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Using the Technological Pedagogical Content Knowledge Framework (TPACK) model to analyse teachers' use of Information Communication Technology (ICT) in Primary Physical Education

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ABSTRACT

During the past decade there has been an increase in the range and quantity of digital technologies available to use within classrooms (Casey et al., 2016; Gard, 2014; Lupton, 2015). It has been recognised that using ICT is an important skill to develop amongst children (Livingstone, 2012), and can provide unique opportunities for developing high quality reflection and feedback skills (Fabian & Maclean, 2014; Weir & Connor, 2009). Qualitative data were collected from both specialist ($n=6$) and non-specialist ($n=3$) PPE teachers. In total, 9 teachers were interviewed from 8 different schools using a semi-structured interview. Key findings show that whilst there were many examples of the use of technology within the primary curriculum in all schools, most teachers used limited digital technology within their teaching of PPE. Those who did include technology reported this as a replacement for a lack of Content Knowledge (CK) or Pedagogical Content Knowledge (PCK), to save time during teaching or assessment activities, or for the delivery of specific activities. Greater emphasis on training and continuous professional development in schools is needed, thus allowing teachers to develop the knowledge and confidence to successfully integrate ICT into their PPE curriculum.

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Introduction

During the last two decades, there has been a dramatic increase in the range and quantity of digital technologies available to use within classrooms (Casey, 2011; Casey et al., 2016; Gard, 2014; Jastrow et al., 2022; Livingstone, 2012; Lupton, 2015). This includes many ways to embed Information Communication Technology (ICT) within teaching practice. In addition, exposing primary-aged children to ICT has been highlighted as an essential component of modern education (Livingstone, 2012). This, alongside the limitations imposed because of the COVID-19 pandemic and its legacy, confirms the necessity for educators to be fluent in using such delivery modes. Through offering unique opportunities for interaction, ICT supports young people to develop high-quality reflective and feedback skills essential for success in Primary Physical Education (PPE) (Fabian & Maclean, 2014; Ofsted, 2009; Weir & Connor, 2009). However, there is debate within current literature regarding best practices in this arena (Casey et al., 2017; Gibbone et al., 2010; Jastrow et al., 2022; Livingstone, 2012), particularly regarding the extent to which digital technology is being used effectively, if at all, in educational environments (Baek et al., 2018; Casey et al., 2017; Fullan, 2013). The notion that technology should complement other teaching approaches (as opposed to replacing them) is echoed throughout much of the literature (Jastrow et al., 2022; Rosenthal & Eliason, 2015; Weir & Connor, 2009), with the primary argument being that practitioners should consider technology when identifying potential new systems, apps or hardware to use within their classrooms. Whilst capitalising on the social relevance of digital technologies and their ability

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to engage learners (Casey et al., 2017), it is crucial that we consider both the merits and potential shortcomings of using these tools within the environment of PPE, particularly concerning the speed at which more of these technologies have been adapted as a result of the COVID-19 pandemic. This paper critically analyses approaches to ICT use within PPE based on understanding the TPACK model (Mishra & Koehler, 2006), which is discussed in depth later in the paper.

Information Communication Technology (ICT): deploying technology appropriately

ICT is becoming more widely accessible to a range of students from varied socio-economic groups (Casey et al., 2017), even more so following the COVID-19 pandemic, suggesting that cost is ceasing to become a significant limiting factor in including ICT in day-to-day schooling. However, it is acknowledged there are still areas where this continues to be a substantial barrier (Scully et al., 2021). When used appropriately, ICT can provide opportunities to engage young people by providing potential benefits for a student's overall physical health and learning (Fogel et al., 2010). It has been postulated that alongside maximising time for physical activity within lessons, using digital technology can save time in teaching, learning and assessment (Casey et al., 2017; Rosenthal & Eliason, 2015) and can allow for more effective personalised student feedback. This is particularly pertinent within PPE as the practical nature of the subject often reduces opportunities for reflection and self-assessment tasks due to a lack of tangible evidence of students' work. To overcome this, Lee et al. (2001), and more recently van Rossum and Morley (2018), suggest that video is often the best method of ICT to record student work and capture assessment evidence.

