Title	Teachers' and students' perceptions of factors influencing the adoption of information communications and technology in physical education in Singapore schools
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Teachers' and students' perceptions of factors influencing the adoption of information communications and technology in physical education in Singapore schools

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Abstract

Although there have been studies on the use of information communications and technology (ICT) as a pedagogical tool to enhance teaching and learning in physical education (PE), more research is warranted to understand perceived barriers and facilitators to usage. The purpose of the present study was to understand key factors that influence the adoption of ICT in PE perceived by teachers and students in Singapore schools. Eleven PE teachers (two females, nine males) with two to 25 years of teaching experience were individually interviewed and 72 students (39 females, 33 males) from 10 to 17 years of age participated in 11 focus groups. The study was guided by ontological relativism and situated within epistemological constructionism. Three themes were developed from the thematic analysis: (a) technological dispositions (i.e. self-efficacy and open-mindedness); (b) teaching approaches (i.e. pedagogical integration; cognitive, affective, and psychomotor stimulation; and balanced integration of ICT and the traditional approach); and (c) contextual factors (i.e. technological conditions; cultural conditions; and teachers' ICT-specific PE knowledge). Findings from the study support the notion that appropriate use of ICT tools has the potential to positively influence teaching and learning during PE lessons while emphasising the need for schools and professional development bodies to improve the ICT pedagogical proficiency of PE teachers. The study provides important insights into how teachers can better leverage ICT tools to support student learning in PE.

Keywords

Physical education, information communications and technology, teaching and learning, pedagogy, teachers' and students' perspectives

Introduction

The rapid advancement of information communications and technology (ICT) has transformed the world, particularly with the current generation of young learners who have been exposed to technology from their infancy (Soparat et al., 2015). ICT refers to various technologies (e.g. mobile applications, computers, the Internet) that allow access to information through telecommunications (Sargent and Casey, 2020). In education, the impacts attributed to advancements in ICT have highlighted the need for schools to find ways to optimally integrate ICT tools in order to meet desired educational goals (Casey et al., 2017; Fullan and Langworthy, 2013). Indeed, educational systems around the world are integrating digital competencies in curricula and assessments to foster 21st century skills such as communication and critical thinking (Roure et al., 2019).

Digital literacy and the use of ICT in education

Digital literacy has been associated with an individual's ability in handling basic software and executing information retrieval tasks. Buckingham (2015) highlighted that digital literacy should encompass an individual's efficacies in searching for relevant information, critically reviewing it and packaging the information into knowledge. Furthermore, it should not be taken for granted that young people can construct their own learning with digital tools (Selwyn, 2009). It was reported that 38% of adults in Singapore scored at or below Level 1 proficiency (on a scale of 1 to 3) in problem-solving in technology-rich environments. This is below the Organisation for Economic Co-operation and Development (OECD) average of 43% (Kankaraš et al., 2016).

In education, teachers are encouraged to include technology in their teaching to help students become digitally literate citizens to cope with the complexities of today's societies (Fraillon et al., 2020). In the context of physical education (PE), teachers' lack of digital literacy ultimately affects their competencies in using ICT tools (Koh et al., 2020; Sargent and Casey, 2020). Many PE teachers have reported having difficulty in conducting online lessons when schools

were forced to shut down to prevent the spread of the COVID-19 pandemic (Varea and González-Calvo, 2020). Hence, it is crucial for PE teachers to acquire relevant ICT proficiencies to plan, deliver, and intervene in the learning process, especially when their students encounter difficulties in using ICT tools (Bodsworth and Goodyear, 2017). Although studies have documented multiple benefits that can arise from using ICT in education (Fullan and Langworthy, 2013; Villalba et al., 2017), less is understood in terms of what constitutes desired integration and execution of ICT in PE (Tou et al., 2020).

Teachers' attitudes towards using ICT in PE

Past research has shown that teachers' attitudes towards embracing technology in their lessons are a critical factor in understanding patterns of implementation (Tou et al., 2020; Wyant and Baek, 2019). In efforts to explain attitudes towards ICT in education, some scholars have used the Technological Acceptance Model (TAM; Davis, 1989) to frame their research (Gibson et al., 2008; Hu et al., 2003). Essentially, the TAM is used to situate how intentions to use information technology tools are governed by factors such as perceived usefulness and perceived ease of use. Moreover, attitudes towards technology are shaped by external variables, such as self-efficacy, subjective norms, and facilitating technology use conditions (Schepers and Wetzels, 2007). Other scholars have explained that PE teachers' apprehension regarding using technology in their lessons is due to their lack of proficiency (e.g. digital literacy) and inadequate training in employing the tools/gadgets (Gibbone et al., 2010; Tou et al., 2020). According to Tou et al. (2020), biographical factors such as gender, age, and teaching experience must be considered in understanding PE teachers' attitudes towards using ICT tools in their lessons. Taken together, the findings of previous studies shed some light on how attitudes and the biographical factors of teachers can influence the adoption of technology in PE.

