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DOI: https://doi.org/10.46502/issn.1856-7576/2025.19.02.18

Cómo citar:
Lutsenko, I., Leshchenko, H., Prots, T., Gvozdetska, S., & Omok, H. (2025). Classification of innovations and challenges in teaching physical education in the digital age. *Revista Eduweb*, *19*(2), 266-279. https://doi.org/10.46502/issn.1856-7576/2025.19.02.18

Classification of innovations and challenges in teaching physical education in the digital age

Clasificación de innovaciones y desafíos en la enseñanza de la educación física en la era digital

Iryna Lutsenko
PhD in Physical Education and Sports, Associate Professor, Head of the Department of Physical Training and Special Training, Faculty of Finance, University of Customs and Finance, Dnipro, Ukraine.
https://orcid.org/0000-0001-9259-8203
irinaucf@gmail.com

Hennadii Leshchenko
Doctor of Pedagogical Sciences, Professor, Associate Professor of the Department of Special Physical and Pre-Medical Training, Faculty of Specialist Training for Criminal Police Units, Donetsk State University of Internal Affairs, Kropyvnytskyi, Ukraine.
https://orcid.org/0000-0001-9780-060X
galelza7@gmail.com

Tetiana Prots
PhD, Teacher, Department of Mental and Physical Health, Faculty 2, Andrei Krupynskyi Lviv Medical Academy, Lviv, Ukraine.
https://orcid.org/0000-0002-0251-5206
t.prots@lma.edu.ua

Svitlana Gvozdetska
Candidate of Sciences in Physical Education and Sports, Associate Professor of the Department of Theory and Methods of Physical Culture, Sumy State Pedagogical University named after A.S. Makarenko, Educational and Scientific Institute of Physical Culture, Department of Theory and Methods of Physical Culture, Sumy, Ukraine.
https://orcid.org/0000-0002-7744-7471
sveta-gvozdecka@ukr.net

Hanna Omok
PhD in Pedagogy, Associate Professor, Department of Physical Culture and Sports Management, National University «Zaporizhzhia Polytechnic», Zaporizhzhia, Ukraine.
https://orcid.org/0009-0001-2428-6002
annaomok1@gmail.com

Recibido: 21/04/25
Aceptado: 27/06/25

Abstract

Introduction: Digitalization in the field of physical education requires additional assessment. The purpose of the article is to conduct a systematic analysis of new innovative solutions and key problems of their implementation in the process of teaching physical education in the era of digital technologies. Methods: The PRISMA scientific approach was used, which made it possible to identify the most relevant scientific sources (n=40). Time range: 2017-2025. The content analysis method was used to process the materials. Results: The following types of

digital innovations were identified: mobile applications and platforms, gamification, artificial intelligence, intelligent educational ecosystems, wearable technologies, inclusive digital tools, flipped learning, and virtual and augmented reality technologies. There are serious challenges to their application: insufficiently developed digital infrastructure in educational institutions, low level of digital literacy of physical education teachers, pedagogical inconsistency, technological challenges, and psychophysiological limitations. For the further use of digital technologies, a classification of innovative solutions is proposed. It is proposed to distinguish such solutions by functional direction, degree of interactivity, format of use, and general purpose. Conclusions: The conclusions emphasize the importance of continuing research, since digitalization in the educational dimension is constantly developing.

Keywords: innovative technologies, physical education, digitalization, classification.

Resumen

Introducción: La digitalización en el campo de la educación física requiere una evaluación adicional. El propósito del artículo es realizar un análisis sistemático de nuevas soluciones innovadoras y problemas clave de su implementación en el proceso de enseñanza de la educación física en la era de las tecnologías digitales. Métodos: se utilizó el enfoque científico PRISMA, que permitió identificar las fuentes científicas más relevantes (n=40). Rango temporal: 2017–2025. Para el procesamiento de los materiales se utilizó el método de análisis de contenido. Resultados: Se identificaron los siguientes tipos de innovaciones digitales: aplicaciones y plataformas móviles, gamificación, inteligencia artificial, ecosistemas educativos inteligentes, tecnologías wearables, herramientas digitales inclusivas, aprendizaje inverso, tecnologías de realidad virtual y aumentada. Existen serios desafíos para su aplicación: infraestructura digital insuficientemente desarrollada en las instituciones educativas, bajo nivel de alfabetización digital de los profesores de educación física, inconsistencia pedagógica, desafíos tecnológicos y limitaciones psicofisiológicas. Para un mayor uso de las tecnologías digitales, se propone una clasificación de soluciones innovadoras. Se propone distinguir dichas soluciones por dirección funcional, grado de interactividad, formato de uso y objetivo general. Conclusiones: Las conclusiones enfatizan la importancia de continuar la investigación, ya que la digitalización en la dimensión educativa está en constante evolución.

