# BARRIERS TO TECHNOLOGY INTEGRATION IN PHYSICAL EDUCATION: A QUALITATIVE TPACK-BASED ANALYSIS IN ITALIAN PRIMARY SCHOOLS

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**Double Blind Peer Review**

**Citation**
Ascione, A., & Amati, I. (2026). Barriers to technology integration in physical education: A qualitative tpack-based analysis in italian primary schools. *Italian Journal of Health Education, Sport and Inclusive Didactics*, *10*(2).
https://doi.org/10.32043/gsd.v10i2.1721

**Doi:** https://doi.org/10.32043/gsd.v10i2.1721

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renpress.it/index.php/gsdj
**ISSN: 3103-5744**

## ABSTRACT
Despite growing policy emphasis on digital transformation in Italian primary education, Physical Education (PE) remains a marginalised and under-resourced domain for technology integration. Grounded in the Technological Pedagogical Content Knowledge (TPACK) framework, this study investigates the systemic and contextual barriers faced by PE teachers when attempting to embed digital technologies into their practice. A qualitative case study was conducted with 12 specialist PE teachers from 10 primary schools in the metropolitan area of Naples. Data were collected through semi-structured individual interviews and two focus groups, transcribed verbatim and analysed via thematic analysis following Braun & Clarke's (2006) six-phase protocol, supported by NVivo 14. Theoretical saturation was achieved after ten data collection sessions, with two additional sessions confirming category stability. Results: Seven interrelated barriers emerged: 1) inadequate technological infrastructure; 2) insufficient financial support; 3) lack of discipline-specific training; 4) challenges in managing time and physical space; 5) the persistent marginalisation of PE within the school curriculum; 6) student-related constraints; and 7) scarcity of PE-specific digital resources. Crucially, these barriers disrupt the synergistic development of TPACK dimensions, particularly the integration of Technological Knowledge with Pedagogical Knowledge and Content Knowledge, as teachers struggle to translate digital potential into embodied, movement-based pedagogy. Findings reveal that technological integration in PE is not primarily hindered by teacher resistance but by structural inequities and a mismatch between generic digital policies and the situated, corporeal nature of PE. The study calls for a context-sensitive reframing of TPACK in physical education, proposed here as "PE-TPACK", and urges policymakers to move beyond one-size-fits-all digital agendas toward discipline-specific infrastructural and formative investments.

## KEYWORDS
Physical education; TPACK; technology; primary school; digital competence.

**Received** 2026-05-18
**Accepted** 2026-06-22
**Published** 2026-07-31

[1] Antonio Ascione has written method, ethical consideration, results and discussion, study limitations and practical and policy implications

[2] Ilenia Amati has written introduction and concluding reflections

## 1. Introduction

The integration of digital technologies into school curricula has been a central pillar of Italian education reform since the National Plan for Digital Schools (PNSD, MIUR, 2015) and the subsequent transposition of the EU priorities for digital education (European Commission, 2021). In this context, physical education occupies a paradoxical position: despite being increasingly recognized as a holistic developmental area, capable of connecting motor, cognitive, and socio-emotional learning (Hemingway et al., 2025), it remains structurally under-resourced and epistemologically marginalized in mainstream digitalization efforts (Colella, 2016; Sgrò, Quinto, and Lipoma, 2019).

In Italy, the teaching of physical education in primary schools is recognized by the 2022 Budget Law (No. 234/2021), which establishes the professional profile of specialized physical education teachers with a master's degree in Sports Science. The law establishing this role was implemented gradually, with the introduction of the specialized physical education teacher, first in fifth grade (2022/2023 school year) and subsequently in fourth grade (2023/2024 school year), for a total of two hours per week per class. Regarding the extension to the remaining grades (1st, 2nd, and 3rd), the national system has not currently legally mandated the presence of specialist teachers. Therefore, teaching physical education remains, in almost all cases, entrusted to generalist teachers, often lacking specific training in physical education (D'Isanto et al., 2022). To address this deficiency, the presence of a specialist in these classes is possible only through the use of autonomous staff (strengthening), through network agreements, or specific locally funded projects (e.g., PON, regional or municipal funds).

