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RESEARCH LANDSCAPE OF E-LEARNING IN PHYSICAL EDUCATION: 2020–2025

ANDRII YEFREMENKO, ILLIA SHUTIEIEV, HANNA POLTORATSKA, ALINA MELNYK, NATALIIA DOLHOPOLOVA*

*Corresponding author: literasearchukr@gmail.com

Abstract. In the modern conditions of digitalization of education, e-learning in physical education is defined as a promising direction of transformation of the educational process, especially in the context of distance and blended learning. However, the lack of a systematic analysis of the research landscape complicates the development and organized implementation of digital tools. Objective. To carry out a comprehensive analysis of the research landscape of e-learning in physical education for the period 2020–2025. Materials and methods. We used a bibliometric approach with the analysis of data from Google Scholar using the programs Publish or Perish, Zotero and Vosviewer. The final analysis included 414 scientific sources after careful selection. Key terms were mapped, clustered into thematic groups, and the strength of the relationships between concepts was assessed. The bibliometrics were supplemented by an empirical survey of 24 specialists in the field of physical education who assessed their attitudes towards the main directions of e-learning development using the author's questionnaire. The analysis of respondents' answers demonstrated the consistency of the questionnaire at the level of α–Cronbach = 0.92. Results. Strong conceptual connections between terms indicate the formation of sustainable research directions. The keyword analysis revealed 27 relevant terms grouped into five clusters: 1) mobile technologies and gamification; 2) online and blended learning; 3) advanced technologies (artificial intelligence, virtual/augmented reality); 4) big data and massive open online courses; 5) video and learning platforms. The most commonly used terms were "application", "platform", and "internet", which indicates the dominance of applied network technology research. The survey results showed that the majority of teachers positively perceive the idea of introducing digital technologies in physical education. The areas that received the most support were the creation of national platforms (associated with clusters 4 and 5), adaptation of digital resources to the age and physiological characteristics of students (associated with cluster 1), and the need for professional training of teachers (associated with clusters 1–5). At the same time, respondents emphasized that traditional forms of learning cannot be completely replaced by digital tools, emphasizing the importance of blended learning models (associated with cluster 2 and 3). The research draws the conclusions that the research landscape of e–learning in physical education is structured around key technological concepts, where the highest level is occupied by digital platforms, mobile applications and multimedia content. At the same time, immersive technologies (virtual and augmented reality) and analytical tools are less common in research, which indicates the potential for their development. It is expected that the identified clusters will be used to build effective learning platforms focused on physical education. After all, the pedagogical community shows readiness for digitalization, but needs methodological support, training, and institutional assistance. Further research should focus on experimentally testing the effectiveness of immersive technologies, developing Ukrainian learning management systems, and studying the impact of e-learning on students' educational and practical outcomes.

Keywords*:* e-learning, mobile applications, physical education, digital technologies, educational innovations.

1. INTRODUCTION

Electronic learning (e-learning) is becoming increasingly widespread in modern higher education practice, covering both general and specialized disciplines. In particular, physical education, which has traditionally been perceived as an exclusively practical discipline taught face–to–face, is also gradually being digitalized. These changes are driven by the development of information and communication technologies, mobile applications, online learning platforms, and the use of artificial intelligence, virtual and augmented reality in the educational process. The growing role of e–learning contributes to the renewal of teaching methods and approaches to the organization of the educational process, which, in turn, actualizes the need to study the scientific landscape of this issue.

2. THEORETICAL BACKGROUND

The analysis of scientific sources on e-learning in physical education demonstrates a variety of approaches and research areas that reflect current trends in the development of educational technologies. Considerable attention of researchers is attracted to mobile technologies (app) and gamification, which help to increase motivation, physical activity and involvement of students in the process of physical education (Arufe-Giráldez et al., 2022). However, the effectiveness of gamification depends on the characteristics of physical fitness of participants and equal access to mobile technologies (Camacho–Sánchez et al., 2023). Blended learning, which combines traditional methods with online components, is growing in popularity in physical education. The use of learning platforms (LMS) helps to increase motivation and improve students' motor skills (Wang et al., 2023; Babachuk et al., 2024). However, the effectiveness of blended learning depends on the nature of physical activity and the specifics of the motor activity being taught (Goad et al., 2021). The introduction of innovations such as artificial intelligence (AI), augmented reality (AR), and virtual reality (VR) opens up new opportunities for physical education. The use of AR optimizes the development of motor skills, while the use of VR is associated with a decrease in stress levels in students in the process of physical education. AI contributes to the development of individualization of learning and automation of learning progress assessment (Cui et al., 2025). However, the high cost of technologies for the formation of a holistic digital learning ecosystem is noted (Guo & Li, 2021). The use of big data and massive open online courses (MOOCs) in physical education allows us to analyze student behavior and adapt curricula to their needs (Gumantan et al., 2021; Zhu, 2024). However, the problem is to ensure the confidentiality and protection of students' personal information.

3. RESEARCH OBJECTIVE, METHODOLOGY AND DATA

A preliminary analysis of scientific sources demonstrates a variety of approaches and research areas that reflect current trends in the development of educational technologies. Against the background of research on the digitalization of education and the use of electronic tools in the educational process, the issue of integrating e–learning into physical education remains insufficiently studied. The main difficulties lie in the specifics of physical education as an academic discipline based on the active physical participation of students and direct contact with the teacher. However, modern information technologies open up new opportunities for organizing learning, with the involvement of an online format that is not traditional for physical education.

The problem that led to the current study is the lack of scientific data on the peculiarities of e-learning implementation in the process of physical education. There is a need for a quantitative and qualitative analysis of scientific works in order to identify the main trends and highlight areas for

further research. In particular, it is important to find out which technologies are most widely used, which methods are implemented most successfully and which areas need further development.

The purpose of the study is to comprehensively analyze the research landscape of e–learning in physical education for the period 2020–2025.

The research design framework is determined by the features of mapping the scientific landscape of e–learning in the field of physical education. The bibliometric approach was applied, which allowed to quantify the key areas of research in the field of physical education.

Data collection. The literature search was carried out using the Publish or Perish v.8 software, which allows retrieving bibliographic data from various scientific databases. In this study, the Google Scholar database was chosen because of its wide coverage of publications in the social sciences, education, and sports. Compared to other databases of scientific and metric information, which partially overlap, Google Scholar indexes the so-called "gray" literature (dissertations, conference materials, etc.), the analysis of which is relevant in the context of the subject matter of the study. The search queries were formed taking into account key terms that reflect the topic of e-learning in physical education, in particular: "e-learning", "online learning", "digital learning", "blended learning", "virtual learning", "distance learning", "mobile learning", "physical education". The search was limited to the period from 2020 to 2025. The search was not limited to document types (see additional materials for more details).

Table 1 shows the inclusion and exclusion criteria for the analysis (Tab. 1).