Palabras clave: tecnologías innovadoras, educación física, digitalización, clasificación.

Introduction

The active application of digital technologies and new innovative solutions is changing the modern educational environment. However, unlike many other fields of education, physical education has its own unique needs, limitations, and potential in the digital environment, which requires a separate analysis. The current scientific literature indicates that modern physical education plays an important role in the formation of a healthy lifestyle, development of motor skills, physical endurance, and psychosocial well-being of students (Martínez-Rico et al., 2021; van Hilvoorde & Koekoek, 2018). However, its specificity, namely the focus on physical activity, interaction in the real environment, and bodily presence, creates special challenges for the implementation of digital innovations (Goodyear & Armour, 2022). At the same time, modern technologies, such as wearable devices, mobile applications for activity monitoring, and gaming platforms with exercise elements, allow us to unlock the potential for motivation in students and apply a personalized approach to teaching (Otravenko, 2020; Almusawi et al., 2021). In particular, the research by Almusawi et al. (2021) indicated that the use of digital technologies had a positive effect on increasing the level of motivation. Authors pointed out that analytics can improve the personalization of learning. It has been proven that the use of innovative technologies also increases the level of student interest (O'Brien et al., 2020; Ferriz-Valero et al., 2020). However, the scientific literature also emphasizes that the introduction of digital technologies has its limitations (high cost, problems with technical equipment) and specifics in use (the need for digital competencies) (Chiu et al., 2024; Lee & Lee, 2021; Deng et al., 2023). Despite the active implementation of digital solutions and, in some situations, their adaptation process in physical education, the scientific literature still lacks a systematic approach to their classification. There are no generalized typologies of innovations, and the specific difficulties faced by teachers in implementing these technologies have not been sufficiently studied. Accordingly, such nuances make it difficult to

formulate effective strategies for integrating digital tools into physical education teaching practice. In addition, the relevance of this study is due to the need for a meaningful and structured approach to the digital transformation of physical education, which is currently lacking in the scientific space. Accordingly, the scientific novelty of the work is an attempt to systematize the existing innovations and challenges based on the analysis of modern scientific literature (from 2017 to 2025). This will help to form an important scientific basis for more effective implementation of technologies in this area.

Thus, the purpose of the study is to conduct a detailed systematic analysis of new innovative solutions and key problems of their implementation in the process of teaching physical education in the digital age.

Accordingly, the research questions are as follows:

1. What are the types of digital innovations that are actively used in the physical education system?
2. What are the main difficulties faced by teachers in implementing these innovations?
3. What classification can be proposed for innovative solutions to support the systemic integration of digital technologies in physical education practice?

Methodology

Research design

The study was created as a result of a systematic review of the scientific literature. The purpose of using this approach was to analyze and interpret the results in relation to predefined research topics and criteria that demonstrated the existence of potential areas for future research. A systematic review of the scientific literature is a type of research that is important because it systematizes the existing knowledge on the use of AI, which is currently lacking in the scientific literature.

Materials

The selection of sources was based on a purposive sampling carried out according to established criteria. The research involved the use of various types of sources: scientific articles, chapters of monographs, individual monographs, materials of scientific conferences, etc. An important aspect was the use of materials that were indexed in the scientific and metric databases Scopus, Web of Science, etc. The selection was made taking into account the chronological range from 2017 to 2025. This approach made it possible to use only the most relevant scientific literature and the latest sources in the study. In addition, we emphasized the reliability of scientific literature and certain methodological aspects. Relevant content is another additional criterion. The main language of scientific publications is English. Table 1 summarizes the main criteria used to include and exclude sources.