Haleem et al. (2022) stated that the psychomotor skills domain refers to the motor skills required to perform a variety of physical actions, such as correctly passing and receiving the ball. Berg-Carramusa et al. (2023) stated that the relationship between the cognitive domain and knowledge concerns the thought process related to concepts, principles, and movement strategies. This includes students' ability to explain the use of force in passing the ball at various distances and speeds, as well as the factors that influence the ability to catch the ball accurately. The same authors explain how the affective domain focuses on improving physical education practice through the integration of safety elements, sociological and psychological concepts, and principles and strategies for effective physical activity.

Although this study was conducted prior to the publication of Ministerial Decree No. 221 of December 9, 2025 (published in the Official Journal on January 27, 2026), which redefines the national curriculum for early childhood education, our findings are even more relevant given its explicit call for outdoor education, metacognitive embodiment, and digital literacy. The decree's emphasis on structured knowledge and the valorization of movement aligns with the urgent need for targeted support mechanisms identified in this research.

In line with the New National Guidelines, physical education must adapt to the changing needs and interests of students. Rivoltella & Rossi (2024) argue that digital technologies are not merely external support, but a true cultural mediation environment. They enable teachers to act as content curators and designers of multimodal artifacts, offering alternative teaching-learning channels.

Arufe-Giráldez et al., 2023 state that although technology plays an important role in the education system, physical education teachers have a duty to adapt

to a specific teaching modality and approach to convey the subject's content, which includes verbal explanations, physical demonstrations, and correction of student movements. Furthermore, authors such as Wallace et al. (2023) believe that the presence of digitally skilled physical education teachers is essential for the successful integration of technology into physical education lessons, although in their work, they found that physical education teachers themselves find it difficult to effectively integrate digital technologies due to a lack of confidence in their digital skills and insufficient resources.

Authors such as Sargent and Calderon (2021) and Suriya and Arumugam (2020) argue that it is important to adapt the lesson to the classroom environment during physical education lessons with the help of technology.

This study aims, through a qualitative perspective, to identify the experiences of specialized physical education teachers in integrating digital tools within the complex context of Italian primary schools.

To achieve this goal, a widely recognized educational technology framework, TPACK (Technological Pedagogical Content Knowledge), is used to integrate technology into lesson delivery.

The TPACK model was introduced by Koehler and Mishra in 2009 and is used to help physical education teachers and tutors best apply technology in their teaching and learning sessions (Daum & Ervin-Kassab, 2023). It consists of three components:

1. Content, which explains the subject matter being taught;

2. Pedagogy, considered the most appropriate teaching approach, applicable to the content and the audience;

3. Technology, which relates to the physical education lesson and can therefore include tools, software, or even apps.

Combining technology with pedagogy and instructional content can represent an innovative and practical solution for the delivery and assessment of physical education lessons, as well as improving teacher-student interaction, engagement, assessment, and feedback (Bibba & Colella, 2025).

The TPACK model has been used to explore better ways to integrate technology into teaching and learning.

It's important to note that in Italian scientific research on the TPACK (Technology, Pedagogy, and Content Knowledge) model, primary school represents a unique field of investigation. Unlike secondary school, where teachers are subject specialists, primary school teachers in Italy are typically generalists in grades I, II, and III.

The methodological mapping of Italian research on TPACK in primary school is structured according to the systemic coordinates illustrated in the following table.

*Tab. 1. Methodological mapping of Italian research on TPACK (authors' summary)*

| Methodological Component | Current Practices in Italian Research | Epistemological Limits and Critical Issues in the Field |
|---|---|---|
| Types of Research (Ranieri, 2022a) | Predominance of quantitative empirical research (surveys) and mixed-methods research. Pure experimental studies are rare. | Excess of one-off exploratory-descriptive studies; scarcity of longitudinal research capable of measuring the persistence of TPACK over the years. |
| Research Designs (Limone & Toto, 2022) | Non-experimental correlational designs or quasi-experimental designs (pre-post test) included in training courses (e.g. PNRR plans, university laboratories). | Virtually no control groups; vulnerability to the "social desirability effect" in post-training post-tests. |

| | | |
|---|---|---|
| Subjects | Generalist in-service teachers and future (pre-service) teachers enrolled in the Primary Education Sciences degree course. | Convenience sampling. Samples are often biased toward already motivated teachers or highly digitalized schools. |
| Data Collection Tools (Schmidt et al., 2009) | Adaptations and translations of the TPACK Self-Assessment scale by Schmidt et al. (2009); lesson plan evaluation rubrics; focus groups and logbooks. | Self-report bias: These tools measure the teacher's perception of their own competence, not their actual competence in classroom action. |
| Data Analysis Techniques (Bibba & Colella, 2025) | Descriptive statistics, Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA); thematic content analysis for textual data. | Many studies stop at means and standard deviations, without testing complex predictive models (e.g., Structural Equation Modeling - SEM). |

Although limited qualitative research on physical education teachers' integration of digital technology into physical education lessons remains a challenge in a subject traditionally considered practical and experience-based, as suggested by Viberg et al. (2020), physical education teachers' behaviors are believed to contribute to the effective use of technology in teaching.