Benefits and challenges in using ICT in PE

With an ever-growing number of ICT tools made available for teaching and learning, PE teachers have explored various ways to integrate technology to enhance their lessons (Legrain et al., 2015; Villalba et al., 2017). Studies have highlighted some benefits related to the use of gadgets (e.g. pedometers) and mobile applications (e.g. MyFitnessPal) in enhancing PE teachers' instruction (Villalba et al., 2017), encouraging movement, improving students' critical-thinking skills (Phillips et al., 2014), promoting healthy lifestyles for adolescent students (Seah and Koh, 2020), enhancing students' acquisition of knowledge and concepts (Hinojo Lucena et al., 2020), improving students' motivation for learning (Soparat et al., 2015), and performance (Palao et al., 2015). However, PE teachers have reported challenges when using ICT tools in teaching. In teaching, the most common being insufficient preparation to integrate ICT into their lessons in meaningful ways (Hill and Valdez-Garcia, 2020; Palao et al., 2015), ICT curtailing physical activity time (Villalba et al., 2017), ICT reducing students' interest in learning (Zhu and Dragon, 2016), and ICT being logistically demanding (Lupton, 2015).

Despite the drawbacks reported in the literature, some scholars have argued that there is untapped potential for ICT to better support learning in PE (Calderón et al., 2020; Seah and Koh, 2020). Indeed, Krause (2017) found that pre-service teachers experienced much success and efficacy in using ICT tools during their teaching placements when they were provided with ICT-specific knowledge and training. These findings highlight the importance of quality pre-service training and professional development opportunities to better equip pre- and in-service PE teachers with the knowledge and skills needed to integrate ICT in their lessons. There have been limited studies examining the concerns of PE teachers in using ICT in their lessons (Casey et al., 2017). Indeed, Bodsworth and Goodyear (2017) suggested that the influence of ICT in PE is an area that must be further researched to suitably inform practitioners on how technology can be better utilised in PE lessons.

The present study

Tou et al. (2020) compared 422 Singaporean PE teachers' attitudes towards ICT in PE across different demographics and found that attitudes differed between teachers of different gender, age, and teaching experience. Although the results from this study provided a valuable knowledge base to guide future interventions for increasing ICT usage in PE, the study was descriptive (i.e. quantitative survey) and hence limits the extent of the inferences that can be made based on the results. Given the strong influence PE teachers have on student learning experiences, their attitudes and perceived competence towards ICT usage in PE should be examined (Krause and Lynch, 2018; Sargent and Casey, 2020). In addition, insights from students on ICT usage in PE are warranted (Calderón et al., 2020). Therefore, the purpose of the present study was to understand the key factors that influence the adoption of ICT in PE perceived by teachers and students in Singapore schools. The study was guided by three research questions: (i) What attitudes shape the perspectives of PE teachers and their students on ICT use during PE lessons? (ii) How do teachers integrate ICT tools into their PE lessons and how is this integration received by their students? (iii) What are the conditions that facilitate/hinder the design and delivery of ICT-based lessons by PE teachers?

Method

In terms of paradigmatic positioning, the study was guided by ontological relativism and epistemological constructionism. Ontologically, it was deemed that there are multiple, yet mutually constituting, mind-dependent realities as to how teachers and students perceive factors influencing the use of ICT in PE (Smith and McGannon, 2018). Epistemologically, the researchers subscribed to the belief that knowledge is subjective and socially constructed through interaction with the participants. In line with this assumption, the researchers sought to acquire meaning in the subjective experiences of the individuals who engaged with the use of ICT in PE.

Participants

Recommendations were sought from the Singapore Physical Education and Sports Teacher Academy (PESTA) to identify potential participants for this study. PESTA works closely with qualified PE teachers, conducting regular professional sharing sessions for teachers, including sessions on ICT use in PE. Eleven PE teachers (two females, nine males) aged 29 to 60 years old (M = 37.18, SD = 9.45), with two to 25 years of teaching experience (M = 7.54, SD = 6.49) were purposefully recruited from different parts of Singapore. The 11 teachers were from seven primary schools, three secondary schools, and one junior college. To be eligible to participate in the study, teachers needed to: (i) have at least two years of experience using/experimenting with ICT in their teaching of PE; (ii) be formally trained as physical educators; and (iii) be actively teaching PE (at least 30% of total lessons being allocated to PE during the school year). The selection criteria allowed for a good representation of Singapore PE teachers, ranging from department heads, experienced teachers, and novice teachers. From the schools where teacher participants were recruited, 72 students (39 females, 33 males), ranging from 10 to 17 years old, which the 11 PE teachers taught, gave their consent and participated in this study.

Procedure and instruments

Before data collection, ethical clearance from the university's review board and permission from the Ministry of Education's (MOE) data management branch were obtained. In consultation with PESTA, all school principals and PE heads of department listed in the MOE database were either contacted via email or phoned by a research associate. They were asked to invite their PE teachers and students to participate in the study. Student participants were recommended by their respective PE teachers. As they were below 18 years of age, student assent and parental consent were obtained before participation in the focus groups. Those who met the inclusion criteria and volunteered to participate were informed about the study purpose, and their rights to confidentiality and withdrawal.

A semi-structured interview guide comprising 13 open-ended questions was used to gather PE teachers' perspectives in using ICT during PE lessons. These questions focused on teaching philosophy, teaching strategies used, challenges encountered while using ICT tools, and recommendations for using ICT to better engage students' learning during PE lessons (see Appendix 1). The interview duration ranged between 45 and 68 minutes. Eleven focus groups with students were conducted (i.e. 10 groups of six students and one group of 12 students) to gather their perspectives and experiences on ICT-supported PE lessons. The interview guide comprised 13 open-ended questions concerning benefits, challenges, and recommendations in using ICT in PE (see Appendix 2). The focus groups lasted between 38 and 46 minutes. To capture responses, all interviews were audio-recorded and transcribed verbatim. All interviews were conducted in a quiet meeting room on the school premises by the research associate, who had 12 years of experience in qualitative research.