Tab. 1

Criteria for inclusion and exclusion of studies for analysis

Criteria	Inclusion	Exceptions
Type	Peer-reviewed articles, conference materials, reviews, dissertations	Journalism, unverified sources, blog posts, non-academic sources
Language	English or other languages	Other languages without translation or annotation
Availability	Full text or at least an extended abstract is available	Lack of access to the content of the article
Methodology	The article has a clear scientific apparatus: purpose, methods, results	Lack of scientific structure, subjective reflections
Context	Education, pedagogy, physical education, teacher training	Research focused exclusively on medicine, adult fitness, etc.
Focus	Integration of ICT, digital technologies, LMS, e-learning in physical education	Mentions of technology without a specific focus on physical education

Source: created by authors

Survey. In order to empirically test the clusters identified in the modeling process, a specialized questionnaire ("Attitudes towards e-learning in physical education", contains 10 questions) was developed to identify the assessment and attitudes of teachers/lecturers towards each of the identified areas (see additional materials). The wording of the questions was based on the key indicators of each cluster. The questions were in the form of statements assessed on a five-point Likert scale ranging from strongly disagree to strongly agree. The survey was conducted among educators and, in particular, teachers working in the field of physical education who have experience in using or implementing digital educational tools. The survey was voluntary and involved the participation of qualified professionals who, at the time of the survey, work in the field of physical education and have at least 3 years of professional experience (cumulatively). After data cleaning, 24 questionnaires were suitable for use. General characteristics of the participants: representatives of the Department of Athletics (4 persons); representatives of the Department of Informatics (6 persons); representatives of the Department of Physical Education (6 persons); representatives of the different middle schools (4

persons); representatives of professional colleges (4 persons). All participants were blinded to the purpose of the survey and were not informed about each other's participation. The survey was conducted anonymously using the gmail service.

The collected data were processed using descriptive statistics (the results are presented in format S ± SD. The internal consistency of the questionnaire was analyzed using Cronbach's reliability coefficient (α). The value of α>0,70 was considered an acceptable level of internal consistency of the scales, which confirmed the consistency of the statements related to the assessment of individual clusters.

Data analysis. The obtained bibliographic data of 812 documents were exported in BibTeX format and uploaded to Zotero. After removing duplicates and retracted articles, 414 documents were exported in RIS format and imported into Vosviewer software for visualization and analysis of scientific networks. A keyword analysis was performed to identify the main topics and trends in e–learning research in physical education. Co–authorship analysis to identify key authors and collaboration networks was conducted, but the connections found were few and not meaningfully complementary to the research results. The analysis of joint citations to identify the main scientific sources and their influence was not conducted due to the peculiarities of extracting these publications by the PoP tool. The analysis of co–authorship of organizations to identify the leading institutions in the field was not conducted, as it is not related to the subject of the study. The analysis of country co–authorship to determine the geographical distribution of research was not conducted, as it is not related to the subject of the study. Zotero software was used to process and manage bibliographic data. When mapping by key terms in Vosviewer, the minimum number of repetitions of a term was 10; the number of terms to select was 33 (60% of relevant terms out of 55). An independent analysis of the identified terms by two researchers led to the exclusion of terms that are not directly related to the research field: covid, pandemic, study, design, example, child, luck, impact, participant, class, strategy, university, integration, tool, teacher, physical education class, improve, investigation, case, include, policy, COVID-19, readiness, level, format, class, during, outcomes. Both researchers, who checked their relevance to the subject of the study, reached a consensus on all terms.

Visualization. The results of the analysis were presented in the form of a map of the interrelationships of relevant keywords found in the title and abstract of the article, followed by a study of the selected clusters. A visual demonstration of the hypothetical structure of the research field and the relationships between its elements (clusters) was made.

For the bibliographic analysis of the research landscape, the criteria for including sources were determined according to the criteria presented in the supplementary materials (see supplementary materials). To facilitate the presentation of the research selection strategy for the review, the PRISMA Flow Diagram (2020) tool was used (see additional materials). Two researchers analyzed the sources according to the defined criteria. In case of a conflict regarding the possibility of including certain sources in the review, a third researcher was involved.

4. RESULTS AND DISCUSSION

As a result of the analysis of the constructed map in the Vosviewer environment, which is shown in Figure 1, the key terminology of the research landscape was identified (Fig. 1).

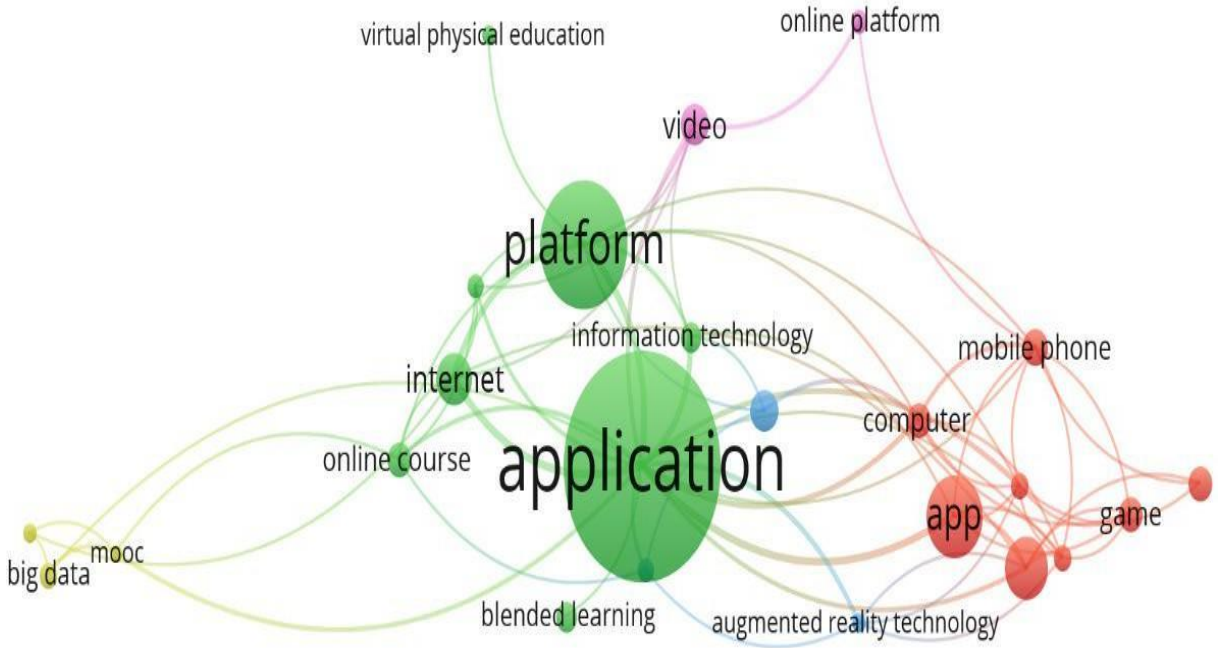

Fig. 1. Key words of the research landscape of e-learning in physical education 2020–2025
Source: created by Voswiever

The results of the analysis demonstrate the presence of 27 unique terms used in research on e-learning in physical education in 2020-2025. The most frequently mentioned term is "application" (66 mentions). Next most frequently mentioned are "platform" (37 mentions), "app" (24), "mobile application" (18) and "internet" (15). All terms are generally associated with the term "application" in the context of mobile and web applications. Researchers' attention is focused on the use of applications and platforms in digital learning (see additional materials). Other terms have a lower frequency: "mobile phone" (11), "game" (10), "mobile learning" (10). The distribution of frequencies shows that the study focuses on technological resources (applications, platforms, the Internet), mobile learning and game elements.