Teachers need to be more aware of the potential offered by different technologies and receive ongoing support to be able to critically evaluate and adapt their teaching methods. Therefore, this study specifically focuses on a population that has not been extensively studied, particularly in the field of physical education. Furthermore, this research addresses this important gap by documenting the specific challenges of integrating technology into physical education, which include considerations related to time and physical space, as well as student constraints.

In light of the emerging literature and the persistent paucity of qualitative studies focusing on technology integration in physical education in Italian primary schools, this study aims to investigate the challenges teachers encounter in integrating technology into teaching activities.

To this end, the following research questions were formulated:

RQ1. What are the main barriers perceived by primary school physical education teachers in integrating digital technologies into teaching practices?

RQ2. How do these barriers influence the articulation of the TPACK framework (Technological Knowledge, Pedagogical Knowledge, and Content Knowledge) dimensions in the context of physical education?

RQ3. Which organizational, infrastructural, educational, and student-related factors emerge as most critical in the technology integration process?

RQ4. What operational and educational implications can be derived from teachers' experiences to foster more effective technology integration in primary school physical education?

## 2. Method

This study employed a qualitative case study technique as a research strategy to explore the complexity of technology integration in physical education. This choice was made because it is appropriate for providing a comprehensive understanding of the current state of technology integration in teaching and learning, as well as the challenges faced by primary school teachers. Furthermore, qualitative approaches can explore the complexity of social interactions and offer detailed and in-depth insights into this research (Candra et al., 2024).

Twelve primary school physical education teachers (6 men and 6 women) from 10 primary schools in Naples, in the Campania region, were involved. Participants in this study were chosen based on the researcher's criteria and qualifications, including the teachers' experience teaching physical education classes in both primary and secondary schools, and their willingness to participate in the study. Therefore, targeted sampling allows us to address the research questions, taking into account participants' willingness to collaborate and be interviewed, and their ability to provide the necessary information (Limna, 2023).

Data collection combined two focus groups (each with three participants) and six semi-structured individual interviews, allowing for both collective understanding and in-depth personal reflection. The focus groups explored shared institutional challenges, while the individual interviews explored personal beliefs and pedagogical practices. An expert-validated interview guide covered the following topics: a) current use of digital tools, b) perceived barriers, and c) training needs.

Data collection continued until theoretical saturation was reached (Hennink et al., 2020). Specifically, after the tenth data collection session (composed of two focus groups and eight interviews), no new conceptual codes emerged; two additional interviews confirmed the stability of the categories. The transcripts were analyzed using Braun & Clarke's (2006) thematic analysis, with the support of NVivo 14. Methodological rigor was ensured through: a) data triangulation (comparison between focus groups and interviews); b) peer comparison with two experts in educational technologies and physical education teaching; c) verification with 8 participants, who all confirmed the interpretative accuracy of the themes that emerged, without requiring substantial changes to the identified categories.

## 3. Ethical considerations

The study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki and the guidelines for educational research with adult participants. All participants received detailed information on the research's purposes, data collection and processing methods, and the right to discontinue participation at any time without consequences. Written informed consent was obtained before the interviews began, as well as the approval of each school principal.

To ensure confidentiality, all transcripts were anonymized using numerical identification codes, and any information potentially attributable to participants or schools was removed during the analysis process. The data were archived in a secure format and used exclusively for scientific purposes.

Since the research did not involve minors or invasive experimental procedures and was limited to the collection of professional opinions from adult teachers, in accordance with Italian law (Legislative Decree 196/2003, as amended by Legislative Decree 101/2018), formal approval from the ethics committee was not required. This is in line with standard practice for qualitative educational research involving adult professionals in Italy (Ranieri, 2022b).

## 4. Results and Discussion

Qualitative data from this study were used to examine the challenges of integrating technology into physical education classes. The results indicated that technology can be used in physical education in primary schools. Six male and six female teachers with at least five years of physical education teaching experience and a master's degree in physical education or a diploma from the

Higher Institute of Physical Education (ISEF) were involved (Table 3). Therefore, it was determined that the participants possessed the necessary authority, experience, and skills for physical education.