Although pupils are often seen as individuals within their learning journey it is important to remember that learning is not a solitary process. Recent pedagogical work in physical education has tended to embrace Vygotskian notions of social constructivist approaches to learning (Vinson & Parker, 2019) and that social interaction is an integral part of the learning process (Bates, 2016). Cremin and Burnett (2018) critically consider the importance of social interaction in learning – particularly within PPE – arguing that if technology is introduced, it must be done cautiously to support learning in all domains. An idea supported by Goodyear et al. (2014) who identified issues with video technology in suppressing some pupils' work in the psychomotor domain. In addition, education scholars have identified the potential for the negative impact (such as off task behaviour and the removal of the humanness in learning) that an ever-growing focus on digital technology may have on students' development (Acquaviva et al., 2013; Casey, 2011; Jastrow et al., 2022; Rosenthal & Eliason, 2015). Furthermore, there is evidence to suggest that removing some communication technologies can impact some groups of students more than others; specifically, those in lower attainment groups benefit most from removing mobile phones from school environments (Scutt, 2019). However, it is unclear to what extent this claim is supported if mobile phones are used as a learning technology device instead. This collective evidence suggests that it is the management of technology rather than technology itself, which is the issue (Jastrow et al., 2022). Therefore, it is paramount that digital technology does not subtract from the social interaction element of learning; rather, it should be used to enhance such interactions to develop learning further. Underscored by the UK minister for Standards in Education, Nick Gibb, there is growing concern that increased online time can limit young people's opportunities for interaction (Mason, 2019). However, Fabian and Maclean (2014) contest that digital technology can provide opportunities for social interaction (e.g. discussing technique with a performer) when integrated appropriately into lessons. This type of interactive learning support has been shown to be crucial in improving student performance significantly (Livingstone, 2012; Roure et al., 2019), therefore identifying a need for effective technology integration into teaching practices.

Developing an appropriate approach to ICT in Primary Physical Education: embracing the Technological Pedagogical Content Knowledge Framework (TPACK)

To assist teachers in making impactful use of digital technology, several frameworks exist that seek to support practitioners in making informed choices about integrating technology into their teaching. One such framework is the Technological Pedagogical Content Knowledge Framework (TPACK), first

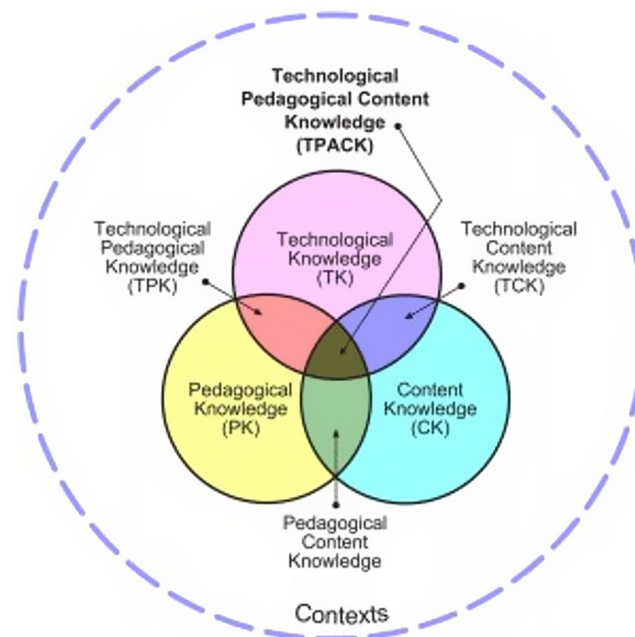


Figure 1. Technological Pedagogical Content Knowledge Framework (TPACK).

introduced by Mishra and Koehler (2006). The framework (see Figure 1) ‘emphasises the connection, interactions, affordances, and constraints between and among content, pedagogy and technology’ (Mishra & Koehler, 2006, p. 1025).

To successfully integrate technology and positively impact student learning, all three pieces of knowledge (technological, pedagogical and content) must be utilised effectively. The framework also serves as a professional development tool for teachers, ensuring planned learning experiences are informed by content-driven, pedagogically-sound, and technologically forward-thinking approaches. Whilst we have presented a case for the benefits of using digital technologies within PPE throughout all levels of mainstream education, this should be cautioned against using or underusing such technologies due to the potential for teacher overwhelm (Palao et al., 2015). It has been identified that prior to the COVID-19 pandemic, few schools routinely used ICT within their lessons to support student learning (Casey, 2011; Ofsted, 2009; Rosenthal & Eliason, 2015; Weir & Connor, 2009). Although all practitioners need to engage in teaching with digital technology, there is still some evidence to show that teachers experience limiting factors when using ICT within their teaching (Scully et al., 2021). Evidence suggests that these limiting factors can be classified into three dominant themes; (1) Technological Pedagogical Knowledge; (2) Pedagogical Content Knowledge; and (3) Barriers to using technology in education.