Data analysis

Interview transcripts were analysed using inductive thematic analysis (Braun et al., 2016). The analytical approach consisted of four steps. First, the research associate familiarised herself with and made sense of the data by going through the transcripts' content several times. Second, codes were identified and were grouped to form themes and sub-themes. These themes and sub-themes were reviewed to assess how they formed a logical structure and answered the present study's three research questions. Consistent with constructionism, the data analysis was led by the research associate and supported by the first author who acted as a critical friend. The role of the critical friend was to encourage reflexivity by challenging each other's construction of knowledge (Smith and McGannon, 2018). A thematic table was created to visually explore the relationships between the different levels of themes that were created. The final stage of analysis involved writing the report by selecting the quotes best illustrating the essential meaning of the themes deemed most salient and representative of ICT use in PE. Letters were assigned to participants to maintain

confidentiality and to differentiate the teachers and students. For example, a Teacher from School A and a Student from School B were coded as Teacher School A and Student School B, respectively.

Results

The results (see Table 1) are organised according to the themes developed during the analysis, aligning with the three research questions: (1) technological dispositions (i.e. self-efficacy and open-mindedness); (2) Teaching approaches (i.e. pedagogical integration; cognitive, affective, and psychomotor stimulation; and balanced integration of ICT and the traditional approach); and (3) contextual factors (i.e. technological conditions; cultural conditions; and teachers' ICT-specific PE knowledge). The themes and sub-themes reflect factors perceived to influence the adoption of ICT in PE lessons.

Table 1. Themes and sub-themes for factors influencing the adoption of information and communications technology (ICT) in physical education (PE) perceived by teachers and students.

Theme	Sub-theme	Quotation Examples
Technological dispositions	Self-efficacy	Not all teachers may be very receptive to this as well, especially those who are not very tech-savvy and they are not very familiar with the tool, which will then take up more time for them… Yes it [ICT] does take away lesson time, and it may create some constraint or difficulty in conducting the lesson because you know it will take some time and a million things can go wrong. (Teacher School K)
	Open-mindedness	For PE teachers, from time to time they will have some resistance when using different types of ICT tools… sometimes ICT tool A, I have maybe 7 accepting, 2 rejecting, ICT tool B, I have half of them rejecting, half of them accepting… and we don't want to force them (Teacher School E)
Teaching approaches	Pedagogical integration	ICT is good for PE, we get to learn from our friend's mistake, because we post it on the Google Classroom. So all of us will get to post our own videos with our friends on the app itself. So we get to see each other especially when our teacher gives us the homework to actually go and comment on others' video, so we will actually get to look for the mistakes of our friends and try not to follow the mistakes they did. So it's like learning from one another. (Student School I)

	Cognitive, affective, and psychomotor stimulation	They are able to be aware of whatever I'm trying to teach them compared to just talking to them and showing them my demonstration…when they see themselves and getting peer feedback or comments from me, they clearly understand whatever they need to do. (Teacher School K)
	Balanced integration of ICT and the traditional approach	I think, for example, if you want to learn a new sport, like rugby, instead of showing it first, which is what they are doing, I think students should just try it first. From that, then, you know what you know, what you don't know, what you're good at, then you watch. For understanding broad jump, you watch like a model, your legs should be 90 degrees, but for some people, maybe they need to bend all the way down to 45 degrees then they can jump further. I think if you show like how you should do it first, it restricts their freedom to stretch their potential. (Teacher School K)
Contextual factors	Technological conditions	So, ICT tool, it needs to be time saving, it needs to be effective and efficient process, and it needs to be reliable . . . it works sometimes and doesn't work sometimes, there is no point for me, and gives me frustration. Because if I bring something into my class, I need to handle all these . . . and if the thing don't work, I get very frustrated. (Teacher School E)
	Cultural conditions	I think school support is one big factor . . . then you see your PE teachers are open to trying out new devices. For me, I'm always on the lookout, there is sharing of this kind of thing. I think if it helps us, why not? So I think more sharing would be great. I think a course will be a bit too long, so just a few of us, officially, will be fine. (Teacher School A)
	Teachers' ICT-specific knowledge	I feel that in the future, the National Institute of Education could help to level up this proficiency. I feel [it] is a key step to at least make teachers feel more confident dealing with ICT tools, and at the same time understanding that even for people who are comfortable with ICT tools, we can also have failures... and how do we embrace it and then make use of this to enhance the future application. (Teacher School H)

Technological dispositions

The first research question focused on understanding what attitudes shape the perspectives of PE teachers and their students on ICT usage during PE lessons. Results of the present study show that

participants' dispositions (i.e. self-efficacy of teachers as well as open-mindedness of teachers and students) were identified as key in shaping and embracing participants' ICT usage in PE.

Self-efficacy. Teacher self-efficacy in relation to adopting ICT tools in PE lessons was perceived as a fundamental factor in influencing how ICT was used in PE. As illustrated by a teacher from School K, 'Not all teachers are very receptive to this teaching approach, especially those who aren't very tech-savvy and they're not very familiar with the tools, which will then take up more time for them.' When asked about his teaching philosophy, a teacher from School B highlighted the importance of teachers having the competence and confidence to align teaching pedagogy to student learning outcomes in their lessons. As the head of his PE department, one of the expectations he sets for his PE teachers is that they should be able to clearly articulate 'what [content] they [the teacher] are teaching and what pedagogy they are using' when observing their lessons. He further highlighted that 'teaching has to be anchored in pedagogy' (Teacher School B). Additionally, a teacher from School F mentioned how his criteria for using ICT in PE lessons depended on whether he perceived that 'the process of using it [ICT] is practical, seamless, and enhances learning.' Hence, such perceived expectations suggest teachers' desire to be sufficiently competent in using ICT in PE lessons as an important factor prior to ICT adoption.