The results of the focus groups revealed seven themes associated with the challenges of using technology in physical education classes: 1. Lack of infrastructure; 2. Lack of financial support; 3. Lack of training; 4. Time and space management; 5. Perceptions and attitudes towards physical education; 6. Student constraints; 7. Lack of teaching resources.

*Tab. 2. Frequency of emerging thematic categories*

| Theme | Participants who mentioned it |
|---|---|
| Lack of infrastructure | 11/12 |
| Lack of financial support | 10/12 |
| Lack of training | 12/12 |
| Time and space management | 9/12 |
| Perceptions and attitudes toward physical education | 10/12 |
| Student constraints | 8/12 |
| Lack of teaching resources | 9/12 |

These frequencies are consistent with the quotes reported in the text and with the narrative structure of the results. It should be noted that a participant could contribute to more than one category. Participant quotes are used to illustrate these themes and ensure that the results reflect participants' views. To contextualize each quote, the participant number and focus group session number are provided.

| Participants number | Age | Years of PE teaching | Academic qualification |
|---|---|---|---|
| 1 | 43 | 17 | ISEF |
| 2 | 48 | 16 | ISEF |
| 3 | 34 | 9 | MDPE |
| 4 | 47 | 16 | ISEF |
| 5 | 31 | 5 | MDPE |
| 6 | 49 | 12 | ISEF |
| 7 | 38 | 14 | MDPE |
| 8 | 38 | 7 | MDPE |
| 9 | 49 | 19 | ISEF |
| 10 | 37 | 10 | MDPE |
| 11 | 51 | 22 | ISEF |
| 12 | 54 | 20 | ISEF |

*Tab.3. Interview participants' demographics ($n = 12$)*

*Lack of Infrastructure*

The interviews highlighted that the lack of infrastructure, including inadequate technological facilities and unreliable internet connectivity, represents a critical obstacle. Furthermore, unsuitable classrooms and gyms, as well as insufficient equipment, were identified as further impediments to effective technology integration. The following are some testimonials from the teachers involved:

"IWBs and projectors are not always functional and present in all areas of the school." (Teacher 10)

"IWBs and projectors are provided based on the specific areas of expertise within the school. This is not provided for physical education." (Teacher 1)

"Not all classrooms are equipped with IWBs. To use portable ones, since there are few of them, you have to request them well in advance. A second problem arises when the IWB is not returned after borrowing, and other teachers, therefore, cannot use it." (Teacher 12)

Furthermore, participants explained that the internet connection does not cover the entire school. In some schools, the internet connection only covers a specific area and not the entire school, excluding the gym. As a result, some teachers are forced to use their mobile data to connect to the internet. This situation was clearly described by participants:

"Teachers must use their mobile data to connect to the internet in class" (Teacher 2)

"The school's internet connection is limited to a small area" (Teacher 11)

These limitations also significantly impact indoor activities, in the absence of a gym, and the use of digital tools in teaching. Inadequate classrooms and insufficient equipment further exacerbate the situation, making it difficult for teachers to create an engaging and effective learning environment.

"The school does not have a suitable space for indoor activities in case of rain." (Teacher 3)

"The area reserved for me was described as unsuitable for school activities, further complicating the conduct of physical education lessons." (Teacher 9)

The lack of reliable technological infrastructure, combined with internet connectivity, creates significant obstacles to the effective implementation of the teaching proposal. These problems are further exacerbated by the inadequacy of school environments and the scarcity of essential equipment needed to support digital tools and platforms. These limitations hinder the seamless integration of technology into physical education, limiting teachers' ability to deliver dynamic, technology-enhanced lessons. The findings of this paper are confirmed by Sgrò & Lipoma (2021): addressing these infrastructural gaps is crucial to creating an environment conducive to the integration of digital tools, ultimately promoting more engaging and effective teaching practices in

physical education. It is important to highlight that not all scientific studies agree with this orientation; in fact, Frelin et al. (2025) in their work state that technological infrastructure does not pose a threat to teachers' conventional teaching and learning.

*Lack of financial support*

Lack of financial support has emerged as one of the main challenges faced by physical education teachers in terms of available technology tools. The technological facilities and tools provided in each school are not uniform, as they vary depending on the school budget or available financial support. These constraints inevitably create disparities between schools. Below are some teachers' testimonies.