The overall strength of the links reflects how closely each term is related to other terms in the research network. Frequently used terms usually also have strong connections to other concepts. "Application" (66 mentions) also has the highest total link strength (48), and "platform" (37 mentions) has the second highest link strength (21). Similarly, "internet" (15 mentions) has a link strength of 16. Some terms with a moderate frequency of mention demonstrate relatively low connectivity – "blended learning" (9 mentions) and "virtual physical education" (6 mentions) have a very low total link strength (1). These concepts are still less integrated into the overall research network.

The Vosviewer tool divides terms into 5 clusters according to their thematic proximity (Fig. 2). Each cluster corresponds to a certain group of conceptually related concepts.

For further analysis, it seemed logical to us to combine studies that correspond to Cluster 4 and Cluster 5. This is due to the logic that the key terms of Cluster 5 – "online platform", "video" are rather not a separate direction of development of physical education courses in electronic format, but act as elements of the distance learning structure (for example, in the structure of MOOCs).

Cluster 1 combines mobile technologies and gaming elements. The most common terms here are those related to mobile applications and smartphones, as well as gamification. According to general trends, mobile learning is becoming more and more relevant, and game elements are increasingly used in physical education.

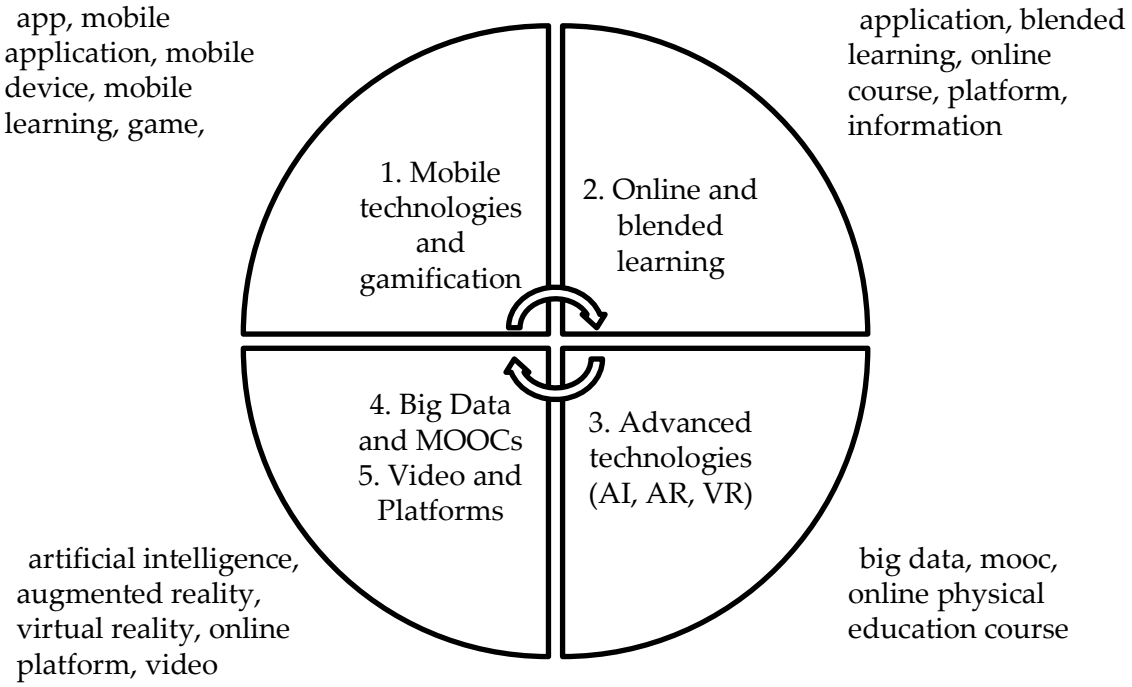

Fig. 2. Clustering of the research landscape of e-learning in physical education 2020–2025
Source: created by authors

Cluster 2 covers basic infrastructure and general e-learning terms. It includes the concepts of applications and learning platforms as basic elements of distance learning using Internet technologies. There are also terms related to blended and online learning models. It is worth noting virtual physical education, which reflects the gradually emerging trend of distance learning courses in physical education.

Cluster 3 focuses on immersive and intelligent technologies such as AR/VR and AI. The growing interest in VR/AR in education is confirmed by global trends: virtual and augmented reality make e-learning more realistic and engaging. Artificial intelligence manifests itself, in particular, in the individualization of learning content and coordination of learning environments. The massive adoption of VR/AR in learning environments is expected in the coming years.

Cluster 4 focuses on data analytics and massive open online courses. The relevance of big data and MOOCs courses indicates the prospects for the development of these scientific areas in physical education.

Cluster 5 emphasizes the role of platforms and video in e-learning. These tools are seen as an important area for organizing learning content through the use of multimedia and LMS systems.

The average year of publication helped to identify the most relevant areas of e-learning development in physical education. The following terms have the highest average years of mention: gamification, online physical education course, mobile learning, app, game. Obviously, gamification as a direction of updating the educational methodology takes the leading place. The second earliest trend is specialized online physical education courses, which appeared in publications in 2023 and reflects the research interest in distance learning in physical education. Also new are “mobile learning” and “mobile application”, which is in line with the established trend of using mobile technologies in modern education. Other notable terms are “video”, which indicates the relevance of video content in education, and “online platform”, which indicates the spread of online environments.

Guided by the results of clustering, a questionnaire was developed to study the attitude to e-learning in physical education of industry professionals. Table 2 presents statistics of the processed answers of respondents (Tab. 2).

Tab. 2

Attitudes towards e-learning in physical education

№	Questions	S	SD
1	E-learning has the potential to improve physical education	3.25	1.26
2	I am ready to implement digital technologies in my lessons/activities	3.33	0.87
3	Development of electronic resources for physical education is relevant and necessary	3.58	1.06
4	Electronic tools can improve pupils'/students' motivation to study	3.25	1.19
5	I lack the knowledge/skills to use digital technologies effectively	2.75	1.03
6	Systematic training of teachers on the use of ICT in physical education is needed	3.46	1.14
7	Traditional forms of physical education cannot be completely replaced by digital technologies	3.33	1.09
8	National electronic platforms for physical education (videos, courses, teaching materials) should be created	3.42	1.10
9	The use of e-learning should take into account the age and physical characteristics of students	3.29	0.96
10	Electronic tools allow you to better monitor student progress and activity	3.38	1.01

Source: created by authors

The reliability of the developed questionnaire is confirmed by the high value of the Cronbach's coefficient ($\alpha = 0.92$), which indicates the internal consistency of the statements.

The overwhelming majority of respondents expressed a positive attitude towards e-learning opportunities as a means of improving the physical education process and increasing student motivation. Teachers' attitudes indicate a moderate readiness to integrate digital technologies into their activities, which may be the result of limited methodological support or resource provision. High ratings for statements about the need for systematic training and the creation of e-platforms indicate a demand for structural changes in the educational environment. At the same time, most teachers do not support the complete replacement of traditional forms of physical education with digital technologies, recognizing the need for mixed learning formats.