Open-mindedness. The open-mindedness of students and teachers was found to be an essential factor in ICT use. The students voiced how their openness to ICT influenced their perception on whether ICT was beneficial to their learning experiences in PE lessons. A student from School D expressed that, 'being someone who likes technologies and can't stay for more than three days without them, it's kind of fun because I want to use technology more than just at home.' Despite being open to ICT use in PE, many students expressed a preference for live demonstrations and opportunities to try physical movements, rather than watching videos. One student from School A opined, 'instead of watching a video over and over again, you can ask your teacher to help you

improve by going through the movements. This is because by just watching a video, you're not actually going to improve.' Corroborating comments made by students who had negative perceptions on the use of ICT in PE lessons, a teacher from School K stated that students are 'more used to a very passive learning approach.' This is despite teachers' efforts to complement traditional teaching approaches by explicitly highlighting to students the affordances of using ICT during PE lessons.

From the teachers' perspective, being open to learning was considered a prerequisite to embracing ICT in their lessons. When asked about key barriers preventing schools from embracing ICT in PE, one teacher from School K stated, '…the buy-in is the critical thing. Because if you don't have the buy-in, it's hard to motivate people [teachers].' Moreover, one teacher spoke about 'the willingness to come onboard [adopting ICT in PE]' and that 'we [PE teachers] need to be open-minded' (Teacher School J). Open-mindedness was thus a key attribute for the teachers who adopted ICT in their PE lessons, even if they had not yet attained the necessary level of ICT proficiency. As one teacher from School F aptly summed it up, 'It shouldn't just be one way [student's willingness to try] … we [teachers] have to always experiment for the benefit of the kids.' Hence, to encourage ICT usage, the open-mindedness of both teachers and students is pivotal.

Teaching approaches

The second research question aimed to gain insights on how PE teachers integrated ICT tools with pedagogy in their lessons and the perception of their students of this integration. Participants believed that integrating ICT tools seamlessly with pedagogy and providing students optimal stimulation in the cognitive, affective, and psychomotor domains are needed to enhance teaching and learning in PE.

Pedagogical integration. The most common teaching strategies highlighted by teachers were the promotion of opportunities for self-directed and collaborative learning. Teachers cited how the use of ICT creates situations for students to practice in small groups without teacher assistance. A teacher from School H proposed a structure for a PE lesson supported by ICT, stating that 'it's all about self-directed learning... I'll teach them [using the ICT tool] first, and they'll gather in their groups of four, and learn [the skill] step by step by themselves.' In addition, teachers used ICT to create learning opportunities for students to constructively support their peers. Sharing his experiences in PE lessons that involved self-directed ICT peer learning, a student remarked that 'if you do it [perform the task] with your peers, it's fun, they won't criticise you if you made a mistake…it's helpful instead of having to figure out mistakes by yourself' (Student School I).

The use of ICT in PE creates opportunities for students to reach out and provide guidance to their peers through constructive feedback such as in aiding them to refine their movements. One teacher mentioned, 'I use ICT to promote collaborative learning, in particular, photo feedback allows students to communicate information about their learnings with their peers… it enhances students' interest in learning' (Teacher School J). Another teacher observed the 'increased tendency of students helping one another during the lesson, and that helped to foster a positive learning environment for all students with the use of ICT' (Teacher School K). In addition to tailoring feedback to individual students, ICT tools were also perceived to help students learn from their peers, through the use of collaborative applications (e.g. Google Classroom) and video recordings which allowed students to learn 'from one another… not follow[ing] the mistakes of their peers… such an approach helps facilitate greater learning among the students' (Student School K).

Cognitive, affective, and psychomotor stimulation. The participants voiced that the integration of ICT tools in PE lessons has the potential to enhance cognitive, affective, and psychomotor learning. Teachers shared how the use of videos can help each student refer to past

performances and identify areas for improvement. A teacher from School I expressed that 'in a traditional lesson, you can't give feedback to all 40 students at once. Whereas with technology, they can see for themselves, what's being done, because it's recorded, and feedback is given continuously.' Beyond facilitating cognitive learning, a teacher from School G expressed that it could also facilitate affective learning among students through their interactions with one another during the lessons, '…the affective side, because it's a lot of pair work, they have to deal with their friends… So in this particular class, they get to choose their own partners. It's a seasonal partnering.'

While students acknowledged that the use of ICT could stimulate the learning of skills, one common challenge to the psychomotor domain associated with ICT usage during PE lessons was the reduced physical activity time for students. Students shared how the use of digital gadgets often reduced the time for practice. When asked whether he preferred PE lessons with or without ICT, one student from School A said, 'I like the one without ICT… because you have more time to actually practice …with the iPad you have to record, have to save up under a name, then you have to show your friend… it takes up time.' This challenge is exacerbated when teachers need to spend time to give instructions for ICT tool usage. A student from School J said, 'we have to use the computer, then we have the instructions for using the computer, and have to figure out what to do.'