Table 1.
Inclusion and exclusion criteria of publications

Criterion	Description
Inclusion criteria	
Chronological framework	Research 2017-2025
Authority of sources	Articles, which were published in peer-reviewed journals or scientific monographs
Quality of methods	Papers and monographs of various methodological types (for example, review materials, experimental data, analyses etc).
Aspect of relevance	All papers and monographs must relate to the problem of the proposed paper
Language of publication	English
Exclusion criteria	
Outdated sources	Papers and monographs written before 2017
Duplicates	All duplicates and similar scientific works
Non-peer-reviewed publications	Fiction publications and popular science articles without scientific confirmation
Lack of full text	Only full accessed publications were used

Instruments and Procedure

The PRISMA scientific approach was used to search, classify and review the scientific literature. This allowed us to effectively collect new scientific and relevant information. The keywords for the search were the search queries included the following keywords: “physical education”, “digital innovations”, “challenges”, “ICT in PE”, “technology in education”. In total, the search yielded 2292 results. After eliminating all duplicates and materials that lacked scientific novelty, the list was updated (-1103). Those materials that were not relevant to the subject matter of the proposed article were rejected. Such actions were the result of an analysis of keywords and titles (-814). Similarly, other publications that, although relevant to the topic, were published in journals that did not meet the search criteria were eliminated (-231). After that, the remaining 4 exclusion criteria were used. Figure 1 shows all the stages of inclusion of scientific sources.

Data analysis

Further processing of scientific sources took place in accordance with the use of the method of content analysis. The content analysis process in this study was carried out in stages using a combined approach, which included both manual thematic coding and preliminary organization of sources in the Zotero software environment. Zotero was used to collect, categorize and systematize sources according to basic parameters: year, country, educational context, type of innovation, availability of empirical data, etc. This made it possible to simplify the application of inclusion/exclusion filters and structure the data for further interpretation.

The content analysis involved thematic coding with elements of open coding. The first stage involved open coding, during which the researchers manually identified key ideas, terms, types of innovations and challenges mentioned in the texts. These codes were grouped into generalized themes: for example, “automated assessment”, “VR/AR”, “gamification”, “lack of teacher training”, “low physical activity”, etc.

The second stage involved coding, which identified logical connections between themes and performed higher-level grouping. This allowed the codes to be summarized into four functional categories, which later formed the basis of the proposed classification of educational innovations:

Hence, as a result of content analysis, recurring phenomena, individual themes and innovative approaches were identified, which demonstrate modern practices and individual main challenges:

- Using of digital platforms;
- Current innovative instrument;
- Gamification;
- Automatic assessment;
- VR and AR technologies;
- Insufficient physical activity;
- Lack of teacher training;
- Technical limitations.