Teachers pay special attention to the adaptation of digital solutions to the age and physical characteristics of students, which confirms the need to individualize the process of physical education at both school and higher education levels.

The identification of relevant studies in the context of their relation to individual clusters allowed us to identify the key areas of development of e-learning in physical education and, accordingly, to conduct a bibliographic analysis.

Mobile technologies and gamification

Mobile and digital devices, as well as related apps and games, are central to the debate on the integration of technology into physical education (Al Ardha et al., 2024). Students often prefer more portable devices. These gadgets have become popular for learning due to their widespread use in everyday life and the availability of wireless connectivity (Chang et al., 2020; Kurniawan et al., 2022). Digital and smart devices can also be used as an output port, for example, to view materials (Lizandra et al., 2020; Pratama et al., 2022; Mokmin et al., 2024). Wearable devices play an important role by enabling the measurement and tracking of physical activity, such as distance traveled, number of steps, speed, and energy consumption (Almusawi, Durugbo, & Bugawa, 2021). Wearable sensors can be used for biomedical surveillance (Alsalhy et al., 2023).

Mobile apps are seen as tools to optimize learning and increase physical activity. They are used to

assess the quality of hybrid learning (Estrada-Oliver & Mercado-Gual, 2022). As tools for researching or completing learning tasks, mobile applications are used in the form of: access to resources (Saklani, 2023); physical activity tracking (Vega-Ramírez, Notario & Ávalos-Ramos, 2020); fitness improvement (Liu & Gao, 2022); video analysis (Adams et al., 2025); data collection and communication (Papastergiou et al., 2021; Zulkifli & Danis, 2022). Specific apps, such as Polar Beat, Coach's Eye, WeChat, TikTok, WhatsApp, and Kahoot! are mentioned as aggregate tools that combine learning and assessment opportunities (Shang, Moss & Chen, 2023; Xu, Zhang & Xu, 2024). Mobile apps can help eliminate the need for expensive equipment.

Games and gamification are considered a separate block of technology implementation in the process of physical education based on unique approaches – exergames, location-based competitive IoT games, physical computing devices (Arufe-Giráldez et al., 2022). The use of gamification elements helps to increase students' motivation and engagement in physical education (Nuraini et al., 2023). The combination of technologies in the form of gamified mobile applications effectively motivates adolescents to an active lifestyle and physical activity (Camacho-Sánchez et al., 2023). Game competition between students using fitness bracelets is noted as an influential factor in the formation of a positive attitude towards gamification (Rakha, 2023). In the context of physical education gamification, users increase physical activity, which indicates the effectiveness of gamification in stimulating it. However, there are certain limitations to the use of gamification. The effectiveness of classes can be reduced if participants have significant differences in physical fitness, which primarily affects the motivation of less fit participants (Tjitroharjo et al., 2024). It is necessary to take into account the individual characteristics of students and ensure the accessibility of technology to avoid inequalities in learning (Tagimaucia et al., 2024).

Despite its widespread use, there are challenges associated with the use of wearable technologies, mobile devices and apps, such as limited access to digital devices and the internet connectivity they require, the cost of devices and internet, technical issues and difficulties with the use of new technologies (Chang et al., 2020; Kurniawan et al., 2022; Adams et al., 2025). Mobile devices can disrupt traditional physical education learning experiences (Guo & Li, 2021; Alsalhy et al., 2023; Mokmin et al., 2024). At the same time, the use of devices can make learning time more functional.

Our survey shows a moderate level of agreement among respondents with the statement about the positive impact of electronic tools on students' motivation to engage in physical education. Therefore, we note the consistency of the survey with the findings of studies that emphasize the effectiveness of such tools in increasing students' interest and activity. Not only cautious optimism, but also ambivalence was recorded: some teachers recognize the potential of mobile applications and game mechanics, while others doubt their effectiveness or lack sufficient experience in using such technologies. Gamification in combination with mobile technologies is considered in the literature as an effective tool for increasing motivation through emotional engagement, immediate feedback, and an achievement system. However, the average level of support in the respondents' answers indicates the need for empirical examples of successful implementation of such approaches that would take into account the specifics of physical education, including motor activity, spatial conditions, and load control.

Online and blended learning

Online learning is an area that is often considered in the context of distance education. Online learning is associated with the adaptation of the physical education process to learning in crisis situations (González-Calvo et al., 2020; Botagariyev et al., 2024). The advantages of online learning are identified, such as access to resources and overcoming geographical limitations (Estrada-Oliver & Mercado-Gual, 2022; Babachuk et al., 2024).

Blended (hybrid) learning, which combines traditional and online formats, is gaining popularity in physical education. It is considered as a combination of online and offline components (White et al., 2021). Various platforms and environments used for online and distance learning in physical education

have been identified, including Google Services, Moodle, Blackboard Collaborate, WeChat, online platforms and collaborative environments (Hendriansyah et al., 2020), as well as specific systems such as JIT.SI and Zoom (Cojocaru et al., 2022). The successful application of blended learning depends on the compatibility of the selected digital components with mobile devices. The use of online platforms in combination with traditional classes helps to increase students' motivation for physical activity (Kela, Muswalali & Mukwambo, 2022; Østerlie et al., 2023). Blended learning can also contribute to improving students' attitudes toward exercise and fitness (Ng, 2021). However, there are challenges associated with ensuring the quality of educational content (Klochko & Fedorets, 2022).

Online resources in physical education are diverse in content. Discussion of devices, tools, and applications used in online learning is common among researchers and educators (Tegero, 2021). Internet access is critical, as its absence or instability is a serious obstacle to online learning (Tjitroharjo, Nopembri & Kriswanto, 2024; Tagimaucia, D'Souza & Chand, 2024). Equipment is also an important part of both traditional and online learning. Problems with access to equipment are one of the main obstacles in building an online physical education learning process. However, the possibility of effective training at home with minimal or no equipment has been argued (Wallace J., Scanlon & Calder, 2023). Among the obstacles to the effectiveness of online and blended learning are the transactional distance (sense of distance) in online physical education (Zhu, 2024), technical problems (Xu, Zhang & Xu, 2024), and digital inequality associated with the availability of this learning format (Cojocaru et al., 2022). Blended learning does not always lead to a significant improvement in skills in certain types of physical activity, which may be due to the specifics of these disciplines and the level of students' fitness (Goad, Killian & Daum, 2021).

In our survey, the average score demonstrates a cautious but positive attitude of teachers towards the introduction of e-learning in the educational process of physical education. This result may be due to both limited experience and existing stereotypes about the incompatibility of physical activity education with the online format. At the same time, a slightly higher rate of readiness to implement digital technologies indicates that teachers are open to innovation, provided they receive proper training, methodological support, and technical resources. Considering the opinions of teachers in the context of the current scientific debate on the effectiveness of blended learning, we find consistency in the desire to combine the advantages of face-to-face and distance learning formats. Systematic training and development of digital competence are key conditions for a successful transition to blended models in physical education.