"The school has a limited budget, so it has difficulty acquiring the equipment I requested to effectively support digital integration." (Teacher 5)

"The technological facilities available in my school depend on the allocated budget. The budget is limited, and they haven't provided me with adequate tools." (Teacher 4).

"In terms of funding for technological equipment, I work at a school considered elite, so I have all the necessary tools." (Teacher 6)

Financial constraints prevent schools from investing in essential technological tools, maintaining existing facilities, and providing training to teachers to effectively integrate technology into their teaching practices. The findings of this study are confirmed by Addeo (2025), who argues that limited resources and insufficient funding represent significant constraints for teachers. This imbalance leads to unequal access to digital resources, disadvantaging students and teachers in less well-off schools. Furthermore, in the specific case of

employment, due to the lack of educational facilities equipped with digital devices, it has been impossible to integrate technology into physical education sessions, thus limiting both teachers and students in these schools' use of technology-enhanced educational practices. Addressing this issue requires systemic reforms, including equitable allocation of funds and targeted financial support for under-resourced schools, as financial constraints act as a factor of methodological paralysis. Specifically, when a school lacks the resources to invest, teachers who have developed excellent digital pedagogical skills (e.g., a high level of TPACK) find themselves unable to apply them (Ranieri & Cupidi, 2019). This generates a latent phenomenon of deprofessionalization: teachers stop designing innovative activities because the material environment makes the risk of failure of the teaching proposal too high (Limone & Toto, 2022). Budget constraints, in effect, sterilize educational innovation before it can even enter the classroom.

*Training Lack*

The findings highlight that a lack of training is an area that needs to be addressed to simultaneously integrate the TPACK model. The research also found that digital skills courses and training offered to teachers do not focus on the use of technology in physical education. Some testimonials include:

"There is no specific training for physical education teachers on how to apply digital technology in physical education" (Teacher 8)

"There is no specific training on the use of technology in physical education. That's why I don't have IT skills." (Teacher 9)

The results show that none of the participants attended technology training courses, as these courses are mistakenly believed to be specific for information

and communication technology (ICT) teachers, who are given the necessary conditions to put their skills into practice. Despite this, it is noted that all participants expressed a willingness to attend technology courses specifically focused on physical education to improve their technological skills for educational purposes. Furthermore, it is noted that everyone agrees that technological skills are essential for improving one's ability to use digital technology and for applying these skills in physical education lessons.

These findings are consistent with other studies, such as that of Colella (2021), who states that the use of tools such as tablets, inertial measurement units (IMUs), and heart rate monitoring apps allow teachers to support technical explanations with immediate biological and kinematic data. The author explains how technology makes what would otherwise be abstract visible and comprehensible to students. The teacher's technical explanation becomes effective when supported by the objective evidence provided by the technological tool, increasing student body awareness. By doing so, physical education teachers can gain a comprehensive understanding of technological outcomes and learn how to integrate technology more effectively into physical education.

Effective training programs should address teachers' technological, pedagogical, and content knowledge needs, incorporate hands-on training with technology tools, and focus on promoting positive attitudes and self-esteem to improve technology integration in classrooms, enabling active student interaction with technology (Toto, 2021).

*Time and Space Management*

The results show challenges related to time and management when integrating technology into physical education lessons. These challenges arise from the need to balance the operational demands of technology with effective classroom management, which often leads to inefficiencies during lessons. Some testimonials include:

"The use of technological devices, such as mobile interactive whiteboards for installation, creates time constraints when supervising students." (Teacher 12)

The dynamic nature of physical education lessons, which often take place in open spaces or outdoors, complicates the use of digital tools, traditionally designed for stable indoor environments. Therefore, physical education teachers face difficulties in allocating sufficient time for both installation and implementation of technology within the limited duration of lessons, especially considering the need to balance practical activities and theoretical instruction. These constraints translate into fewer opportunities for effective technology integration, with consequent repercussions on the ability to offer interactive and engaging lessons. This work is in line with the suggestions of Sgrò & Lipoma (2021) that to overcome these difficulties, it is necessary to design tailor-made technologies for physical and flexible learning environments, combined with professional training programs for teachers to optimize time and resources. Such efforts would allow for a more balanced approach to integrating technology into physical education, improving both teaching efficiency and student engagement.