Balanced integration of ICT and the traditional approach. Students expressed the view that for ICT to be a useful tool for teaching and learning in PE, a balanced integration of ICT use with non-ICT ways of learning PE is needed. Specifically, the students mentioned that there are specific games for which ICT can be successfully and appropriately used, for example, to show students tactical movements or the breakdown of a skill. The notion of adopting a balanced approach was echoed by teachers as trial and error experiences are an important part of learning. For promoting a balanced approach, one teacher stated, 'students should just try [playing the sport]

first. From there, they know what they know, what they don't know, what they're good at, then they watch the video and learn' (Teacher School K). Moreover, providing opportunities for trial and error experiences allows students the 'freedom to stretch their potential' when learning a movement (e.g. standing broad jump). For example, 'some [students] may need to bend [their knees] all the way down to 45 degrees [in contrast to bending at 90 degrees] to jump further' (Teacher School K).

Teacher participants reported how the use of ICT tools made them more efficient in teaching PE. For example, a teacher from School E shared how Plickers cards (a formative assessment mobile application) helped him gather '40 [student] responses within three seconds.' Furthermore, teachers expressed that when ICT is used appropriately, it can facilitate time for student movement. For instance, a teacher from School E stated how ICT was useful in organising information on movement concepts and allowed him to 'spend more time in action and movement refinement' with his students.

Teachers also reported how the use of ICT allowed them to be more efficient in preparing, managing, and storing teaching resources. One teacher illustrated how 'a lot of time is saved from printing, cutting, and laminating instructional materials' in comparison with 'uploading [materials] online where students can access them at any time' (Teacher School H). Moreover, the use of ICT facilitated the creation of teachers' lessons. A teacher shared how despite not being present to conduct a PE lesson, the substitute teacher made 'use of video links to facilitate learning for students' (Teacher H). In another example, the use of Edmodo (a classroom management application) allowed for the 'extension of learning beyond the classroom' as students could 'access questions, quizzes, videos… at their own time, and learn at their own pace' (Teacher School E).

Contextual factors

Both teachers and students believed that for ICT adoption and integration to be successful in PE lessons, contextual factors should be satisfied. In particular, technological conditions, cultural

conditions, and teachers being trained and equipped with ICT-specific PE knowledge must be considered in order to promote teachers' adoption and integration of ICT in their lessons.

Technological conditions. To promote the use of ICT in PE lessons, ease of access to ICT usage is an important condition that must be met, given that technical difficulties can act as barriers to ICT usage in PE. These difficulties affected lesson time, as teachers reported connectivity issues in approximately 30% to 40% of lessons. According to a teacher from School F, 'with Wi-Fi, students need to [enter a] password, so really a lot of passwords, I can't take it…even with a password, it doesn't mean you can get in.' A teacher from School H expressed similar difficulties and frustrations when he 'had to keep pressing, pressing, and pressing… then it finally loaded… keep giving permission, permission… but sometimes it will not work.' Students also provided accounts of their difficulties and frustrations in using ICT tools during PE lessons. One student shared a frustrating experience when she 'tried to login to Wi-Fi, most [ICT applications] require a password, and sometimes the teacher doesn't even know the password, then you can't use the app at all' (Student School A).

Cultural conditions. The culture for the adoption of ICT in PE was identified as an important factor to facilitate ICT use in PE. Teachers highlighted the importance of the continuing support of school leaders and fellow teachers as key elements to making the use of ICT in PE lessons sustainable with meaningful gains for both teachers and students. With school leaders and heads of department as key drivers in the use of ICT in PE lessons, a teacher from School K elaborated that 'the environment must be conducive, the school must support PE as well as provide the resources.' To further promote a culture for the adoption of ICT, teachers recognised the importance of sharing their experiences in ICT use during PE lessons within their school and across communities of teachers. To encourage favourable conditions for integrating ICT in PE, teachers recommended more 'sharing sessions about ICT integration in PE lessons' (Teacher School A) within the teaching

community. Another teacher recommended 'the sharing of case studies or examples of schools that are doing it well' to encourage PE teachers to adopt ICT tools by 'seeing the actual examples of usage' (Teacher School C). A teacher from School K proposed that ICT be 'packaged' as a beneficial and efficient tool for teachers to conduct PE lessons. The teacher further recommended explicitly demonstrating to 'teachers how to use ICT tools together with useful teaching approaches to increase students' engagement time in physical activity.' Consequently, the learning culture would also have a profound effect on teachers' willingness to experiment with ICT tools in their PE lessons.

Teachers' ICT-specific PE knowledge. When teachers lack specific knowledge on how to use a wide range of ICT tools in their PE lessons, students are likely to be less motivated due to the perceived monotony and repetitiveness. One student shared an unpleasant experience, '… using the iPad and doing the same things for all PE lessons, we get a little bored… Because we're using the same thing over and over again, like a routine... It gets monotonous' (Student School A). To address this issue, a student from School J suggested 'having multiple apps with attractive features and useful learning resources' to sustain student engagement.

To facilitate the development of ICT-specific PE knowledge, teachers recognised the key roles of the National Institute of Education and the Ministry of Education in providing professional development for teachers. Teachers were cognisant of the valuable help these institutions can provide to improve PE teachers' competence with ICT tools. This would help develop the confidence and competence of pre-service teachers in 'integrating pedagogy with ICT tools' (Teacher School H). Another in-service teacher from School J said, 'If PESTA can come up with a module on the use of ICT in PE, I think that would be nice. … More subject- and context-specific modules will be useful for us in delivering quality PE lessons.'