Advanced technologies: AI, AR, VR

The introduction of advanced technologies, such as artificial intelligence, augmented and virtual reality, opens a new page in physical education. Advanced technologies are seen as a real sector of change in educational approaches to the organization of physical education in the near future. So far, VR has been mentioned mainly as a training tool in the use of wearable VR equipment (Xiaofen et al., 2020; Meng, 2021). But virtual courses in physical education and the use of immersive technologies in education have already been tested (Gumantan, Nugroho & Yuliandra, 2021; Hamizi, Mokmin & Ariffin, 2022). They potentially determine the possible development of VR/AR applications in the online environment (Zhu, 2024; Wang et al., 2024). The use of virtual reality can help reduce students' stress levels, which is especially important in conditions of increased psycho-emotional stress (Niu, 2021; Klochko et al., 2022).

Augmented reality is more noted in the context of practical use to optimize student learning of motor skills. The use of AR in physical education contributes to the improvement of motor skill acquisition (Pratama, Sucipto & Hanief, 2022) and safety of motor learning (Klochko & Fedorets, 2022), as well as student motivation to exercise (Chang et al., 2020). The development of online VR/AR applications (Mokmin & Rassy, 2024; Zhang & Huang, 2023) and technical equipment for viewing them (Ariffin, Mokmin & Akmal, 2022) is also mentioned in the context of preparing educational materials and structuring physical education courses.

Artificial intelligence, in the context of physical education, is a technology used to develop distance multimedia learning platforms. There are concepts of an educational robot with artificial intelligence, smart physical education based on body image positioning algorithms, and machine learning applications (Wang, 2022). AI can be used in models for automated evaluation of algorithm-based learning. A promising area is the use of big data and AI to create a system for monitoring physical education courses (Cui et al., 2025).

Further research is needed to assess the effectiveness of advanced technologies and their impact on learning outcomes. Potential risks associated with VR/AR should be considered, such as the possibility of dizziness or neck injuries with prolonged use (Meng, 2021; Hamizi, Mokmin & Ariffin, 2022; Saklani, 2023), as well as high equipment costs (Klochko et al., 2022; Zhang & Huang, 2023).

In our survey, despite the absence of a direct assessment of advanced technologies such as AI, AR/VR, the positive assessment of the potential of electronic tools for monitoring student activity indirectly demonstrates the openness of respondents to using such solutions. These technologies have the potential to provide individualization, instant feedback, and simulated exercise in a controlled environment. However, the cautiousness of the respondents in their answers indicates the risks of ill-considered integration of high-tech solutions without adaptation to the real needs of students. Therefore, further research using AI/AR/VR should include not only technical implementation but also pedagogical support of this format.

Big data and MOOCs

The features of the application of big data analysis in physical education of students are determined. They are used to develop the design of a system of physical education classes based on intelligent vision (Niu, 2023). In another direction, it is proposed to develop online physical education classes based on big data and an AI monitoring network (Wang, 2022; Liu & Gao, 2022; Cui et al., 2025). Models for assessing the effectiveness of education and training can be based on data mining technology (Sargent & Casey, 2020; Varga & Révész, 2023) and combined with blockchain technology in the IoT environment (Zhang & Ma, 2024).

Massive open online courses are mentioned as a form of online learning (Bao & Yu, 2021). It is the application of MOOCs in a blended learning model that is accepted as the main direction of their use in physical education (Yu, 2022). The use of big data and MOOCs in physical education allows us to analyze student behavior and adapt curricula to meet their needs (Baena-Morales et al., 2024). There are concerns about ensuring privacy, security, and ethical use of data. One of the main concerns is the protection of students' personal data. MOOC platforms collect a large amount of information, including IP addresses, geolocation, test scores, forum activity, and other digital traces – sensitive information that needs to be kept confidential and avoided from unauthorized access (Deng & Chen, 2022). There is a risk of data security breaches that could lead to the leakage of students' personal information. Lack of transparency in the use of learning data analysis algorithms can lead to biased or unfair decisions (Maximovich, 2023). Students may not know how their data is being analyzed and used to make decisions about their learning, which undermines trust in the system (Lohmann et al., 2021).

In our survey, the positive assessment of the idea of creating national electronic platforms with teaching materials and videos demonstrates the awareness of the importance of centralized, accessible resources for teachers. Even though the terms "MOOCs" and "big data" were not explicitly mentioned in the survey, this response reflects a potential readiness to use elements of open education. Therefore, there is a demand for systematized and accessible resources that could potentially be based on the principles of open education and educational data analytics. Analyzing data on academic performance and participation in such platforms can become the basis for optimizing educational technologies. Making such decisions requires the development of digital infrastructure, the creation of Ukrainian-language content, and regulatory frameworks for copyright and personal data protection.

Platforms and videos in e-learning

Information technology and information and communication technologies (or digital technologies)

open up opportunities for distance learning and interaction with a large number of participants. Multimedia is used in physical education for various purposes: video analysis of motor skills (Xu, Zhang & Xu, 2024); providing video feedback (Souza et al., 2023); recording video as part of learning tasks or for progress monitoring (Sulistianta, Azhar & Nurhidayah, 2024); used as learning content (including streaming media technology) (Jastrow et al., 2022). Online platforms and learning management systems (LMS) provide centralized access to content, communication tools, interactive tasks, and assessment systems, which allows for automation and individualization of the learning process.

The use of multimedia – learning videos, video instructions, streaming services – contributes to a better perception of educational material (Nuraini et al., 2023), demonstration of rational exercise techniques and creation of conditions for visual learning (Adams et al., 2025). The integration of online multimedia technologies in the context of blended learning contributes to increasing student engagement (Wang et al., 2023), developing independence in motor learning and creating a flexible educational environment (Hendriansyah et al., 2020; Corbin, 2021).

Critical analysis shows that the effectiveness of online platforms and videos depends on several factors: pedagogical content design (Daum et al., 2021); interactivity tools (Reyes, 2023); digital literacy of teachers and students (Moura et al., 2021); relevance of materials to the real needs of practical learning (Jastrow et al., 2022). There are problems with their implementation in the process of physical education related to the lack of practical interaction (Pill, SueSee, & Davies, 2024), a decrease in physical activity with a complete transition to the online environment and the risk of formal knowledge acquisition without real mastery of motor skills (Kjerland & Annerstedt, 2022).

In our survey, the highest level of support was given to the thesis about the expediency of creating specialized electronic resources for physical education, which indicates a general understanding of the value of video content as an effective means of training modules for demonstrating exercises, rational movement techniques and monitoring their implementation. There is an agreement with the dominant trend in scientific publications – the active use of video in physical education as the main component of the digital learning environment. Multimedia are also seen as effective in training future physical education teachers and developing the digital competence of experienced professionals. Therefore, the survey results are consistent with modern educational practices, where multimedia content is a central element of the digital learning environment.

Thus, the overall positive dynamics of respondents' perception of digital technologies in physical education was recorded, but with a pronounced need to raise awareness, provide methodological support and ensure the adaptation of innovations to the conditions of Ukrainian education. The most supported are tools that have obvious applied value (video, platforms), while advanced technologies (AI, VR, AR) require additional legitimization through pilot studies, teacher training, and the study of the experience of their successful implementation in the educational process.

