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RESEARCH ARTICLE

The use of digital technologies in the sport and physical education lesson: Fostering need-supportive behaviours in physical education teachers

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ABSTRACT

In primary and high school settings, the benefits of incorporating technology into curricula have been addressed by several studies; however, wearable technology integration as experienced by physical education teachers is less prevalent. Physical education teachers' lack of confidence teaching P.E. using wearables, along with a lack of appropriate preparation and unclear curricula frameworks that define how wearables could be used, are additional factors which require further exploration. As such, due consideration of the opportunities and barriers that physical education teachers encounter with wearable usage is presented. This article contributes to pedagogical practices in physical education using wearable technology. This is achieved by highlighting the opportunities that wearable technology presents as a student learning support tool as wearable allow cross curriculum learning opportunities with science, technology, engineering and mathematics. In this paper, the practicality and curriculum relevance of wearable usage in physical education is highlighted. Our paper discusses implications for research and practice and provides a knowledge base for the establishment of professional development courses based on teacher needs.

Keywords: wearables; education; physical education; teaching; health; physical literacy; technology

1. Introduction

The learning of health and physical education within a school based physical education curricula are inextricably connected from a young age. Typically, health and physical education (henceforth P.E.) teachers address a range of content and skill areas such as the teaching of fundamental motor and movement skills (FMS), motor development, motor learning, agility, mobility, and sport-specific skills. Thus, from early life, children act upon and understand the environment using mostly sensorimotor actions[1]. Broad changes in perception, cognition, and behaviour appear with the development of a child's sensorimotor repertoire[2] as children experience and learn different types of motor actions that vary in complexity. The responsibility of imparting knowledge and assessing motor skills is the remit of a suitably qualified P.E. teacher. Here, P.E. teachers apply various pedagogical ideologies to assist student learning and comprehension in both structured and unstructured physical activity and exercise tasks.

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Physical literacy (PL) is commonly described as being motivated, having confidence and physical competence, knowledge and understanding to appreciate and take responsibility for lifelong physical activity. PL has continued to draw global attention as a focus for promoting high quality P.E. and youth development[3]. Along this line, physical activity is usually oriented towards daily habits that promote a healthy lifestyle in primary and high school children.

Physical activity assessment has been considered a key factor to promote, monitor, and encourage lifelong physical activity amongst both primary and high school aged students. Contemporary physical activity assessment is increasingly contingent on wearable devices[4]. Herein, we define a wearable device as a sensor or sensor suite unencumbered by wires for the incessant and non-invasive detection of biosignals, analytes, or biomechanical and impact forces (e.g., acceleration, ground reaction force) for monitoring primary and high school children's physical activity and exercise.

In recent years, there has been an increase in the number and type of wearable equipment available to evaluate physical activity[4,5]. Hence, the continued expansion and diversification of wearable technologies in contemporary society has led to their assimilation in educational settings and contexts. At this point, the conventional education disciplines of science and technology (information communication technology, ICT) have arguably seen a greater uptake in the integration of wearables by teachers as part of their pedagogical methods. The use of wearables is, of course, devised to assist student learning, subject engagement and overall comprehension of the lesson and content that is taught.

With a mounting and varied number of wearables available, some P.E. teachers are also devising ways to utilise these technologies and applications during their P.E. lessons. By using wearables in P.E., both primary and high school children have opportunity to acquire information based on kinetics (forces) and the kinematics (movement) of their own motion in real-time. The advantage being that the P.E. teacher can, by using wearables as a learning support tool, help stimulate interest in numerous cross-curricula disciplines such as science, technology, engineering, and mathematics (STEM). This integrative pedagogical approach can help foster and encourage student interest in working with wearables. However, contemporary P.E. teachers have been relatively slow adopters in integrating wearables into their lessons. This is despite recent contributions in the literature that provide theoretical and practical examples as to how such devices can be harnessed to improve the teaching and learning process in P.E. lessons[6]. For instance, the increase of accessible, transportable digital technologies via wearable applications (e.g., tablets, iPad, Garmin, FitBit) have made them broadly used in science and technology-based lessons. Yet evidence exists of the positive impact that wearables have on children's motor performance and physical activity[7]. Conversely, although wearables are frequently used in sports science disciplines for performance monitoring purposes, their presence in primary and high school settings are far from prevalent. The reasons for this lack of usage differs, however. For instance, teacher ideologies and pedagogies, the circumstance of the school (funding, accessibility, teacher training), logistical issues, shifts in teachers' feelings toward using wearables, and privacy issues have all been listed as probable explanations for the lack of wearable usage in schools.