Technological pedagogical Knowledge

Issues for practitioners in using ICT include factors such as teachers’ knowledge of the applicability and use of digital technology in the classroom (Bennett et al., 2017). It is noteworthy that there is a limited time allocated to ICT training within primary initial teacher training (ITE) (Juniu, 2011), meaning that those who do not already possess digital knowledge through previous ICT experience are left with a restricted understanding of how best to integrate such technologies into their teaching. Similarly, limited availability of continued professional development (CPD) in this field (Casey et al., 2017; Weir & Connor, 2009) can leave some teachers lacking support in obtaining or improving their knowledge about digital technologies once in practice. This is especially problematic considering Weir and Connor’s (2009) statement that practitioner ICT skills and knowledge are vital for underpinning its practical use within schools and was made more pertinent during the COVID-19 pandemic (Scully et al., 2021). Ross (2015) echoes this by exploring the potential impact of a teacher’s attitude towards ICT, identifying that this can significantly affect how digital technology is successfully integrated into a classroom. Indeed, teachers who

lack confidence in their digital literacy may actively resist additional CPD opportunities in using technology, resulting in a poor ability to execute its use in an impactful way (Fabian & MacLean, 2014). As a result, teachers are indirectly limiting student development and potentially forfeiting the varied benefits that well-chosen digital support can provide within schools.

Pedagogical content knowledge

Adopting ICT within the school environment (across all key stages) has proved to be a contentious issue, particularly when used to give instruction instead of a tool for supporting learning (Acquaviva et al., 2013). Central to this argument is the consideration that the use of digital apparatus and ICT-based tasks are not necessarily apropos to the topic or learning aims, particularly in PE, where these are generally of a physical nature (Fabian & MacLean, 2014). Livingstone (2012) suggests an optimum level of use of technology in classrooms, indicating that there is a need to recognise the difference between maximising use (i.e. to support student learning) and overuse (i.e. causing a decrease in student performance). This suggests that more is not necessarily better where digital technology is concerned. An idea supported by Bodsworth and Goodyear (2017) who identified the importance of reflection in its effective use in learning. A careful consideration of technology integration must be included in teachers planning to ensure that its use is appropriate and impactful (Wintle, 2019).

The overarching argument against using technology within PE lessons is the potential risk of reducing the time students will spend physically active (Casey, 2011; Hill & Valdez-Garcia, 2020; Weir & Connor, 2009). Encompassed within this, Casey et al. (2017) identify the potential for ICT – if used incorrectly – to reduce PE teaching to a surveillance of activity levels and performative measures that can negatively impact student experience. Thus, it ultimately reduces education outcomes to only that which can be measured and undermines the professionalism of PPE as a whole (Gard, 2014; van Hilvoorde & Koekoek, 2018). This suggests that integrating technology into PE classes requires careful consideration. Weir and Connor (2009, p. 161) propose that activities with ‘specific discrete skills’ such as athletics, gymnastics and dance may be better suited to the use of digital technology, although Casey et al. (2017) posit that this focus on skill development can alienate rather than engage some students in PE. Evidence suggests a difference in the effect that digital technology can have on the depth of learning in different tasks or subjects (Jastrow et al., 2022; Livingstone, 2012). Yet, there is a lack of clarity about what these differences may be and how these should impact teaching practice. This lack of evidence-based practice is a significant limitation in integrating ICT, particularly in Primary PE teaching, particularly in the psychomotor domain (Diekhoff & Greve, 2023; Greve et al., 2022). Without adequate guidance and support, teachers may continue to reinforce traditional beliefs about the activities within the National Curriculum and forfeit the potential for digital technology to enhance student learning and engagement.