Thus, e-learning is becoming an integral part of the physical education infrastructure. It helps to individualize learning, expand didactic opportunities and support the educational process in distance or blended learning. At the same time, the introduction of e-learning should be accompanied by scientifically based methodological approaches and systematic training of teachers, taking into account the specifics of physical activity as the main component of the physical education process.

The research landscape of e-learning in physical education is multidimensional and dynamic. The main trends are the dominance of mobile technologies, the growth of gamification, the development of online courses, the use of immersive and advanced technologies, and the introduction of data analytics. These trends reflect modern approaches to the organization of the educational process and indicate the prospects for further research.

5. CONCLUSIONS

According to the results of the study on the analysis of the research landscape of e-learning in physical education for 2020-2025, it was found that the dominant concepts in the scientific literature are "application", "platform", "internet", which reflects the focus on practical digital tools and mobile technologies. The mapping of key terms allowed us to identify five substantive clusters: mobile and gamified technologies, infrastructure elements of distance learning, immersive innovations (VR/AR, AI), analytics and mass online courses, and multimedia resources. The study confirmed the growing interest in the use of electronic solutions in physical education and the formation of new research areas. A survey of teachers and educators showed a generally positive attitude toward the introduction of digital technologies in this area, despite a lack of knowledge, practical skills, and structural support.

The identified clusters and key terms can be used as a basis for the development of national e-learning platforms for physical education, preparation of digital learning materials, and systematic training of teachers. In particular, the results of the survey indicate a high demand for the creation of adapted methodological solutions and platforms with video content that take into account the age and physiological characteristics of students, as well as the need to improve the digital literacy of teachers.

Prospects for further research include deepening the analysis of the integration of immersive technologies (AR/VR), studying the effectiveness of blended learning models in physical education, as well as developing and testing authoring online courses and digital platforms. It is important to systematically study the impact of e-learning on students' physical activity and fitness.

Limitations: Among the limitations of this study are the use of only one database (Google Scholar), which could limit the coverage of academic publications; the emphasis is mainly on English-language sources; limited sample size for empirical surveys. In addition, the evaluation of the effectiveness of e-learning in the practice of physical education has not been directly studied, which requires the implementation of a separate practical research area.

Author Contributions:

Conceptualization: A. Yefremenko, I. Shutieiev.
Data curation: A. Yefremenko, H. Poltoratska, N. Dolhopolova.
Formal analysis: A. Yefremenko, I. Shutieiev, N. Dolhopolova.
Investigation: A. Yefremenko, I. Shutieiev, H. Poltoratska, A. Melnyk, N. Dolhopolova.
Methodology: A. Yefremenko, I. Shutieiev, A. Melnyk.
Project administration: A. Yefremenko, I. Shutieiev, A. Melnyk.
Supervision: A. Yefremenko, I. Shutieiev.
Validation: A. Yefremenko, I. Shutieiev.
Visualization: A. Yefremenko, H. Poltoratska, N. Dolhopolova.
Writing – original draft: A. Yefremenko, I. Shutieiev.
Writing – review & editing: H. Poltoratska, A. Melnyk, N. Dolhopolov.

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REFERENCES

[1] Adams, A., Belcher, D., Jenkins, A., & Goad, T. (2025). Utilizing Video Feedback for Effective Motor Skill Learning in Online Physical Education. *International Journal of Kinesiology in Higher Education*, 9(1), 14–30. https://doi.org/10.1080/24711616.2024.2421764

[2] Al Ardha, M. A., Nurhasan, N., Nur, L., Chaeroni, A., Bikalawan, S. S., & Yang, C. B. (2024). Analysis of Android-Based Applications in Physical Education and Sports: Systematic Review. *Retos*, 57, 390–398. https://doi.org/10.47197/retos.v57.107158

[3] Almusawi, H. A., Durugbo, C. M., & Bugawa, A. M. (2021). Innovation in physical education: Teachers' perspectives on readiness for wearable technology integration. *Computers & Education*, 167, 104185. https://doi.org/10.1016/j.compedu.2021.104185

[4] Alsalhy, M. J., Ahmed, I., Hussien, N. A., khalid Hussain, A., Hussian, A., & Al-Shaikhli, T. R. (2023, November). Application of Wearable Sensors in Physical education for biomedical surveillance and human-machine interface. In *2023 Annual International Conference on Emerging Research Areas: International Conference on Intelligent Systems (AICERA/ICIS)* (pp. 1–6). IEEE. https://doi.org/10.1109/AICERA/ICIS59538.2023.10420331

[5] Ariffin, U. H., Mokmin, N. A. M., & Akmal, M. A. (2022). Augmented reality technology in physical education: A systematic review in instructional design, and AR implementation option over the last 5 years. *Advanced Journal of Technical and Vocational Education*, 6(1), 13–20. https://doi.org/10.26666/rmp.ajtve.2022.1.3

[6] Arufe-Giráldez, V., Sanmiguel-Rodríguez, A., Ramos-Álvarez, O., & Navarro-Patón, R. (2022). Gamification in physical education: A systematic review. *Education Sciences*, 12(8), 540. https://doi.org/10.3390/educsci12080540

[7] Babachuk, Y., Mysiv, V., Rodikov, V., Ivanenko, O., & Koshliak, M. (2024). Physical education of students in the conditions of distance education. *Amazonia Investiga*, 13(75), 185–196. https://doi.org/10.34069/AI/2024.75.03.16

[8] Baena-Morales, S., Prieto-Ayuso, A., Merma-Molina, G., & González-Víllora, S. (2024). Exploring physical education teachers' perceptions of sustainable development goals and education for sustainable development. *Sport, Education and Society*, 29(2), 162–179. https://doi.org/10.1080/13573322.2022.2121275

[9] Bao, L., & Yu, P. (2021). Evaluation method of online and offline hybrid teaching quality of physical education based on mobile edge computing. *Mobile Networks and Applications*, 26(5), 2188–2198. https://doi.org/10.1007/s11036-021-01774-w

[10] Botagariyev, T., Mambetov, N., Aralbayev, A., Mukhanbetaliyev, A., Ispulova, R., & Akhmetov, N. (2024). Web-Based Technologies in Middle School Physical Education. *Retos: nuevas tendencias en educación física, deporte y recreación*, 51, 172–178. https://doi.org/10.47197/retos.v51.100310

[11] Camacho-Sánchez, R., Manzano-León, A., Rodríguez-Ferrer, J. M., Serna, J., & Lavega-Burgués, P. (2023). Game-based learning and gamification in physical education: A systematic review. *Education Sciences*, 13(2), 183. https://doi.org/10.3390/educsci13020183

[12] Chang, K.-E., Zhang, J., Huang, Y.-S., Liu, T.-C., & Sung, Y.-T. (2020). Applying augmented reality in physical education on motor skills learning. *Interactive learning environments*, 28(6), 685–697. https://doi.org/10.1080/10494820.2019.1636073

[13] Cojocaru, A. M., Cojocaru, M., Jianu, A., Bucea-Manea-Ţoniş, R., Păun, D. G., & Ivan, P. (2022). The impact of agile management and technology in teaching and practicing physical education and sports. *Sustainability*, 14(3), 1237. https://doi.org/10.3390/su14031237