The intent of this paper is to provide an up-to-date practical general "primer" to better guide both primary and secondary school P.E. teachers and the wider P.E. education community, in the pedagogical benefits of wearable usage—in all environments and sporting scenarios, with emphasis on how educators can use wearables in their lessons. Moreover, the benefits of using wearables in a P.E. context are explored alongside extenuating explanations, that is—the obstacles perceived by P.E. teachers concerning the integration of wearables in lessons.

2. Value proposition for wearables in physical education

The convergence of wearables for predictive health, physical activity and physiological analytics has enhanced its utility for educative purposes. Notably, the detection and subsequent application of wearable-based metrics pertinent to and indicative of physical activity in children has persisted throughout the past decade. As such, the various forms of wearables available to P.E. teachers has the potential to be used in theoretical-based P.E. lessons and during practical-based physical activity components.

Off-the-shelf wearable devices that are available at sporting retailers and electronic stores are now cheaper and more resilient than what P.E. teachers previously had at their disposal in the early 2000s. Subsequently, the need for widespread programming is mitigated as an immediate concern due to how many wearable devices are already equipped and designed to store and transfer data. Integrative wearable and web-based programs are cost-effective, convenient for the user (i.e., the P.E. teacher) and allow self-paced learning.

Previous research has demonstrated the benefits of wearables for monitoring the fidelity and effectiveness of physical activity interventions[8,9] and for tracking progress and encouraging movement through quantified monitoring in children[10]. For instance, scholars have combined wearable global positioning system (GPS) devices in afterschool clubs[11], wearable video cameras for classroom teachers to reflect on their practice[12], and accelerometer enhanced gloves for immersive and interactive simulations[13]. These efforts are noteworthy as they demonstrate the value that wearables can provide to the contemporary P.E. teacher. Here, the P.E. teacher can utilize wearables to suit the required pedagogical approach. Furthermore, the P.E. teacher can review and reflect on the child's experience; thus, the teacher can subsequently change how the child relates to the experience of using the wearable for learning support. This presents opportunity in that not only do wearables have promise in P.E., but their usage can be applied in other educational settings. For instance, Evans et al.[14] used wearables as part of a pedagogical program (STEMfit) to provide a pathway for students to engage with STEM by using and analysing personally obtained data in different physical activity contexts. This highlights how wearables can be used to increase interest in other disciplines of learning such as using data obtained from wearables to acquire greater numeracy experience or exploring the engineering and technological mechanisms of wearable technology. This represents a unique, interactive, and meaningful way for P.E. teachers to connect students to physical activity and the wider discipline of health and physical education. Wearable devices offer a myriad of capabilities to fill a niche in a P.E. context that previously went either unfilled or unnoticed. While corporations and consumers continue to negotiate a permanent niche for wearable devices, the expectation is that interest and uptake in physical education will grow.

3. Practical examples for wearables in primary and high school settings

Work on wearable technologies for learning, or educational wearables, has continued to advance[15]. Generally, wearables are considered an appealing educational tool that can help both primary and high school students obtain firsthand information (i.e., data) related to physical activity outputs. However, teachers need to be convinced that wearables devices can help them do their job better, without increasing their teaching load, before they fully subscribe to integrating the technology into lessons. Bartholomew et al.[16] reason that teachers are more likely to implement activities that demonstrate academic-related outcomes than just increased physical activity levels. Thus, the importance of assessing practical outcomes that speak the language of P.E. teachers is important to the sustainability of any school-based intervention that uses wearables.