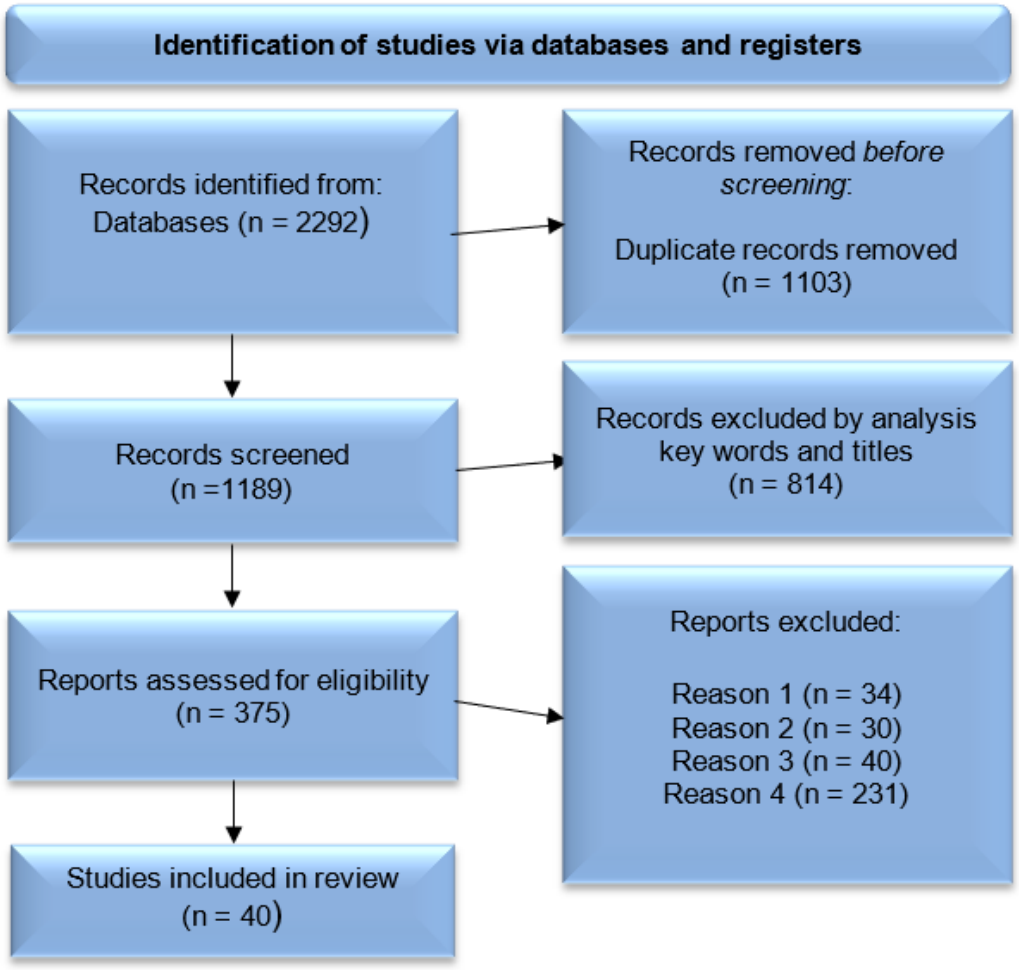

Figure 1. The process of searching and identifying scientific materials

The information obtained was structured accordingly using induction and deduction methods. Individual innovations were highlighted taking into account their functional purpose (motivational, pedagogical, structural and organizational, etc.), and challenges - according to the source of origin (scientific and pedagogical, technological, social, etc.). The use of this method made it possible to carry out a general understanding of the information and form a systemic idea of the state of physical education in times of total digitalization.

Results and Discussion

The selected scientific materials (40 references) discuss several types of digital innovations that are actively used in physical education. First, there are the so-called wearable technologies: various smartwatches, fitness trackers, and other sensors that allow students and teachers to track their heart rate, number of steps, calorie consumption, and the duration and intensity of classes. Mobile workout apps, instructional videos, and fitness programs also play an important role in today's digital learning space. Educational platforms and networks are used to provide a variety of assignments and feedback. An important trend that has recently become popular in the academic space is the use of virtual and augmented reality. Such technologies have made it possible to create interactive spaces for classes, while AR technologies can visualize the correct technique for performing exercises in real time. A noticeable trend that has been

actively implemented in physical education in recent years is gamification, which increases the level of students' motivation to play sports. Analytical systems and AI technologies represent a separate area in the modern scientific space, as they automate assessment and provide personalized recommendations. Table 2 shows the main innovative technologies, their descriptions, and references to relevant authors.