Barriers to using technology in education

Logistical issues of embedding ICT in learning environments can pose problems – even for teachers enthused to integrate digital technology into their classroom practice (Jastrow et al., 2022). As a result of budget constraints set by the Department for Education in the UK (AoC, 2014), there are often limited funds available to purchase or update technology in schools (Acquaviva et al., 2013; Casey, 2011; Gibbone et al., 2010; Rosenthal & Eliason, 2015). Indeed, the sheer cost of some digital equipment may limit the volume of possible purchases, dampening its effectiveness in classrooms (Acquaviva et al., 2013; Weir & Connor, 2009). Furthermore, the continual rapid (re)development of technology can leave the most affluent of schools reluctant to invest financially in digital apparatus that can quickly become redundant.

Villalba et al. (2017) analysed the barriers to technology integration, demonstrating a potential for disruptive behaviour and logistical problems when using ICT within lessons (for example, time taken to set up/log in/starting programmes or applications, etc.). Intermittent internet connectivity can also raise problems with speed and access to resources (Fabian & MacLean, 2014; Franklin & Smith, 2015), which can negatively impact the flow of a lesson or students’ progress. This means that there is an argument to suggest that digital technology is (at times) not being used to its full potential due to circumstances outside of the teachers’ control (Baek et al., 2018; Casey et al., 2017; Lee et al., 2001). In addition, Fabian

and MacLean (2014) identify the potential for data protection issues to pose problems for teachers. Although none were raised in their research, their study was conducted in a further education environment, which will inevitably have different regulations for PPE. General Data Protection Regulations (GDPR) guidelines may also create barriers when using some forms of technology although this appears to be a bigger concern for teachers than pupils (Engen et al., 2018). They can disincline teachers to use ICT due to the potential for misuse of pupil data, thus fueling critics of 'DigiTech' in education (Lupton, 2015). The storage of personal data and student images is a potential site for dispute (Casey et al., 2017; Jastrow et al., 2022) and needs to be carefully considered by practitioners before using any form of digital technology. These logistical barriers aren't unsurmountable for teachers using technology within lessons, and when carefully planned, the many benefits can outweigh the costs.

Materials and methods

Introduction

Following British Sociological Association guidelines, ethical approval from the research ethics subcommittee for the School of Sport and Exercise Research Panel at the University of Gloucestershire to complete the project; a range of both PE specialist (n=6) and non-PE specialist (n=3) teachers in a range primary educational environments were recruited via a hybrid of convenience and purposive sampled (Patton, 2002; Flick, 2009). To participate in the study, teachers needed to self-identify as current, practising teachers and agreed to partake in the study following participant requests through the lead author's professional networks. In total, nine teachers from eight different UK-based primary schools were interviewed. Following British Sociological Association guidelines, all gave either written or recorded verbal consent to participate in the research after being given information about the project and how their data would be recorded, anonymised and stored.

Participants

The teachers were aged between 24 and 57 years (mean = 34 years), had between 3 and 36 years of teaching experience (mean = 11 years), and had employment in a range of school settings (see Table 1). All but two were qualified teachers (others were Higher-Level Teaching Assistant (HLTA) and a sports coach, both with additional qualifications in teaching PPE), and all teachers participating in this research were from countries in the United Kingdom.

Procedure

A semi-structured interview was deemed to be the most appropriate method for this study (Arksey & Knight, 1999), allowing for an in-depth and rich exploration of teachers' experiences, which was central to this investigation. Due to location constraints, some interviews took place online rather than in person. The interview schedule was designed by the research team, who were trained in various research methods and possessed appropriate knowledge about using ICT in PPE. The lead researcher is a qualified secondary physical education teacher with experience teaching across primary and secondary settings. The background and experience of the research lead helped in overcoming the problem of the

Table 1. Participants experience and school information.

Teacher age	Teaching experience (years)	School size (pupil no.)	Characteristics
33	12	<200	Independent, mixed, Wales
32	12	>400	Comprehensive, Mixed, 78% EAL*, 62% FSM**, Wales
33	11	>400	Comprehensive, Mixed, 78% EAL, 62% FSM, Wales
57	36	<200	Church of England, 2% FSM, Mixed, Gloucestershire
29	7	<200	Church of England, Mixed, Gloucestershire
26	4	>400	Academy, Mixed, 52% FSM, Blackpool
45	18	>200	Community School, Mixed, 37% FSM, Cheshire
25	3	>200	Academy, 16% FSM, Mixed, Oxfordshire
24	3	>600	Community School, 30% FSM, Mixed, Manchester

*EAL: English as an Additional Language, **FSM: Free School Meals.

participants' willingness to complete the interview by ensuring a degree of familiarity with the research participants—thus alleviating to some extent the 'researcher as professional stranger' metaphor (Flick, 2009, p. 110)—and to access, what Adler and Adler (1987) describe as an 'insider perspective' on the reality of being a teacher in this particular case. Interview data were collected over 5 months, and questioning within the interviews focussed on five broad topics: (1) teachers' experiences of technology; (2) their teaching philosophy and approach; (3) types of technology used; (4) the perceived impact on learners; and (5) the perceived benefits and barriers of the use of specific technology on teaching and learning in a primary setting.