The ability to apply wearables as a practical learning support tool does, however, offer P.E. teachers an alternative method to assess academic outcomes when contrasted to traditional methods. For instance, wearables can be used to integrate fitness-based knowledge, to augment learning, and to increase students'

attitudes/self-efficacy toward physical activity and fitness. Wearables could also be applied to measure and monitor students' physical activity level and to help with physical activity goal setting. Additionally, students can construct their own games or participate in a varied intensity activity or sport, providing that the activity is varied enough to initiate variations to heart rate. From here, the teacher can project different student heart rate responses to physical activity on a screen or mobile tablet device. The ongoing challenge for the teacher is using wearables in a developmentally appropriate way. Nevertheless, using wearables will predictably bring broader pedagogical concerns. Direct examples of past wearable-based projects may provide P.E. teachers with the opportunity to understand the context of how wearables can effectively be used. For instance, Lee and Shapiro[17] conducted a survey that, based on a review of recent and present wearable technology projects, identified the forms of benefits that wearables can offer for learning as including: (i) the promotion of personal expression; (ii) the integration of digital information into social interactions; (iii) the support of educative role-play; (iv) the provision of just-in-time notification in a learning environment; and (v) the manufacture of records of physical experience for consequent inspection, reflection, and understanding. Additional benefits of using wearable technologies in P.E. have included providing students with voice, ownership of learning and reflection, increasing engagement and relevance, improving learning, building social presence, increasing accessibility, and differentiated instruction[18]. Researchers have also included using smartwatches as activity trackers in physical and health education[19] and using devices to provide feedback on language learning[20], examining cross-curricular connections[21] or assessing emotions during student learning[22]. For instance, Siering et al.[19] noted that a key benefit of wearable usage is the immediate-time feedback that tactile, or touch devices provide, which can enhance student engagement in practical physical activity learning. Lastly, Lindberg et al.[23] added that the novelty factor of learning with innovative technology (e.g., wearable devices) heightened student enthusiasm to learn. This may also lead to greater accessibility of wearables that may help students overcome limitations or a reluctance to engage in physical activity.

Other practical uses for wearables in education have included traditional metrics such as burned calories and use of the metabolic equivalent (MET), heart rate and heart rate variability, steps walked, floors climbed, distance travelled and movement speed. These metrics allow the P.E. teacher to set targets, embody assessment requirements, and apply pedagogical approaches that require students to analyse data, make predications, device figures, graphs, and tables, and set longitudinal targets. Nevertheless, it is feasible that many P.E. teachers are still exploring the practicality and efficacy in improving and understanding the importance of wearables in physical activity lessons. Here, contextualization establishes the practical benefits of wearables as a viable learning support tool.

Disciplinary physical education, or physical literacy, requires that students utilize their cognitive, affective, psychomotor, and motivational skills from a personal, social and community health, and movement and physical activity perspective. In this regard the wearable is a teaching and learning support tool as students use the device as part of their typical school P.E. class. The teacher can then build productive, inquiry-based learning, when the students collect data to challenge themselves toward more refined ways of seeing patterns and tendencies in data.

Classroom management, that is—helping P.E. teachers understand the value status of their students and removing obstacles to accessing data analytics, digital dashboards or popup notifications received from wearables can be used as student reminders and notifications or as part of an applied data tracking taxonomy. This will likely be contingent on the pedagogical approach used by the teacher and the method of application. The World Health Organisation's policy brief for 'promoting physical activity through schools' recognises the importance of creating active classrooms alongside P.E. lessons and opportunities for physical activity during recess, within the school day[24]. A contributing factor of practical wearable usage in P.E. is that students can

get a clearer picture of what they are going to do, facilitating their interest in working with these devices which can lead to a greater understanding for the importance of lifelong participation in physical activities. Despite this, whereas wearable technologies could be used to empower P.E. teachers and the wider school community, further research is required to investigate how teachers integrate devices into the school day. Additional insight is also necessary into the role wearables can play in supporting whole of school methodologies relative to the current inequalities in physical activity that exist.