Table 2.
The main innovative technologies

Innovation Type	Short description	Sources
Mobile Apps & Online Platforms	● Online lessons, video instructions, applications, remote interaction, interactive platforms ● Video lessons in different networks	Almusawi et al. (2021) O'Brien et al. (2020)
Gamification	● Using game elements: points, competitions	Ferriz-Valero et al. (2020) Zhouxiang (2024) Dzhym et al. (2023)
Analytics & Artificial Intelligence (AI)	● Automatic assessment, personalized lessons, movement recognition	Chiu et al. (2024) Lee & Lee (2021) Deng et al. (2023) Zhang (2021) Brem et al. (2023) YanRu (2021)
Intelligent Educational Ecosystems	● Integrated learning management systems using big data and AI ● Digital fitness techonology	Deng et al. (2023) Rudd et al. (2020) Freitas et al. (2024) Dzhym et al. (2023)
Wearable Tech	● Fitness trackers, smart technological tools, smart watches, sensors for monitoring student activity ● Digital fitness techonology	Almusawi et al. (2021) Oke & Fernandes (2020) Shepelenko et al. (2023) Kang (2024)
Inclusive Digital Tools	● Tools to support students with special needs	Chiu, Tochilnikova, & Harteveld (2024) Dzhym et al. (2023) Shepelenko et al. (2023)
Flipped Learning	● Theory - online, practice - in class	Hinojo Lucena et al. (2019)
Digital Assessment Platforms	● Automatic assessment, analysis of results, adaptive learning	Zhang (2021) Brem et al. (2023) Shepelenko et al. (2023) Freitas et al. (2024) Dzhym et al. (2023)
Virtual & Augmented Reality (VR/AR)	● VR games and simulations for physical activity ● Visualization of the correct technique for performing exercises ● Digital fitness techonology	Chiu et al. (2024) Shepelenko et al. (2023) Craig et al. (2024) Röglin et al. (2023) Kang (2024) Lin et al. (2024)

Overall, content analysis was conducted using a thematic coding approach that combined elements of open and axial coding. The next step in open coding was to identify recurring patterns and key concepts across the 40 selected documents. Each document was read line by line, and initial codes were generated inductively based on the terminology, pedagogical frameworks, and technological elements present in the texts.

Axial coding was then used to establish connections between the initial codes and group them into broader categories, such as “Mobile and Online Technologies,” “Gamification,” “Artificial Intelligence,” “Wearable Technologies,” “Inclusive Tools,” “Digital Assessment,” and “VR/AR.” These categories emerged organically during the iterative coding process and were refined based on the frequency of occurrence,

conceptual similarity, and educational applicability of each innovation.

All analysis was conducted manually, without the use of specialized software. However, to ensure methodological rigor, the process was guided by a pre-defined coding protocol developed during the pilot phase of the study. Coding sheets were used to track and synthesize data across documents.

The analysis was conducted by a team of three researchers with expertise in educational technology and qualitative methods. Each researcher independently coded a subset of the documents. To ensure inter-coder reliability, a sample of 20% of the documents (n = 8) was double-coded by all three researchers. Cohen's Kappa coefficient was calculated for key categories, yielding κ = 0.82, indicating strong agreement. Disagreements in coding were discussed in consensus meetings, and final coding decisions were made collaboratively to enhance internal validity. Iterative refinement of categories and codes allowed the team to reduce subjectivity and increase the reliability of the results. Zotero was used to organize the bibliography and apply criteria for inclusion and exclusion of sources. It allowed to standardize the metadata of publications and avoid duplication. Table 3 shows a summary table with the analysis of research, types of innovations, educational context and countries.

Table 3.
Summary table of innovation analysis content

Author(s)	Year	Type of Innovation	Educational Context	Country/ Region	Main Findings
Almusawi et al.	2021	Mobile Apps, Wearable Tech	Higher Education, PE	Oman	Mobile and wearable tools increase engagement and track fitness metrics.
O'Brien et al.	2020	Mobile Apps	Online Learning	USA	Interactive apps improve student motivation and participation.
Ferriz-Valero et al.	2020	Gamification	PE, Blended Learning	Spain	Game mechanics enhance enjoyment and physical activity.
Zhouxiang	2024	Gamification	Digital PE	China	Promotes competition and collaborative learning.
Dzhym et al.	2023	Gamification, AI, Inclusive Tools	Physical Education (PE)	Ukraine	Multifaceted innovations improve accessibility and personalization.
Chiu et al.	2024	AI, VR/AR, Inclusive Tools	Smart Classrooms	Taiwan	AI and VR personalize and visualize learning effectively.
Lee & Lee	2021	AI	Remote Education	South Korea	Movement recognition algorithms improve motor skill learning.
Deng et al.	2023	AI, Ecosystems	Digital PE	China	AI platforms automate assessment and personalize PE instruction.
Zhang	2021	AI, Assessment	Online Platforms	China	Adaptive assessment enables differentiated learning.
Brem et al.	2023	AI, Assessment	Online Higher Ed	Switzerland	Predictive analytics enhance student outcomes.
YanRu	2021	AI	Smart PE	China	Personalization via machine learning increases engagement.
Rudd et al.	2020	Ecosystems	Digital Health Education	UK	Platforms support interdisciplinary health and PE delivery.
Freitas et al.	2024	Ecosystems, Assessment	Online and Hybrid Learning	Brazil	LMS and adaptive systems improve inclusivity and feedback loops.
Oke & Fernandes	2020	Wearable Tech	School-based PE	Nigeria	Wearables foster student autonomy and health awareness.
Shepelenko et al.	2023	Wearables, Inclusive, Assessment, VR	Blended PE, Inclusion	Ukraine	Multimodal innovations ensure accessibility and individual tracking.
Kang	2024	Wearable Tech, VR	Smart PE	South Korea	Sensors and VR enhance physical technique visualization.
Hinojo Lucena et al.	2019	Flipped Learning	Pre-service Teacher Training	Spain	Blended formats improve practical application of theoretical content.
Craig et al.	2024	VR/AR	K-12 PE	Canada	VR boosts student engagement and realism of physical instruction.