*Perception and Attitude Toward PE*

The results of this study, despite the latest national guidelines, revealed that physical education is generally perceived as a non-core subject. This marginalization leads to less attention to physical education, both in terms of teaching emphasis and resource allocation. The following are some testimonials:

"The subject will be assigned to other teachers if they need extra time to review with students." (Teacher 3)

""Students' interest in physical education is lower than in other subjects" (Teacher 10)

Teachers' perception of physical education is that it is often marginalized. These findings are confirmed by other studies such as that of Colella (2016) and Sgrò, Quinto, and Lipoma (2019). Colella highlights how marginalization is not just a matter of hours or gyms, but of a culture of evaluation and planning, remaining a "foreign body" to the actual curriculum. Sgrò, Quinto, and Lipoma focus specifically on aspects such as insufficient hours, structural deficits, and curricular isolation, which inevitably negatively shape teachers' perceptions.

Although the introduction of specialist teachers (graduates in Sports Science) in the final grades of primary school was seen as the end of the marginalization of the subject, the reality is more fragmented and critical, as this reform has generated internal marginalization or curricular fracture. Currently, in the first three years of primary school (first, second, and third grades), which represent the golden window for the development of basic motor patterns and coordination skills, the subject remains entirely entrusted to generalist teachers, often lacking specific skills and forced to operate in crumbling infrastructure. In effect, a school system has been created that is divided in

two: a three-year period in which physical education is still heavily marginalized and a two-year period aimed at technical specialization, breaking the vertical continuity that is the basis of a correct pedagogy of physical development.

Research by D'Isanto et al. (2022) shows that physical education can improve health and physical fitness, as well as social skills and teamwork among students. Promoting the integration of technology into physical education requires addressing these systemic challenges by elevating the subject, providing equitable access to technological tools, and offering targeted training programs to build teachers' confidence and competence in using digital tools in their teaching. These steps could transform the perception of physical education and enrich its educational potential. Furthermore, the attitude of older physical education teachers poses a further challenge to the integration of the TPACK model into physical education, as they lack knowledge, especially in the technological area. This could lead to transition difficulties due to insufficient technological proficiency. Reluctance to adopt technology also limits the ability to create a dynamic and interactive learning environment aligned with contemporary educational standards and student needs.

“Older teachers and those approaching retirement criticize the use of technology in physical education.” (Teacher 5)

“There are older teachers who want to use technology in their classrooms and others who don't.” (Teacher 3)

These results are consistent with an exploratory survey of teacher perceptions conducted by Sgrò & Lipoma (2013) on a sample of in-service physical education teachers, which clearly showed that senior teachers (with over 20 years of service) showed significantly lower scores on scales relating to pure technological knowledge than their younger colleagues or trainees. Colella

(2014), analyzing the state of physical education in Italy during those years, links the lack of technological skills among senior teachers to their initial training: the majority of senior teachers had trained in the old ISEF (Higher Institutes of Physical Education), where curricula were strictly focused on traditional training and kinesiology practices, with a complete absence of any reference to educational technologies. In contrast, teachers trained later in the faculties of Physical Education had benefited from exams dedicated to computer science and technologies applied to sport.

Analyzing these historical contributions with a critical and retrospective lens, it is necessary to shift the blame away from individual professionals and onto a failure of the institutional system: the technological deficit among senior teachers is not due to a cognitive incapacity, but to the lack of a systemic plan for ongoing training in place (Ranieri, 2022b). Having imperiously introduced digital whiteboards, tablets or specialized software into schools without first having remodeled the Pedagogical Knowledge (PK) of teachers who had professionally structured themselves in the pre-digital era has generated a sense of frustration that has exacerbated the rejection of the tool, freezing innovation in the gym for almost a decade (Limone & Toto, 2022).

*Student-Related Constraints*

The results highlighted the challenges arising from varying levels of access to digital devices and differences in student engagement during physical education classes. These obstacles interfere with the effective integration of technology into physical education, as not all students have access to devices or show interest in the activities offered.