4. Obstacles perceived by physical education teachers to integrating wearables

The school environment is an ideal setting for promoting physical activity. Wearables have previously been implemented as intervention tools within the school-environment[25]. Yet, the use of wearables as a teaching and support tool continues to pose challenges within P.E. lessons due to the unique nature of the class, limitations on space, time, and training[26]. This is despite some P.E. teachers having integrated some forms of wearables in their lessons, for example via pedometers and heart rate monitors[27], triaxial accelerometers[28], and mobile applications related to PA and sport[29]. Another obstacle is the time needed to train teachers. Cuckle and Clarke[30] found that a lack of ICT education in schools was a barrier to wearable usage in the classroom. It takes time for the teacher to learn how to use the wearable, and to plan and understand how to integrate it into practice during the teaching-learning process in an appropriate, interactive manner. However, it could be that it is the time to truly integrate wearables as a learning support tool within a P.E. curriculum that poses the biggest obstacle and not time to learn basic operational usage. Though, there are approaches to overcome these obstacles. For instance, a whole of school approach to ensure an appropriate duration of time is allotted preceding the start of a semester to ensure that P.E. teachers can integrate the devices into appropriate academic lessons is a logical first step. In addition, professional trainings and developmental opportunities for further learning to enhance teachers' competencies in the technology may significantly affect teachers' confidence in wearable integration. Grainger and Tolhurst[31] reference teachers' lack of confidence when they use ICT (e.g., wearables) in the classroom. This deprivation of confidence may be caused by a fear of failure due to technical problems with the wearable[32], as well as accidents and failures that may arise during classes. This reinforces what Thibaut et al.[33] propose in that greater professional development is needed for P.E. teachers to highlight the different tasks that wearables can perform and how wearable technology can be used and how potential technical problems can be overcome. Notably, professional development offers opportunity to improve teachers' motivation and confidence in teaching and integrating engineering and technology activities into their classroom[34,35]. Yet additional obstacles have also been identified by teachers, including lack of accompanying technology to support wearable use (e.g., computers/laptops to sync devices) and a lack of school funding to purchase additional devices[10].

5. Pedagogy

One of the overarching challenges in contemporary P.E. education, is to understand how wearable technology impacts pedagogy. Yet a risk for teachers exists in that using wearable devices for the sake of using new technology could create a school culture of technology before pedagogy[36]. Teachers risk putting the affordances of wearable technologies before pedagogical practice and potentially misusing or overusing the technology in their classrooms and during their practical P.E. lessons. Bower and Sturman[37] added that an overreliance on technology can limit the development of critical thinking skills and may result in teachers treating technology as a one-size-fits-all, cure-all, solution to learning. More research is needed on identifying and evaluating effective learning straggles for using wearable technologies.

One key concern, nonetheless, is the lack of research at the nexus of wearable technologies and applied P.E. pedagogy, rather than for physical activity data collection objectives. This could be because little is known about the application and usage of wearable technologies in school P.E. This, then, can mean that P.E. teachers can be opposed or confused about the pedagogical and potential ethical implications of using them in practice. This potential research 'gap' is due to an endured focus on what technology could or should look like in practice rather than investigating what occurs in school-based practice.

6. Uptake and implementation

Away from the discussion about the conceivable benefits and risks of wearable technology to support school-based physical activity, studies have focused on aspects of uptake and implementation. For instance, Marttinen et al.[35] explain that when teachers do use wearables, they use it to augment—rather than replace—their existing practices and implement it within their chosen pedagogical approach. This is a salient point as an embodied approach to P.E. learning may grant additional opportunities for student comprehension and greater levels of physical activity.

Although classroom-based physical activity programs exist[38] many do not address key barriers to implementation. For example, a significant drawback of previous interventions is that they rely heavily on teacher initiative and require specific teacher training to ensure implementation success. These programs require schools to provide ongoing training opportunities for new incoming teachers, as well as annual training for long-term teachers to ensure the upkeep of skills and knowledge. In this scenario, schools frequently require a dedicated teacher champion to encourage colleague accountability. Alas, teachers are critical to engaging students in classroom physical activity[39]. To successfully promote wearables within P.E., establishment of curriculum standards, and properly trained in- and pre-service (student) teachers is important to first identify the extent to which technology education is taught, the current problems and perceived barriers in the integration of technology practices, and how competent and confident teachers feel regarding the integration of wearables.