Participants also shared that teachers need enough time to experiment and be open to trying different ways to use ICT to enhance students' learning. A teacher from School A expressed that 'more time has to be given to [teachers to] think about how to have continuity [in ICT use].' As teachers were unaware of any framework guiding the use of ICT in planning for PE lessons, they shared the need to experience trial and error cycles to attain proficiency. One teacher shared that his process of learning was through 'planning of the softball unit and lesson plan' and subsequently 'experimenting the plan with my students for a few lessons until I got it right' (Teacher School K). This suggests that teacher self-efficacy may be influenced by opportunities for trial and error experiences to attain ICT proficiency. Furthermore, as illustrated in the earlier sub-theme *open-mindedness*, the evidence further suggests that being open to learning is a prerequisite to the development of ICT-specific PE knowledge through trial and error experiences.

Discussion

The purpose of the present study was to understand the perceived key factors that influence the adoption of ICT in PE lessons in Singapore schools from the lens of PE teachers and their students. The main findings have been summarised and presented in Figure 1.

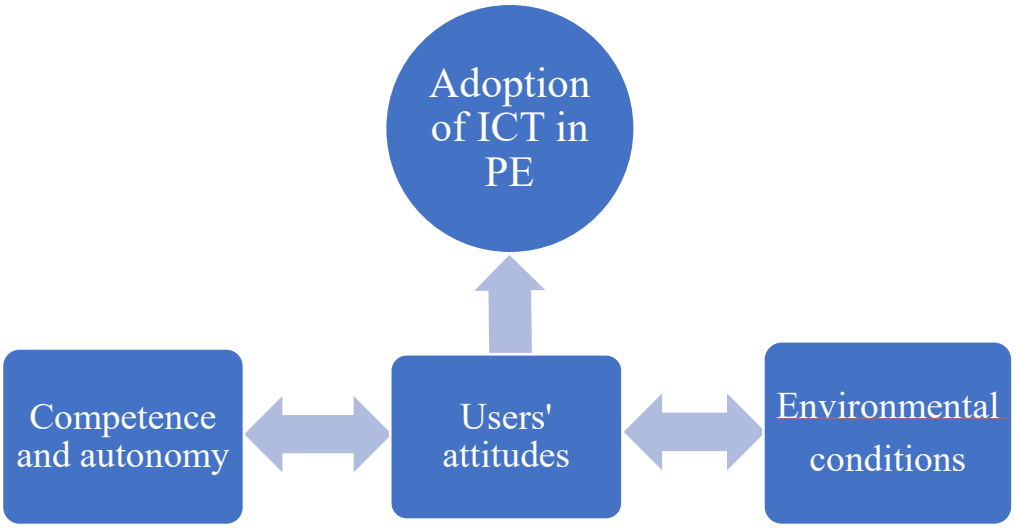

Figure 1. Factors influencing the adoption of information and communications technology (ICT) in physical education (PE) perceived by teachers and students.

Users' attitudes – the key to ICT adoption

Results from the present study show that users' attitudes towards ICT is a key factor that influenced their willingness to embrace ICT in PE lessons. This is consistent with many studies in the education literature that indicate the importance of teachers' and students' attitudes towards the use of ICT in PE lessons (Gibbone et al., 2010; Goktas, 2012; Kretschmann, 2015; Tou et al., 2020). The need for teachers to believe that ICT can be useful to teaching may be explained by the findings of the Hu et al. (2003) study, which lead to the creation of the TAM. Adopting such an open mindset to willingly embrace ICT is the key reason why many teachers in the present study persisted in refining their ICT-supported lessons through continual efforts of trial and error, despite the inherent challenges. Further, their high level of perceived self-efficacy in using ICT tools contributed to their positive attitudes that such tools can work to their advantage. As literature suggests, the concept of self-efficacy is an important factor influencing teachers' willingness to adopt new technologies into their lessons (Goktas, 2012). It also reinforces the notion that if the basic psychological needs for competence (through mastery of knowledge and skills necessary to be successful in using ICT) and autonomy (through opportunities that allow for independence in the selection of ICT tools for lesson design and delivery) are supported, users are likely to be intrinsically motivated in integrating ICT in PE lessons (Ryan and Deci, 2000). Taken together, when developing teachers' technological proficiency, it is important to focus on helping them feel competent while providing opportunities to empower them in designing and delivering ICT-based lessons in PE. For example, this entails making user-friendly ICT tools easily accessible to teachers and providing the necessary support to ensure they experience success in ICT integration in PE. This may influence PE teachers' attitudes over time and increase the likelihood that they will utilise ICT in their lessons.

