleagues[11] push this concept in games to extremes by challenging the educational environment to ask:

> How does a particular…game being used by a particular student in the context of a particular …curriculum affect the learning processes as well as the products of school (such as test grades, course selection, retention and interest) (p. 84)?

Thus within a situated learning environment the outcomes are relational; they are specific to a particular context within a particular time and place. From an educational perspective, PA intensity must be discussed with motivation. Both of these variables are better understood relationally by knowing which difficulty level the gamer selected as well as the gamer's goals for that gaming experience. Yes, she may have been moderately active; but was the game physically stimulating and intellectually challenging? At the completion of the game, was the gamer satisfied with her performance, or bored because she set the goal too low? Continued adherence to activity for extended time periods usually requires as sense of mindfulness on the part of the performer, along with a sense of continuing challenge and a deep sense of satisfaction at the completion of the activity. The relational opportunities afforded by the game as selected, adjusted, and played by the gamer can provide experiences that can create learning—both as permanent changes in PA behavior, postural stability, AND as changes in the way the gamer thinks, reasons and solves problems within the gaming and the PA environment.

4.1.3. Authenticity

One of the advantages of exergames is the opportunity to engage physically and socially in the gaming experience. The life-like video settings plus the proprioceptive feel of the careening snowboard, lends a feeling of "being there," totally involved in the experience. The social interactive aspects of some games and some PE gaming contexts also can add to the authenticity of the situated learning gaming environment.[24] Certainly, some students find themselves immersed in the story they create in the context of the exergame. Lu et al.[25] report the story or metaphor created within game helps students feel they are transported to another place and time. Forgetting their daily concerns for the moment, they engage completely in a different space often with a new set of characters that quickly become friends.

4.1.4. Communities of learners

Lu et al.[25] emphasize the impact of interactions within a virtual community of learners on students' willingness to engage and give effort. Perhaps it is a snowboarding activity with a community of others learning to bend around trees and leap over moguls. The total cognitive, physical, and emotional engagement provides unique opportunities to engage students in more than just a fitness exercise. They develop "deep affection" for game characters assisting team members and thwarting opponents as their balance, gaming skills, and PA increase.

5. Future directions for exergaming research

Although Gao et al.,[4] Sheehan and Katz,[8] and Sun[10] have examined some potential benefits of exergaming, they have limited their studies to physiological, psychomotor, and cognitive meditational variables, neglecting knowledge-oriented educational goals central to educational approaches to PE. Although it is certainly of interest to know that exergaming meets participation and enjoyment objectives of recreational approaches to PE, the dynamic activities provided by exergaming can reach other objectives as well. Likewise, it is important to understand the role of exergaming in public health oriented programs, recording MVPA increases and decreases, and comparing MVPA achieved in exergaming to other traditional and fitness-based activities. Nevertheless, exergaming when developed within the educational PE curriculum, can utilize the complex, natural, relational, authentic, and community based environments embedded in exergames to design situated learning environments that integrate the learner, balance and fitness concepts, within an active gaming culture.

Interestingly, there are a host of exergaming research questions yet to be asked related to the potential for student learning. For example, "To what extent can exergaming contribute to students' understanding of the effects of exercise on their bodies?" and "How can exergaming be embedded in a learning-oriented curriculum to increase students' understanding of exercise principles, increasing their ability to create, monitor, and adapt personal exercise programs?" Currently, exergaming is providing situationally interesting environments in which some students can increase their exercise intensity and willingness to persist for longer periods than in conventional exercise and sport.

Because exergaming is in its infancy, scholars have so many opportunities to ask rich questions associated with these unique experiences. Those who see exergaming as a recreational activity will continue to measure students' enjoyment and willingness to participate in PA alone and with others in a social environment. Likewise, epidemiologists will examine levels of PA and consider aspects of the game that can be tweaked or exploited to facilitate and maintain behavioral changes. Perhaps those with the richest research opportunities are educational pedagogy scholars who will explore exergaming as a situated learning environment. Opportunities exist for research examining how students use exergames to better understand the effects of exercise on their bodies. They might investigate and discuss fitness principles such as FITT, overload, progression, and specificity. Other studies may examine the benefits of exergaming for fitness planning, permitting students to learn how to manipulate these principles to create, innovate and adjust their exergaming and other fitness experiences across their lifespan as their interests and needs change. While immediate behavioral change is valuable, sustaining the change and enhancing the experience is critical if currently reluctant students are to learn fitness concepts and skills that increase their ability and willingness to participate in PA on their own for a lifetime.

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