Röglin et al.	2023	VR/AR	Higher Education	Germany	Immersive learning improves motor skill retention.
Lin et al.	2024	VR/AR	PE and Health Education	Taiwan	Enhances visualization and safety in movement instruction.
Chiu et al.	2024	Inclusive Tools	Smart Inclusive PE	USA/Ukraine	Tech integration improves support for students with disabilities.
Shyshkina et al.	2023	Individualized fitness training programs	Fitness and Wellness	Ukraine	Individualized fitness training improves psychophysiological satisfaction
Tjønndal	2017	Typology development of sport innovation	Sport and Physical Education	Norway	Proposed a comprehensive typology of sport innovations
van Hilvoorde & Koekoek	2018	Digital technologies in PE	Physical Education	Netherlands	Discussed integration of digital tech to modernize PE
Bogetz et al.	2015	Professional training innovations	Healthcare Education	USA	Highlighted new training models preparing healthcare professionals for 21st-century practice demands.
Davison & Joia	2022	Digital transformation challenges	Higher Education, Digital	Latin America	Analyzed opportunities and barriers for digital transformation in Latin American educational institutions.
Deroncele-Acosta et al.	2023	Digital transformation post-COVID-19	Higher Education	Latin America	Explored impacts of digital innovation in higher education
Patiño et al.	2023	Active learning & Education 4.0	Open Education	Latin America	Demonstrated effectiveness of active learning approaches for complex thinking
Popovsky	2020	Online education innovation	Higher Education	Latin America (Argentina)	Presented Universidad de Palermo as a model for innovative online education
Rodríguez-Abitia et al.	2020	Addressing digital gap in universities	Higher Education	Mexico, Spain	Identified challenges in bridging digital divide to improve quality education in universities.
Li & Wang	2021	AI-based PE teaching methods	Higher Education	China	Demonstrated effectiveness of AI methods to enhance PE teaching outcomes in college students.
Martínez-Rico et al.	2021	Digital competence of PE teachers	Physical Education	Spain	Assessed PE teachers' readiness for digital challenges, identifying competence gaps.
Mishra et al.	2024	AI-driven analytics for training	Sports Education	Global	Proposed AI analytics model to optimize training and injury prevention in sports PE.
Myronenko et al	2022	Healthy lifestyle promotion via sports	Sports Education	Ukraine	Studied formation of healthy lifestyles through sports activities and education.
Nikolaienko et al.	2022	Long-term training systems for footballers	Sports Training	Various (International comparison)	Analyzed features of long-term football training systems in different countries.
Cui et al.	2024	Multilevel modeling of tech use	Physical Education	China	Found positive correlations between tech use, student engagement, and improved fitness outcomes in PE classes.
Barrantes Cáceres, & Cozzubo Chaparro	2017	Intergenerational internet learning	Lifelong/Informal Education	Latin America	Showed the role of intra-household learning in increasing internet use by older adults.
Trabelsi et al.	2021	Tech-mediated teaching practices	Physical Education	Tunisia	National survey shows uneven access to and use of digital tools by PE teachers in public schools.