Competence and autonomy in ICT usage

The use of ICT in PE lessons was embraced when the needs for competence and autonomy of the participants were supported to create opportunities to enhance teaching and learning experiences. These opportunities should be recognised as the unique potential that ICT can afford to PE lessons. Although the teacher participants attempted to integrate ICT tools as part of their lesson design in PE to promote teaching and learning, they still struggled to deliver their lessons well. This struggle is unsurprising as the teacher participants commonly cited a lack of experience, a lack of opportunities to trial and error, and a lack of consistent use of ICT tools (Koekoek et al., 2018; Koh et al., 2020). Furthermore, amongst the pedagogical approaches discussed in the literature (e.g. flipped learning, guided discovery; Sargent and Casey, 2020; Webb and Cox, 2004), the teachers seemed to mainly embrace collaborative and self-directed learning approaches. As Bingimals (2009) contended, the efficacy of technological integration may differ from curriculum to curriculum, place to place, class to class, depending on how it is applied. Taking into consideration that PE is a unique and dynamic discipline, researchers have argued that the integration of technology with pedagogy requires new perspectives and approaches (Bodsworth and Goodyear, 2017; Krause, 2017; Sargent and Casey, 2020). This argument is not surprising as although ICT in education is in its third decade of integration, PE has made slow progress compared to other disciplines (Bingimals, 2009; Casey et al., 2017; Kretschmann, 2015). Indeed, previous research has shown that PE teachers' perceived lack of competence in using ICT tools in PE settings was a major barrier in their teaching (Kretschmann 2015; Tou et al., 2020). Given that teachers are at the forefront of educational initiatives (Casey et al., 2017) and the strong emphasis by the Ministry of Education (Singapore) towards the use of ICT for teaching in schools (Tou et al., 2020), pre-service and in-service programmes must offer tailored training opportunities to better equip PE teachers with ICT-specific PE knowledge to meet the needs of young learners living in a digital world (Koh

et al., 2020). These customised courses should take into consideration the various factors (e.g. pedagogical approach, teacher's personality) and context (e.g. learner profile, learning content) that would influence how ICT tools should be utilised in PE lessons. In addition, in-service courses should put emphasis on providing PE teachers with a range of user-friendly ICT tools, guiding them to select, design, and deliver ICT-based lessons based on their own interests and strengths. Ultimately, teachers must feel empowered and subsequently take responsibility for understanding the intricacies of their PE context to ensure they choose the right ICT tools and approaches to promote optimal student learning.

Environmental conditions

In the present study, teachers' ICT-specific PE knowledge as well as cultural and technological conditions were factors identified that influenced ICT usage in PE. These factors influenced teachers' attitudes towards ICT adoption in both positive and negative ways. Participants in the present study spoke highly of PE teachers who are competent in designing and delivering ICT-based lessons that sustain students' engagement in the cognitive, affective, and psychomotor domains. Specifically, these teachers were able to skilfully blend movement activities with ICT tools that facilitated an improved understanding of concepts (e.g. watching a video) and improved interactions (e.g. peer learning). Moreover, from the perspective of students, there are specific PE games for which ICT can be successfully used and there are PE games for which ICT may be irrelevant to their learning. Nonetheless, based on the teachers' feedback that they were limited in their knowledge of ICT tools to engage their students, a practical way forward is to ensure teachers are provided with professional development opportunities to develop their ICT-specific PE knowledge to be competent in meeting teaching demands. Indeed, this is consistent with past studies that advocate having a range of ICT tools to sustain students' interest (Casey and Jones, 2011; Legrain et al., 2015). In order to successfully implement ICT in PE, the curriculum should

have the flexibility to allow teachers to choose from a range of ICT tools and teaching approaches (the need for autonomy) to improve teaching and learning. Taken together, it is critical that ICT be viewed by PE teachers as a useful teaching tool (Casey et al., 2017) to *complement* their pedagogies rather than *replace* them (Juniu, 2011). Indeed, student participants of the present study recommended that teachers should use a wider range of ICT tools and carefully select their tools in order to sustain student interest in learning during lessons.

Past literature suggests that a culture of support is necessary for teachers to embrace technology in their teaching (Villalba et al., 2017). This is important as ICT tools may be perceived by other teachers within PE departments as simply a gimmick (Casey et al., 2017). Although it might be challenging to change teacher perspectives as there remains limited and conflicting evidence on successful practices (Sargent and Casey, 2020), appropriate marketing of the benefits that ICT can bring to PE lessons may prove valuable to further increase the buy-in of teachers and students (Schepers and Wetzels, 2007). In addition, creating favourable cultural conditions can have positive effects on teachers' and students' receptivity towards the use of ICT. It is noteworthy that when faced with unfavourable technological conditions, the effect may be reversed, as perceived by the participants in the present study. Such unfavourable technical conditions may lead to a loss of physical activity time (Koh et al., 2020; Villalba et al., 2017). This is a cause for concern as within the school curriculum, PE lessons are susceptible to scrutiny when time is not spent in meaningful motor engagement (Cale et al., 2016). Taken together, enhancing teachers' ICT-specific PE knowledge as well as creating favourable cultural and technological conditions are necessary to catalyse the use of ICT in PE (Kang and Kang, 2020).

Limitations, future directions, and implications

Although the study contributes to the literature by providing insights into how teachers leveraged ICT tools to support student learning in PE, limitations must be mentioned. First, only PE teachers with experience in using ICT tools and selected students from Singapore were involved in the

present study. Future studies should consider gathering insights from PE teachers and their students operating in varied school contexts in different countries. Nonetheless, presenting the voices of both students and teachers is a study strength. Second, participants only took part in one interview or focus group. It may prove important in future studies to examine how PE teachers design and deliver lessons by integrating appropriate ICT tools to achieve students' learning outcomes (i.e. cognitive, affective, and psychomotor domains) through longitudinal designs as well as intervention studies. Longitudinal designs may help identify PE teachers' competency in designing ICT-based lessons and ICT usage across the school year. Intervention studies may provide clues as to optimal ways to equip teachers in adopting pedagogically sound ICT-specific strategies that are genuinely appreciated by students. These intervention studies would, for example, uncover deeper insights in previous findings on the influence of teachers' biographies and use of ICT in PE (Tou et al., 2020).