Data analysis

Interviews were transcribed verbatim, then analysed and coded by the research team using Lichtman's (2013) approach to the 3 C's of data analysis – Codes, Categories and Concepts. To ensure data credibility and being mindful to not to become prematurely wedded to codes that were 'carved in stone' (Henderson, 1991), the researchers independently coded raw data (i.e. quotes or paraphrased excerpts identifying an important point or thought) to characterise each teacher's response to their views on technology use in PPE. Once this initial coding had taken place, the analysis moved from specific data and raw themes to a lower and higher order categorisation of the data based on groups of like responses and common themes of generality to elicit clear notions of the use of technology in PPE. The research team reached a consensus on the categorisation of themes through discussion and reduced the raw codes into the overarching themes discussed below. We note Smith's (2018) call to grapple with the notion of generalisability of our findings. Whilst not claiming what he denotes as 'statistical-probabilistic generalizability' (p. 138), we do proffer that practitioners and teachers might resonate with our findings and find some transferability (Tracy, 2010) or inferential generalisation (Lewis et al., 2014) and in a sense, using Smith's words, we have written our analysis in a way that might provoke teachers to ask 'is this something I can apply to my physical education class?' (2018, p. 141). Data are presented throughout as part of the discussion.

Results and discussion

The analysis identified major themes related to technology use, including (1) technology for communication and delivery of content and (2) technology as a tool for assessment through surveillance and data collection. In addition to their use of technology, teachers also outlined a range of perceived benefits to using technology in their PE lessons. In line with research from Fernández-Batanero et al. (2019) teachers were largely enthusiastic about its inclusion in their teaching practice although this was noted most frequently with those participants of the mean age and below, a finding mirrored by that of Tou et al. (2020):

'If it can enhance our learning in any respect, whether to make learning easier, whether to provide a pathway for learning, whether to provide a pathway for output of learning'
(Ron, Interview 1)

Technology as a tool for communication and delivery

Mishra and Koehler (2006) assert that teachers must use their existing content knowledge to integrate technology into their classes effectively. However, this may present a problem for the non-specialist teacher for whom subject knowledge within PE is a perceived weakness (Jones & Green, 2017; Morgan & Bourke, 2008). Interestingly, 3 out of the 9 participants, including a range of levels of experience, were generalist primary teachers who identified methods in which technology was used to replace PE subject knowledge in specific activities.

'Particularly in gymnastics – because my gymnastic skills aren't the best, I'll show them videos and stuff before we go in'
(Lana, Interview 5)

Lana further explains how, for her, technology is a replacement for content delivery, a theme repeated by other participants' comments, which may perpetuate a lack of engagement in some activities due to students lacking an appropriate in-class demonstration on which to model their learning. This contrasts with much other research, which focuses on the impact of technology on students' learning experience (Nowels & Hewit, 2018; Palao et al., 2015; Trabelsi et al., 2020) and the use of technology to support teacher feedback (Roure et al., 2019; Sargent & Casey, 2019) rather than the initial presentation of new skills.

'I would still use the video component for instructions to begin with before going outside'
(Ron, Interview 1)

'We use videos, you know demonstrating good practice'
(Katie, Interview 8)

There was an increased teacher reliance on external digital sources to provide information and demonstration to pupils for performances in activities such as dance and gymnastics.