[14] Corbin, C. B. (2021). Conceptual physical education: A course for the future. *Journal of Sport and Health Science*, 10(3), 308–322. https://doi.org/10.1016/j.jshs.2020.10.004

[15] Cui, B., Jiao, W., Gui, S., Li, Y., & Fang, Q. (2025). Innovating physical education with artificial intelligence: A potential approach. *Frontiers in Psychology*, 16, 1490966. https://doi.org/10.3389/fpsyg.2025.1490966

[16] Daum, D. N., Goad, T., Killian, C. M., & Schoenfeld, A. (2021). How do we do this? Distance learning in physical education – Part 1. *Journal of Physical Education, Recreation & Dance*, 92(4), 5–10. https://doi.org/10.1080/07303084.2021.1886836

[17] Deng, A., & Chen, A. (2022). Cognitive load and energy balance knowledge in high-school physical education. *Journal of Teaching in Physical Education*, 42(1), 165–174. https://doi.org/10.1123/jtpe.2021-0231

[18] Estrada-Oliver, L., & Mercado-Gual, N. (2022). Physical Education and Apps: The Remote Learning Challenge. *Journal of physical education recreation and dance*, 93(6), 65–68. https://doi.org/10.1080/07303084.2022.2082830

[19] Goad, T., Jones, E., Bulger, S., Daum, D., Hollett, N., & Elliott, E. (2021). Predicting student success in online physical education. *American Journal of Distance Education*, *35*(1), 17–32. https://doi.org/10.1080/08923647.2020.1829254

[20] Goad, T., Killian, C. M., & Daum, D. N. (2021). Distance learning in physical education: Hindsight is 2020—Part 3. *Journal of Physical Education, Recreation & Dance*, 92(4), 18–21. https://doi.org/10.1080/07303084.2021.1886843

[21] González-Calvo, G., Barba-Martín, R. A., Bores-García, D., & Hortigüela-Alcalá, D. (2022). The (virtual) teaching of physical education in times of pandemic. *European Physical Education Review*, 28(1), 205–224. https://doi.org/10.1177/1356336X211031533

[22] Guo, Q., & Li, B. (2021). Role of AI physical education based on application of functional sports training. *Journal of Intelligent & Fuzzy Systems*, 40(2), 3337–3345. https://doi.org/10.3233/JIFS-189373

[23] Gumantan, A., Nugroho, R. A., & Yuliandra, R. (2021). Learning during the COVID-19 pandemic: Analysis of e-learning on sports education students. *Journal Sport Area*, 6(1), 51–58. https://doi.org/10.25299/sportarea.2021.vol6(1).5397

[24] Hamizi, M. A. A. B. M., Mokmin, N., & Ariffin, U. (2022). Virtual reality technology in physical education: A systematic review in instructional design & implementation. *Adv J Tech Vocat Educ*, 6(1), 6–12. https://doi.org/10.26666/rmp.ajtve.2022.1.2

[25] Hendriansyah, D., Castyana, B., Rahayu, T., Ali, M., & Anggita, G. (2020). How Difficult Google Classroom Is? A Case Study of Blended Learning Method in Physical Education. *ISPHE 2020: Proceedings of the 5th International Seminar of Public Health and Education, ISPHE 2020*, 148. https://doi.org/0.4108/eai.22-7-2020.2300267

[26] Jastrow, F., Greve, S., Thumel, M., Diekhoff, H., & Süßenbach, J. (2022). Digital technology in physical education: A systematic review of research from 2009 to 2020. *German Journal of Exercise and Sport Research*, *52*(4), 504–528. https://doi.org/10.1007/s12662-022-00848-5

[27] Kela, G., Muswalali, K., & Mukwambo, M. (2022). Experiences first year physical education university students faced with online learning during Coronavirus Disease 2019 pandemic. *Namibia Educational Reform Forum Journal*, 30(2), 38–46. https://journals.nied.edu.na/index.php/nerfj/article/view/81/23

[28] Kjerland, G. Ø., & Annerstedt, C. (2022). Applying learning theories in learning how to teach physical education: A study of teacher education students collaborative learning processes in a project. *Sport, Education and Society*, 27(6), 689–702. https://doi.org/10.1080/13573322.2021.1902799

[29] Klochko, O. V., & Fedorets, V. M. (2022). Using immersive reality technologies to increase a physical education teacher's health-preserving competency. *Educational Technology Quarterly*, 2022(4), 276–306. https://doi.org/10.55056/etq.431

[30] Klochko, O. V., Fedorets, V. M., Shyshkina, M. P., Branitska, T. R., & Kravets, N. P. (2022). Using the Augmented/Virtual Reality Technologies to Improve the Health-preserving Competence of a Physical Education Teacher. *AET 2020*, 726. https://docs.academia.vn.ua/bitstream/handle/123456789/1673/109278_compressed%20%281%29.pdf?sequence=1&isAllowed=y

[31] Kurniawan, A. W., Wiguno, L. T. H., & Maimunah, I. A. (2022). Application-based walking and running materials for middle school physical education. *Journal of Physical Education and Sport*, 22(12), 2965–2973. https://doi.org/10.7752/jpes.2022.12374

[32] Liu, X., & Gao, J. (2022, January). Research on application of information Technology and Physical education in Colleges and Universities. In *2022 3rd International Conference on Education, Knowledge and Information Management (ICEKIM)* (pp. 45–49). IEEE. https://doi.org/10.1109/ICEKIM55072.2022.00018

[33] Lizandra, J., Valverde-Esteve, T., & García-Massó, X. (2020). Use of mobile devices as a facilitator of the practice of physical activity in physical education lessons: Experience in higher education. *Journal of Physical Education and Sport*, *20*(6), 3629–3634. https://doi.org/10.7752/jpes.2020.06489

[34] Lohmann, J., Breithecker, J., Ohl, U., Gieß-Stüber, P., & Brandl-Bredenbeck, H. P. (2021). Teachers' professional action competence in education for sustainable development: A systematic review from the perspective of physical education. *Sustainability*, 13(23), 13343. https://doi.org/10.3390/su132313343

[35] Maximovich, J. (2023). Competences of physical education teachers in education supported by digital technology. *International Journal of Cognitive Research in Science, Engineering and Education*, 11(2), 331–341. https://doi.org/10.23947/2334-8496-2023-11-2-331-341

[36] Meng, J. (2021). College physical education teaching aided by virtual reality technology. *Mobile Information Systems*, *2021*(1), 3052895. https://doi.org/10.1155/2021/3052895

[37] Mokmin, N. A. M., & Rassy, R. P. (2024). Review of the trends in the use of augmented reality technology for students with disabilities when learning physical education. *Education and Information Technologies*, 29(2), 1251–1277. https://doi.org/10.1007/s10639-022-11550-2

[38] Moura, A., Graça, A., MacPhail, A., & Batista, P. (2021). Aligning the principles of assessment for learning to learning in physical education: A review of literature. *Physical Education and Sport Pedagogy*, 26(4), 388–401. https://doi.org/10.1080/17408989.2020.1834528