Some practical implications, supported by literature, include finding ways to reinforce teachers' attitudes on the worth of ICT, providing training in the use of a range of ICT tools for PE teachers to integrate in their lessons, and better equipping schools with the necessary infrastructure to support the adoption of ICT in PE lessons (Hill and Valdez-Garcia, 2020; Krause and Lynch, 2018; Kretschmann, 2015). As contended earlier, the process starts by getting teachers to embrace the place ICT can have in PE lessons, supporting them with the necessary ICT-specific PE knowledge so that they feel competent in using ICT in PE, as well as empowering and giving them choices to select ICT tools to design and deliver lessons. Hence, it is worthwhile investing in resources that can help shape teachers' attitudes related to ICT during their pre-service training. For instance, the design of PE-specific modules in pre-service teacher training may encourage the use of ICT-tools and complement the learning of trainee teachers. This may improve the confidence of trainee teachers in designing and delivering ICT-supported PE lessons. Moreover, greater technical support in schools may increase the likelihood that PE teachers consistently adopt the use of ICT to enhance teaching and learning in PE (Villalba et al., 2017). Living in a world with a constantly

evolving technological landscape, many stakeholders within the education system must play an active role if we are to improve PE teachers' attitudes and competencies towards ICT throughout their in-service years.

Conclusion

Through the lens of PE teachers and their students, the findings provided some support for the notion that the use of ICT in PE can optimise students' learning, resulting in positive cognitive, affective, and psychomotor outcomes through increased student motivation and engagement when ICT-supported PE lessons are carefully designed and delivered. Based on participants' responses, users' positive attitudes, perceived competence and autonomy, as well as favourable environmental conditions are likely to facilitate the adoption of ICT in PE. With ongoing developments in technology and the monumental educational challenges created by the COVID-19 pandemic in all countries, instead of living in fear and uncertainty about the future of PE (Varea and González-Calvo, 2020), PE practitioners should further embrace the potential benefits that ICT can bring to their lessons by staying up to date on the latest practices and thinking creatively from an implementation standpoint so that they are better prepared for unforeseen circumstances. Although the present findings suggest that overdependence and the misuse of ICT tools in PE may curtail activity time and compromise the psychomotor learning of students, by providing professional development opportunities and allowing substantial time and space for teachers to refine their PE lessons, we can increase the likelihood of advancing our understanding in the design and delivery of ICT-based PE lessons. Consequently, when ICT is used optimally in PE lessons, it has the potential to unlock unique teaching and learning opportunities. Hence, it is important that we remain optimistic in our endeavours to research while continuing to promote the use of ICT in PE.

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Appendix A

Interview Guide for PE Teachers

***Warm-up questions*:**

1. Can you describe your experiences that led to your current position as a PE teacher?
2. Can you talk about your training or certifications to become a PE teacher?
3. Can you talk about other learning situations that inform your teaching (especially ICT tools or strategies) aside from your training or certifications?

Philosophy:

4. Can you describe your teaching philosophy?
5. What type of support do you receive or feel you need to receive to successfully implement your teaching philosophy?

Reasons, strategies, and challenges for using ICT tools in PE lessons:

6. Can you share with me the reasons for using ICT in your PE lessons?
7. Can you provide examples of ICT tools and strategies you use to teach your students during PE lessons?
8. How did you learn to develop these tools and strategies?
9. Can you elaborate on some of the challenges or obstacles you might face in implementing such tools and strategies?
10. Describe your students' level of receptivity to this type of teaching approach and materials used.

Recommendations:

11. Provide your thoughts on if or how teacher training could be improved with respect to using ICT tools and strategies to better engage students' learning in PE lessons.

12. Describe your interactions with different people and their influence on your ability to use ICT tools and strategies in teaching PE.

    - Teachers from other schools
    - Colleagues in schools
    - Administrators

Conclusion:

13. Can you provide a final comment that encompasses your perspective on the use of ICT tools and strategies in teaching PE lessons?

Appendix B

Interview Guide for Students

***Perspectives on PE*:**

1. How important would you say PE is in your life?
2. What do you like the most and the least about PE?

***Benefits of ICT-based Lessons*:**

3. You have experienced ICT-based PE lessons and regular face-to-face PE lessons. Can you tell me which approach you liked the most? Why?
4. Can you provide me with some examples of why one type of lesson was more enjoyable than the other?
5. If I ask you to compare ICT-based PE lessons and regular face-to-face PE lessons, from which would you say you learned the most?
   - ICT: In what ways? Give some examples.
   - Regular face-to-face: In what ways? Give some examples.
6. In your opinion, how can the ICT materials and lessons be further improved to make learning more interesting and engaging? Please give examples and state reasons.
7. In your opinion, how does ICT-based lessons engage you in learning?
8. Do the ICT materials help you better execute the movements and techniques taught in PE lessons (psychomotor)?

9. Do the ICT materials help you better understand how or why to execute the movements and techniques taught in PE lessons (cognitive)?

10. Do the ICT materials help you further connect with and relate to teachers and peers during PE lessons (affective)?

***Challenges faced and recommendations*:**

11. Did you experience any difficulties or challenges during PE lessons delivered by teachers who used ICT materials? If yes, how did these challenges affect you and your learning? Give some examples.

12. Moving forward, in your opinion, what could be done to reduce the challenges faced and equip teachers to use ICT materials in ways that benefit you and your learning? Give some examples and state reasons.

Conclusion:

13. Sum up the key points mentioned and discussed during the interview and ask the participants whether they have any further comments.