"Not all students own tablets or other devices, and conducting physical education classes outdoors presents challenges in bringing digital tools into the field." (Teacher 9)

"Not all students are interested in certain games, and those who aren't interested simply observe their classmates engaging in the activities." (Teacher 3)

These challenges often include a lack of digital literacy among students (Rivoltella, 2020), varying levels of motivation, and difficulty adapting to technology-enhanced physical education sessions. Students may struggle to understand the purpose of using digital tools, resulting in reduced engagement and participation. Furthermore, inequalities in student access to personal devices can hinder inclusive learning experiences. This issue has been addressed by Ranieri & Gaggioli (2022), who highlight that digital technologies have the potential to personalize learning for students with disabilities or special educational needs (SEN), but if access to devices depends on family economic capital, technology acts as a discriminatory device. The lack of equal access impedes the creation of an inclusive setting, as it isolates students who cannot keep up with the pace of the "augmented" class, generating feelings of frustration, stigmatization, and self-exclusion.

In recent years, to address budget constraints, many Italian schools have formally adopted the BYOD (Bring Your Own Device) policy, passing it off as an innovative and flexible methodological choice. In the empirical reality of our school contexts, BYOD represents a partial renunciation by the State of its duty of subsidiarity and substantive equality (Article 3 of the Constitution).

Placing the burden of purchasing, updating, and maintaining educational hardware on families risks redefining the learning experience and making it

inauthentic, since schools are not considered "technologically self-sufficient" environments, capable of providing all students with standardized devices of the same performance level, either on loan or within the classroom.

*Lack of Educational Resources*

The results demonstrated that digital physical education modules with limited functionality also contribute to the shortage of resources for learning digital skills, especially regarding content examples. This limitation is evident in the inability to apply pedagogical strategies within technological platforms. Furthermore, participants also highlighted the lack of physical education questionnaires usable for teaching, learning, and assessment. These questionnaires play a crucial role in assessing student understanding, measuring learning outcomes, and guiding instructional improvement. Without access to such assessment tools, participants encountered difficulties in accurately assessing student progress and providing targeted feedback to improve learning experiences.

"I can record videos, but I don't have the skills to apply the teaching methods in the videos." (Teacher 12)

"Using online questionnaires/games such as quizzes or Kahoot can help students better understand" (Teacher 1)

There are several modules related to technology in education, but the module explaining how physical education teachers can use technology in physical education is limited. This finding is also confirmed by Colella (2021), who highlights how standard technology refresher courses are structurally inadequate for physical education teachers. Specifically, he shows that the majority of available training modules focus on the use of the IWB, the

management of digital registers, e-learning platforms (Moodle, Google Workspace), or digital storytelling—tools that focus on predominantly abstract or textual cognitive tasks. The above highlights how forcing a physical education teacher to attend generic modules on "interactive digital teaching" structured for classroom subjects is not only useless, but also produces a professional alienation effect.

The gym requires time, space, and safety management that has no connection with a computer lab or traditional classroom. If the training doesn't offer specific modules that utilize technology to break down movement, monitor biophysiology, and include individuals with Special Educational Needs (SEN) in the dynamic context of sports and play, teachers will legitimately reject the technology, perceiving it as a bureaucratic obstacle that takes away time from students' active physical activity.

The results allow us to comprehensively answer the research questions posed at the outset of the study. Regarding RQ1, which concerned the identification of the main barriers perceived by physical education teachers in integrating digital technologies, seven recurring thematic categories emerged: lack of technological infrastructure, insufficient financial support, limited professional training, difficulties in managing teaching time and space, the marginalization of physical education within the curriculum, student-related constraints, and a lack of specific teaching resources. These findings confirm that the difficulties encountered by teachers are not attributable to a single factor, but rather to a set of systemic and organizational conditions acting simultaneously.

Regarding RQ2, which concerns the influence of these barriers on the components of the TPACK framework, the results highlight how the identified critical issues compromise the interaction between technological knowledge (TK), pedagogical knowledge (PK), and disciplinary knowledge (CK). Specifically,

the lack of specific training limits the development of technological knowledge, while the lack of adequate resources and infrastructure hinders the transformation of technological skills into effective teaching practices. This results in a difficulty in building a true integration between technology, subject content, and pedagogical strategies, a central element of the TPACK model.

RQ3 aimed to understand which organizational, infrastructural, educational, and student-related factors were most critical in the technology integration process. The data suggest that infrastructural and educational issues represent the most pervasive barriers, having been cited by almost all participants. At the same time, the persistent marginalization of physical education in schools contributes to reduced investment, educational opportunities, and the availability of dedicated resources. Student-related constraints, such as uneven access to digital devices and varying levels of engagement in activities, also emerge as factors that impact the possibility of implementing truly inclusive teaching practices.