While digital technologies are actively used and their potential for modernizing the physical education system is recognized in science, the scientific literature indicates that the process of their introduction and use contains serious challenges. The latter differ from the local character and have technological, social, pedagogical and ethical aspects. In particularly, an important challenge is the insufficiently developed digital infrastructure in educational institutions. In particular, some institutions do not have the necessary devices, such as fitness trackers, VR headsets, multimedia equipment, or the technical capabilities to use

them fully (Internet, professional technical support) (Davison & Joia, 2022). Another problem is the low level of digital literacy of physical education teachers. According to current research, a significant number of teachers have a limited understanding of modern EdTech solutions or lack the skills to use them. This situation generally causes resistance to innovation, which is aggravated by the lack of proper training. On the other hand, there is a pedagogical inconsistency (Deng et al., 2023; Patiño et al., 2023). The point is that innovations are often implemented in fragments, without appropriate methodological justification or adaptation to the specifics of physical activity. Technological challenges are highlighted, including problems with personal data protection and inequality of access to digital technologies among applicants (Cui et al., 2024). Separately, the scientific literature highlights psychophysiological limitations associated with long-term use of technology. It has been proven that they can lead to fatigue, disorientation, and coordination disorders. Besides, further implementation of these technologies should take these challenges into account and create an effective digital learning environment.

Moreover, the results of the content analysis directly became the basis for constructing the proposed functional classification of educational innovations in the field of physical education and higher education. During the analysis, thematic coding and grouping of materials from selected publications was carried out, focusing on the nature of the use of technologies, pedagogical goals, and educational context (See Figure 2).

1. According to the functional area	
	Educational technologies: digital simulators, videos, AR/VR platforms, digital learning resources, additional electronic materials
	Organizational and communication technologies: Online educational platforms, digital resources for distributing and storing materials, assignments, assessments
	Motivational technologies: digital resources, platforms, gadgets, applications that include game elements, rankings, competitions, achievements
2. By the degree of interactivity	Passive (content-oriented) technologies: videos, text instructions that do not provide feedback
	Active technologies: services that adapt to the mobile actions of seekers
	Intelligent technologies: Tools with elements of artificial intelligence that analyze data and generate recommendations
3. By format of use	Individual technologies: personal trackers, mobile applications
	Collective technologies: digital games, VR classes in a group format
	Institutional platforms: comprehensive systems integrated into the school IT infrastructure
4. By purpose (goal)	Conducting assessments: analyzing data on the activity, success, or physical performance of applicants
	Direct training: digital resources that provide information, video content, support for the process of mastering movement techniques or various exercises
	Feedback: self-monitoring apps, teacher comments, digital portfolios

Figure 2. Classification of identified innovations

The classification created by the authors will allow teachers to comprehensively assess existing digital solutions and select appropriate technologies according to educational goals and student characteristics. This classification is also aimed at developing strategies for the gradual introduction of innovations into the educational process. Considering the main goal of the study, namely, conducting a systematic analysis of selected scientific literature and forming a classification of the main identified innovations based on this, it is proven that various digital technologies for the development of physical culture are identified in the modern scientific space.