'I've used it mostly in gym, gym or dance'
(Kelly, Interview 3)

'with the dance stuff that... erm, we played the video first and then we work from the video'
(Lana, Interview 5)

'you can find quite decent clips of how to do a forward roll online, rather than me demonstrating'
(Ella, Interview 2)

Quinn (2019) argues this practice could alienate some pupils from the content and limit the depth of their learning. The importance of the teacher as a role model in the primary phase should not be overlooked (Dunn, 2017), and the impact of the disassociation of the teacher from some elements of PPE can be reflected in pupils' attitudes towards certain activities. Therefore, if a teacher is not confident in delivering a curriculum that can use technology to engage and inspire learners, this may be detrimental to the attitudes and potential attainment of the students. Van Hilvoorde and Koekoek (2018) outline the problem with using visual demonstrations in the place of instruction as this alone is not sufficient to support learning. Those teachers using technology to replace content knowledge will often not be able to provide effective feedback to their pupils to develop their skills appropriately, highlighting the importance of training in using technology alongside developing subject knowledge.

The findings of this study support those of Palao et al., (2015) and Nowels and Hewit (2018), showing that most teachers use digital technology to either instruct or support performance analysis, often citing technology as a method to communicate complex aspects of movement techniques.

'if they're the ones *doing* the routine [the children], particularly at this age they don't know what they did well and what they did wrong, the just *did* the routine and they're quite pleased to have done it'
(Lana, Interview 5)

'... [technology] can more effectively show them that [performance] visually if I can take a quick picture of them, than if I actually tell them. I think they understand better if they see it, particularly if they see it in front of each other—that's quite useful'
(Kelly, Interview 3)

Here, Kelly shows how she uses technology to support PCK as a powerful method for giving student feedback (Potdevin et al., 2018; van Hilvoorde & Koekoek, 2018), particularly as evidence has shown that students may pay more attention to videos (Zhang & Li, 2018). Kok et al. (2018) suggest that this increased attention could result in increased retention and understanding of skill-specific feedback due to the need for younger learners to augment the visual and verbal information presented during the discussion process to develop their motor skills more effectively. However, there is also the potential for this strategy to negatively impact students' quality of learning as frequent

reinforcement is needed to maximise student learning, particularly in the beginner or early phases of learning. This may be more difficult to access if high-quality demonstrations or suitable questioning strategies are only available when technology is adopted due to a lack of teacher content knowledge. A similar method of self-evaluation through performance analysis was used frequently by many participants:

'Using the iPads to get them to evaluate their own work, erm, I think is really good practice'
(Lana, interview 5)

'you can see a-a-an increase from, well, you know, in attainment from within 10 minutes of them seeing what they needed to do to improve and then doing it next time'
(Louise, Interview 4)

'show children what they've done and look at, look at the evidence, talk about what they've shown and then be lots of sort of, you know, one to one discussions'
(Fred, Interview 6)

Although participants were largely positive about reflective self-evaluation as an approach, there should be some caution for those using technology as there is no assurance that students can analyse and evaluate their performances any better than teachers, particularly at the primary level. Video analysis can only provide marginal support for pupils observing performances through manipulating speed or the ability to create still images of the delivery of a skill. And as Zhang and Li (2018) warn, pupils may not always be watching recorded performances for the correct things. Teachers must still support students in analysing their performance using carefully constructed questioning and discussion (Nowels & Hewit, 2018; Palao et al., 2015). If this is absent, technology is merely another mechanism to deliver content rather than improve student learning. However, if strategies such as additional CPD or greater integration of technology during subject knowledge sessions during ITE are used to support teachers' digital competence and confidence, this can engage learners who may have previously struggled to develop aptitude in the subject.

Other research has echoed this concern and cited the importance of technology to support rather than lead learning (Rosenthal & Eliason, 2015; Weir & Connor, 2009). Worryingly, however, some participants identified that technology is mainly used to convey subject-specific information they cannot deliver due to a lack of subject knowledge.

'We'll source videos that demonstrate whatever we're trying to teach, as the main teaching tool, so quite a lot of video instruction-based learning'
(Ron, Interview 1)

This was primarily limited to specific closed skills or activities such as dance or gymnastics; a finding in line with other research (Walinga et al., 2018) suggesting that both TPK and CK limit the effective implementation of digital learning strategies within their classrooms (Van Hilvoorde & Koekoek, 2018).