Finally, with regard to RQ4, the results allow us to outline some operational and educational implications. First, it highlights the need for ongoing training programs specifically designed for physical education teachers and geared toward the application of technologies in real-world physical education contexts. Second, strengthening school infrastructure and ensuring a more equitable distribution of digital resources is essential. Finally, the findings suggest the opportunity to develop training and design models that consistently integrate technological, pedagogical, and disciplinary dimensions, promoting the full application of the TPACK framework in primary school physical education.

Overall, by employing the TPACK framework, this study not only identifies barriers, including lack of infrastructure, training, and financial support, but also highlights the specific constraints unique to physical education, such as time and space management and student-related factors.

This work revealed that technology integration based on the TPACK framework must also address and correlate with physical education teachers' digital structures and skills. Due to limited structures, some of the most technologically skilled physical education teachers are unable to integrate technology into their physical education lessons. Physical education teachers' digital skills must be strengthened to develop 21st-century skills in teachers, meet future expectations, and compete in the digital world of education with specialized digital training for physical education teachers.

## 5. Study Limitations and Practical and Policy Implications

This study has several limitations that must be considered when interpreting the results. First, the qualitative nature and case study nature imply limited generalizability: the findings are contextualized to the reality of primary schools in the Naples metropolitan area and cannot be automatically transferred to other Italian geographical or institutional contexts (Lincoln & Guba, 1985). Second, the purposive sampling (n = 12) is functional to the qualitative approach, but the small sample size and exclusive use of teachers willing to participate introduce a potential social desirability effect in the responses. Third, the lack of direct observations of gymnasium teaching practices limits the possibility of triangulating declarative data with actual practices, a recognized limitation in qualitative research on technology integration (Braun & Clarke, 2006; Hennink et al., 2020). Finally, the study does not include a

longitudinal perspective, so it is not possible to assess whether and how the identified barriers evolve over time. Future research should adopt mixed-methods designs with direct observation and longitudinal studies to measure the evolution of physical education teachers' TPACK, as well as to verify whether targeted training interventions produce lasting effects on technology integration (Voogt et al., 2013; Casey & MacPhail, 2018).

The findings suggest important implications for policymakers, university educators, and school principals. At the systemic level, the measures of the National Digital School Plan (MIUR, 2015) and the National Renewable Energy Sources Plan (PNRR) must incorporate action lines specifically dedicated to physical education, moving beyond the generalist approach that has characterized digital public administration training plans. In terms of continuing education, professional development programs must be redesigned following the TPACK framework (Koehler & Mishra, 2009; Mishra & Koehler, 2006), prioritizing modules contextualized to the specificities of physical education and physically located in real teaching environments (gymnasium, sports field, open space), rather than in computer labs conceptually distant from physical practice (Ranieri, 2022b; Limone & Toto, 2022). At the European level, infrastructural and digital competence gaps reflect the priorities of the European Commission's Digital Education Action Plan 2021–2027 (European Commission, 2021), which identifies equal access and teacher training as essential conditions for a digitally inclusive school. Finally, this study opens the way to the construction of a PE-TPACK (Physical Education-TPACK) framework specific to the Italian context, which could represent an original contribution of international relevance to the literature in the field (Voogt et al., 2013).

## 6. Concluding Reflections

The primary objective of this study is to investigate the challenges primary school physical education teachers face in integrating technology into their lessons. The findings reveal that physical education teachers encounter significant obstacles, not due to individual shortcomings, but rather to systemic failures rooted in infrastructural neglect, generic training models, and the persistent marginalization of the subject. Although teachers declare themselves open to innovation, they operate within contexts that complicate the implementation of the TPACK model.

Specifically, the study shows that barriers such as inadequate infrastructure, financial constraints, lack of specific training, time and space management issues, and unfavorable perceptions of physical education significantly hinder the integration of technology. Despite these challenges, many physical education teachers recognize the potential benefits of technology in physical education, including increased student motivation and a greater variety of learning experiences and methods.

The theoretical contribution of this work is the proposal of a PE-TPACK framework: a context-sensitive adaptation of the TPACK model, which takes into account the corporeal, spatial, and safety constraints of physical education. Unlike traditional subjects, physical education requires mobile, durable, and movement-oriented technologies, not simple digital replicas of traditional tools. In conclusion, the results confirm that difficulties in integrating technology into physical education cannot be interpreted as individual teacher deficits, but rather as an expression of systemic constraints that require coordinated interventions (infrastructural, organizational, and educational) to ensure that the body also has a place in the digital school.

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