7. Discussion

Many researchers are interested in both the incorporation of wearables and the beneficial effects they produce in the instructional-educational process. Suggestions for incorporating wearables into physical activity lessons may assist in their uptake, such as introducing the concept of creating 'active classrooms'; incorporating short (3–5 min) active movement breaks and physical activity into the delivery of academic content (e.g., counting steps walked to calculate distance) into academic lessons[17]. Nonetheless, challenges remain in integrating wearables into P.E. lessons. Particularly, few studies have explored teacher perceptions of using wearables in schools to promote child or adolescent physical activity, well-being or learning[38]. Of the research that has investigated teacher opinions on wearables as a learning support tool, feedback suggests that wearables are frequently used as an enabler of sorts, that is—they are used to monitor and promote students' physical activity[18]. Despite this, acknowledging and discussing the hindrances that exist to additional uptake in wearable usage is needed. In this way, teacher concerns are focused on how wearables can be used in the learning process rather than merely being seen as a hindrance or a standalone metric.

The diversity of wearables allows for a tranche of engaging and student-driven learning opportunities. For instance, P.E. teachers can use wearables to track physical activity through a multitude of graphics, sequences or still images, audio-video recordings, and animations, with the intention of keeping the student engaged in the learning process, enabling them to improve their creative thinking skills. In STEM, the aim is to resolve an authentic task using multidisciplinary mathematics, scientific technology, and engineering

knowledge. Here, the advantage attained from wearables is that they allow the P.E. teacher to track and quantify movement while harnessing STEM learning principles.

A conventional use of wearables is to guide the structure of a learning activity by delivering, or providing, meta content such as instructions, prompts or frameworks, mainly using visual means (text and graphics) to assist student learning. This method of wearable usage is akin to the notion of conducting embodied behaviours. Here, cross curricula priorities can be included. Taking this approach, the opportunity for students is to learn connected content, which can be a STEM related subject (i.e., engineering) while engaged in a P.E. lesson. Future research ought to integrate teacher feedback regarding integration of STEM to support classroom physical activity. In doing so, students construct meaningful P.E. and STEM knowledge for themselves. This interplay, and the potential of the technology to improve learning is illustrated well by Kim and Searle[40] who noted:

> *New digital technologies can amplify student voice to provide learning experiences relevant to students' lives, especially for culturally and linguistically diverse students. This vision might be the ultimate expression of student voice offered by digital technology (p.10).*

The operation of wearables within P.E. can become readily accepted by students because they capture the important features of what, when, how and where they are performing a task. In a situation where students are instead taught these subjects in isolation, students rarely make meaningful connections, and mathematics and science are potentially overlooked as being overlain with one another, therein leaving students to the independent act of arbitrary problem-solving.

8. Conclusion

The intent of this paper was to provide an up-to-date general "primer" to better guide primary and secondary school P.E. teachers and the broader P.E. education community, in the benefits of wearable usage. This intent is justified given that physical inactivity remains an ongoing challenge, and P.E. teachers play a vital role in influencing physical activity. Wearable technology is increasingly being used within and outside of schools as a contemporary innovation. However, consulting and engaging with P.E. teachers is important when developing and implementing physical activity promotion strategies that use wearables as a learning support tool. Thus, designing wearable usage in P.E. for the goal of student learning or using wearables as a conduit for STEM engagement is very different than designing for wearable for health management, which is currently the predominant application of wearables. After all, cognitive advancement in children is as critical as physical health. Our hope is that additional theoretical foundations and more refined evaluation studies based on using wearables as a learning support tool occurs so that future research directions are more evident.

Author contributions

Conceptualization, SE; methodology, SE; formal analysis, SE and CW; investigation, SE; writing—original draft preparation, SE and CW; writing—review and editing, CW. Both authors have read and agreed to the published version of the manuscript.

Conflict of interest

The authors declare no conflict of interest.

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