Several participants also highlighted the potential ability of technology to make better use of lesson time. Participants identified that technology was often used to save time during the planning and delivery of lessons as well as within assessment:

'Take away, erm, some of teachers workload time, so things can be duplicated, things can be saved and stored again, things can be shared quite easily'
(Ella, Interview 2)

'You haven't got time to get around to everybody, so if they can do it they...and they absolutely love doing it as well'
(Lana, Interview 5)

'the timekeeping has been a big impact before and this year it's literally straight in and we're not wasting as much time showing erm, PowerPoints, etc' (Alan, Interview 7)

Although it could be said that the activities described above are examples of teachers using technology to deliver content, complete administrative tasks, or collect information, it raises the question of whether this makes using technology less valid. Utilising TCK to improve efficiency within these processes will undoubtedly allow practitioners to spend more time on other tasks to support and develop the learning of those they teach. This may mean teachers can use the time saved in the planning phase of PPE on activities such as additional Continued Professional Development (CPD) or other developmental opportunities that can positively impact pupils experiences. Indeed, this may allow teachers the flexibility within lessons to engage in other activities that will benefit student learning, such as more detailed questioning or giving bespoke feedback (Nowels & Hewit, 2018).

Technology in assessment

As previously identified, digital technology should be used to enhance learning rather than replace content delivery (Quin, 2019; Sullivan, 2019). Many participants gave examples of how they use technology within assessment practices in PE lessons, although these were often 'indoor' activities due to the nature of the technology available to them.

'And with gymnastics it's been useful videoing and taking photographs of children and showing them back, because they don't realise what positions they're in until they see it, and then they...their practice is improved significantly as a result actually'
(Kelly, Interview 3)

'we give them a little challenge to assess a child, link the name to it and link the assessment criteria' (Alan, Interview 7)

'I might video a good example and then put that up on to the screen... so everyone can see. They can do some peer assessment: What went well? What do they need to improve on?' (Ron, Interview 2)

As there is no specified assessment and reporting framework for PPE in schools in England, teachers here have flexibility in their assessment practices and predominantly use information gained through this type of practice to inform planning and intervention during lessons. Indeed, the frequent reference to peer assessment throughout all interviews shows a tendency towards surveillance rather than true assessment. Much of the previous research on digitech is focused on physical activity levels (Fogel et al., 2010; Lee, 2018; Ye et al., 2018) and many comments below show a disconnect between PE assessment and PE learning.

'More for assessment I think in PE than... part of their learning'
(Ella, Interview 2)

'Definitely an element of recording 'cause that's massive for PE, 'cause that is their work, you know, it's not written'
(Kelly, interview 3)

Frequent references to collecting videos as evidence of learning by the majority of participants suggest that technology in PPE may be used to record that work is being completed (surveillance) rather than to delve more deeply into the quality of the performances themselves and also then used to inform future planning.

'it really, really narrows it down to what you're looking for in terms of the skill or the, the objective from the lesson.... the sort of a tick or not on the tick, because you've got it or you haven't got it'
(Fred, Interview 6)

Most teachers reported using technology as a way of capturing information on pupil achievement, also potentially as a method of engaging learners in tasks, in line with previous research (Finco et al., 2015; Hansen & Sanders, 2010; Quintas-Hijos et al., 2020). This, alongside earlier assertions of technology as a means of content delivery, identifies pupils as recipients of information via technology rather than

interacting through it to enhance and develop their learning. Some teachers were able to identify methods in which technology was used in other subject areas to benefit pupil learning, perhaps recognising the impact of limitations in subject-specific knowledge on technology integration within PPE.

'the games you can play for phonics for instance in Reception, erm, they're just a lot more... it's just different'
(Ella, interview 2)

'it takes away like barriers like if their handwriting is really bad'
(Lana, Interview 5)

'children can take a video of themselves and they can explain something. For example, they use it in science to explain how sound travels and make a very simple but effective way of using it
(Ron, Interview 1)

However, Taylor (2011) posits that surveillance is only effective if the group has established norms. If, as previously identified, teachers are using technology as a resource for delivery and cannot effectively articulate the expected outcomes for a task, using technology may not serve to adequately monitor achievement due to the perpetuation of inconsistent or inaccurate levels of performance.