The study proves that adaptive learning platforms, artificial intelligence technologies, fitness devices, mobile applications for tracking activity and sports activities, virtual reality using EdTech capabilities are integral components of the current educational process. Thus, the results obtained determined the presence of a wide range of digital innovations that are actively used in physical education. These data are partially consistent with the results of other scientists, who determined the impact of digitalization on improving the motivational level of students (Li & Wang, 2021). In addition, these data are compared with the study by Lee & Lee (2021) which emphasized the potential of AI in the system of adapting training programs to the individual needs of students. Other studies have proven the importance of AI for conducting physical condition analytics (Shyshkina et al., 2023; Nikolaienko et al., 2022). The results of the study identified several main problems: technical (lack of equipment), pedagogical (lack of proper training of teachers) and ethical problems (data confidentiality). In general, the proposed difficulties are fully consistent with the conclusions of previous scientists. However, the work of O'Brien et al. highlighted other important difficulties. These authors emphasized such a phenomenon as the inequality of digital infrastructure between educational institutions (O'Brien et al., 2020; Bogetz et al., 2015). At the same time, other works recorded the low readiness of teachers to integrate wearable technologies. At the same time, other scientists recorded the current problem of legal regulation of biometric data collection (Popel et al., 2023; Omelchuk et al., 2022). The difficulties identified in the discussion contribute to the improvement of existing digital technologies used in modern physical culture (Devadze & Gechbaia, 2024; Pathak, 2023). The last research question concerned the formation of a classification of the main modern digital innovations in physical education. Accordingly, as a result of the analysis, a functional-typological classification of digital innovations in physical education was proposed. It involves a division by functional purpose: 1) control and monitoring (wearables, artificial intelligence); 2) motivational support (gamification, digital ratings); 3) educational interaction (VR/AR, distance learning); 4) adaptability and inclusion (AI analytics, platforms for inclusive learning). In addition, the developed classification involved paying attention to such components as the purpose of involving technologies (goal) and the format of use (group, individual, institutional use). At the same time, similar approaches can be traced in the works of other scientists (Myronenko et al., 2022). In particular, the study by C. Deng et al proposed the concept of "Smart PE" (Deng et al., 2023). This concept involves structuring innovations by educational functions. At the same time, in the study of Zhang (2021), the formed classification is based on the degree of automation of the educational process. Therefore, modern scholars fully agree that the use of digital technologies in teaching physical education requires a systemic approach, and such classifications are useful for teachers who can choose certain technologies according to their functions, purpose or format (Yang, 2024; Tjønndal, 2017). Therefore, the proposed classification makes it possible to expand existing approaches, since it takes into account not only the technological nature of innovations, but also their pedagogical significance. This generally contributes to the systemic integration of digital solutions into the practice of physical education and sports. The study has limitations. Regarding language coverage, the review was limited to publications in English. This was due to the need to ensure comparability, academic validity, and full-text availability from international databases. At the same time, it is recognized that such a limitation could have led to the omission of relevant sources, in particular from regions where the Spanish language predominates - for example, from Latin American countries or Spain. This potentially affected the representation of local innovative practices. This affects the omission of the latest or highly specialized innovations that are in the non-English-speaking academic space. However, studies by authors from Latin America, the USA, and China, written in English, were used.

Conclusions

Therefore, a systematic analysis of new innovative solutions and key problems of their implementation in the process of teaching physical education in the age of digital technologies demonstrated that this problem is extremely relevant. In particular, the types of digital innovations that were quite actively used in the system of physical education were determined. Among such innovations are characterized mobile applications and platforms, gamification, artificial intelligence, intelligent educational ecosystems, wearable technologies, inclusive digital tools, flipped learning, and virtual and augmented reality technologies.

However, even considering all the advantages of using digital technologies, there are serious challenges to their application. First, among the challenges identified is the insufficiently developed digital infrastructure in educational institutions. Another relevant problem is the low level of digital literacy of physical education teachers, which contributes to the formation of pedagogical inconsistency. On the other hand, it is also worth highlighting technological challenges and psychophysiological limitations associated with long-term use of technology.

The presence of so many barriers indicates a deep structural inequality in access to digital innovations, which complicates their mass and uniform implementation. Therefore, the priority areas of action should be investments in the digital infrastructure of educational institutions, the development of national programs to improve the digital competence of teachers, as well as the adaptation of digital solutions to vulnerable conditions. The functional classification of digital innovations proposed in the study has practical value. It can be useful for teachers (for selecting appropriate digital tools according to pedagogical goals), curriculum authors (a guide for incorporating innovations into the structure of a lesson or module) and managers and educational policymakers (for strategic planning of the integration of EdTech into physical culture) The limitations of the study lie in the language sample, since only English-language sources were included in the analysis, which probably led to an underrepresentation of innovations from Latin American, Spanish or Francophone African countries. There is also no clear segmentation of results by education level.

Therefore, in further research, it is advisable to focus on empirically assessing the effectiveness of each type of innovation in the context of physical education and developing teacher training models that take into account both technical and psychological and pedagogical aspects of digitalization

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