Conclusion

The importance of high-quality PPE cannot be understated as it lays the foundation for pupils to lead healthy, active lifestyles and become physically literate throughout their lives (Duggan, 2020). If the aim is for ICT integration to improve these outcomes and learning within the curriculum (Livingstone, 2012), evidence suggests that digital technology offers the potential to facilitate this, allowing for robust assessment and feedback throughout the PPE curriculum (Nowels & Hewit, 2018; Palao et al., 2015). Teachers within this study are positive regarding integrating technology in their classrooms and it would be detrimental to pupils' development if it were removed from learning environments (Scutt, 2019). This suggests that considerations by Nick Gibb on the removal of technology from schools may be detrimental to pupil progress and performance, especially if there is evidence to indicate that the careful integration of technology to develop learning activities through interaction with subject content will benefit learning (Burden et al., 2019; Finco et al., 2015; Hansen & Sanders, 2010; Quintas-Hijós et al., 2020).

However, there is a need for more research in this area, despite much use of technology to deliver PPE during the COVID-19 pandemic. More information needs to be gathered on how technology is currently used by teachers to determine the benefits it may offer for students in PPE specifically. Rather than just using technology to deliver limited subject content, as we have seen throughout the lockdowns during the COVID-19 pandemic, the consensus reached so far is that careful thought must go into the introduction of digital technologies into school curricula, maximising its ability to support assessment for learning to secure progress and development for all pupils (Acquaviva et al., 2013; Scutt, 2019) and the most appropriate technology use that aligns with the learning aims should be selected (Ross, 2015). It is important to remember that PPE aims to inspire and educate young people on the benefits of physical activity rather than just keep them fit. However, it is also essential that technology is not relegated to simple administration, as this would prevent the benefit of creative deployment of technology from being enjoyed by students (Quinn, 2019). It is also clear that the full potential for the use of digital technologies has not yet been realised (Casey et al., 2017; Sargent & Casey, 2019) despite the pandemic, and it is crucial that subject experts begin to investigate how systems may be used to support and develop the practice of those working in primary schools to ensure that technology is used appropriately within the context of PPE whilst also maximising physical activity in lessons (Sullivan, 2019). Greater support for teachers with little experience or knowledge in this area are also required, with more significant inclusion in ITE and CPD as a starting point alongside better collaboration of research between HEI's and schools to develop digital knowledge throughout the sector.

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The findings of this study was previously presented by Jordan Wintle at a conference (found at https://eprints.glos.ac.uk/11700/10/11700%20Wintle%20%282022%29%20Using_the_Technological_Pedagogical_Content_Knowledge_%28TPACK%29_model_to_analyse_Teachers%E2%80%99_use_of_Information_Communication_Technology_in_Primary_Physical_Education.pdf)

There is some similarity between the reference list of this article and two others, due to the similarity in focus content and relatively small amount of relevant research on this particular topic at the time of writing https://www.researchgate.net/publication/349898613_Teachers%27_use_of_technology_to_support_literacy_in_2018.

https://www.researchgate.net/publication/258135749_Digital_video_The_impact_on_children%27s_learning_experiences_in_primary_physical_education.

Author contributions

Rachel Sullivan- Conception and Study Design, Data Collection, Data Analysis and Interpretation, First paper draft, final approval for submission, edits following reviewers' comments

Jordan Wintle- Data Analysis, Critical revisions, final approval for submission, editing

William M. Roberts- Data Analysis, Critical revisions and Methodology, final approval for submission

Natalie Campbell- Data Analysis and Interpretation, Critical revisions, final approval for submission

All authors agree to be accountable for all aspects of the work

Disclosure statement

Rachel Sullivan, Jordan Wintle, William M. Roberts and Natalie Campbell report there are no competing interests to declare.

Ethical approval statement

The study obtained ethics approval from School of Sport and Exercise Research Ethics Panel, Approval ID RSULLIVAN18-19.

Human participants provided informed consent before taking part. All were provided with an information and consent form. Those interviewed in person (n=4) completed a written consent form, those interviewed over Teams (n=5) gave verbal consent which was video recorded, along with the interview, on Microsoft Teams as this was during the Covid-19 lockdown period.

About the authors

Rachel Sullivan is a Senior Lecturer in Education at the School of Education and Science, University of Gloucestershire, UK. Her work primarily coheres around Initial Teacher Training and the use of technology in educational settings. Having worked in both the education sector and in Higher Education, Rachel's work bridges the theory-practice divide, and she is mainly concerned with the impact of technology on learner experiences in primary and secondary school settings.

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Data availability statement

The data that support the findings of this study are available on request via the corresponding author, [Rachel Sullivan]. The data are not publicly available due to their containing information that could compromise the privacy of research participants.

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