[39] Ng, C. F. (2021). The physical learning environment of online distance learners in higher education – a conceptual model. *Frontiers in Psychology*, 12, 635117. https://doi.org/10.3389/fpsyg.2021.635117

[40] Niu, T. (2021, December). Research on the Application of Virtual VR Technology in Physical Education – Taking College Basketball Teaching as an Example. In *2021 International Symposium on Advances in Informatics, Electronics and Education (ISAIEE)* (pp. 281–287). IEEE. https://doi.org/10.1109/ISAIEE55071.2021.00075

[41] Niu, Y. (2023). Integrated physical education and medicine in general physical education at universities in the age of educational technologies. *BMC Medical Education*, 23(1), 466. https://doi.org/10.1186/s12909-023-04440-9

[42] Nuraini, S., Inggriyani, F., Albar, J., Muchtar, F. Y., Sandi, N. V., & Marini, A. (2023). Games-Based Interactive Multimedia to Increase Student Creativity in Physical Education Course. *Eurasian Journal of Educational Research (EJER)*, 104, 73-86. https://ejer.com.tr/manuscript/index.php/journal/article/view/1224/247

[43] Østerlie, O., Sargent, J., Killian, C., Garcia-Jaen, M., García-Martínez, S., & Ferriz-Valero, A. (2023). Flipped learning in physical education: A scoping review. *European Physical Education Review*, 29(1), 125–144. https://doi.org/10.1177/1356336X221120939

[44] Papastergiou, M., Natsis, P., Vernadakis, N., & Antoniou, P. (2021). Introducing tablets and a mobile fitness application into primary school physical education. *Education and Information Technologies*, 26, 799–816. https://doi.org/10.1007/s10639-020-10289-y

[45] Pill, S., SueSee, B., & Davies, M. (2024). The Spectrum of Teaching Styles and models-based practice for physical education. *European Physical Education Review*, 30(1), 142–155. https://doi.org/10.1177/1356336X231189146

[46] Pratama, B. A., Sucipto, S., & Hanief, Y. N. (2022). Improving learning in physical education: Augmented reality mobile app-based for fundamental motor skill. *Jurnal SPORTIF: Jurnal Penelitian Pembelajaran*, 8(2), 314–326. https://doi.org/10.29407/js_unpgri.v8i2.18508

[47] Rakha, A. H. (2023). The impact of Blackboard Collaborate breakout groups on the cognitive achievement of physical education teaching styles during the COVID-19 pandemic. *Plos One*, 18(1), 0279921. https://doi.org/10.1371/journal.pone.0279921

[48] Reyes, M. N. D. (2023). Readiness, Challenges, Strategies. In *And Work Performance of Physical Education Teachers International journal of advanced multidisciplinary studies, Volume IJAMS III, Issue 10 November*, 417–427. https://www.ijams-bbp.net/wp-content/uploads/2024/03/11-IJAMS-November-417-427-1.pdf

[49] Saklani, A. (2023). Integrating technology into physical education: Exploring the dynamics of AI, virtual reality, apps, and wearables for an enhanced educational odyssey. *International Journal of Physical Education, Sports and Health*, 10(4), 353–358. https://www.academia.edu/download/105383089/10_4_65_243.pdf

[50] Sargent, J., & Casey, A. (2020). Using digital technologies to enhance your teaching of physical education. In *A Practical Guide to Teaching Physical Education in the Secondary School* (pp. 116–128). Routledge. https://doi.org/10.4324/9780429061318-11

[51] Shang, C., Moss, A. C., & Chen, A. (2023). The expectancy-value theory: A meta-analysis of its application in physical education. *Journal of Sport and Health Science*, 12(1), 52–64. https://doi.org/10.1016/j.jshs.2022.01.003

[52] Souza, H. S. D., Lira Quina, M. Á., Santos, S. L. C. D., & Batalla Flores, A. (2023). Technological tools for the teaching of physical education at a distance. *International Journal of Development Research*, 13, 61822–66182. https://doi.org/10.37118/ijdr.26357.02.2023

[53] Sulistianta, H., Azhar, S., & Nurhidayah, D. (2024). Physical education learning media: How important is it for the success of the learning provided? *Advances in Health and Exercise*, 4(1), 17–24. https://www.turkishkinesiology.com/index.php/ahe/article/view/101/108

[54] Tagimaucia, V., D'Souza, G. S., & Chand, S. P. (2024). Exploring Online Physical Education Teaching: What Have We Done and What Have We Learnt? *International Review of Research in Open and Distributed Learning*, *25*(1), 127–151. https://doi.org/10.19173/irrodl.v25i1.7431

[55] Tegero, M. C. (2021). Challenges encountered by physical education teachers in online teaching in times of Covid-19 pandemic. *International Journal of Research Publications*, *91*(1), 157–171. https://doi.org/10.47119/IJRP1009111220212595

[56] Tjitroharjo, Y., Nopembri, S., & Kriswanto, E. S. (2024, April). The Challenge of Implementing Mobile Learning in Physical Education: A Comprehensive Literature Review. In *Proceedings of the 2nd Annual International Conference: Reimagining Guidance and Counselling in the VUCA Era (AICGC 2023)* (p. 25). Springer Nature. https://doi.org/10.2991/978-2-38476-234-7_4

[57] Varga, A., & Révész, L. (2023). Impact of applying information and communication technology tools in physical education classes. *Informatics*, 10(1), 20. https://doi.org/10.3390/informatics10010020

[58] Vega-Ramírez, L., Notario, R. O., & Ávalos-Ramos, M. A. (2020). The relevance of mobile applications in the learning of physical education. *Education Sciences*, 10(11), 329. https://doi.org/10.3390/educsci10110329

[59] Wallace, J., Scanlon, D., & Calderón, A. (2023). Digital technology and teacher digital competency in physical education: A holistic view of teacher and student perspectives. *Curriculum Studies in Health and Physical Education*, 14(3), 271–287. https://doi.org/10.1080/25742981.2022.2106881

[60] Wang, C., Omar Dev, R. D., Soh, K. G., Mohd Nasirudddin, N. J., Yuan, Y., & Ji, X. (2023). Blended learning in physical education: A systematic review. *Frontiers in Public Health*, 11, 1073423. https://doi.org/10.3389/fpubh.2023.1073423

[61] Wang, X. (2022). Thinking and practice of integrating information technology into College Physical Education Teaching. *International Journal of Science and Engineering Applications*, 437–438. https://doi.org/10.7753/IJSEA1112.1061

[62] White, R. L., Bennie, A., Vasconcellos, D., Cinelli, R., Hilland, T., Owen, K. B., & Lonsdale, C. (2021). Self-determination theory in physical education: A systematic review of qualitative studies. *Teaching and Teacher Education*, 99, 103247. https://doi.org/10.1016/j.tate.2020.103247

[63] Xiaofen, K., Liu, X., Stephenson, R., Guan, J., & Hodges, M. (2020). Student health-related fitness testing in school-based physical education: Strategies for student self-testing using technology. *European Physical Education Review*, 26(2), 552–570. https://doi.org/10.1177/1356336X19874818

[64] Xu, M., Zhang, L., & Xu, Y. (2024, May). Design and Application of a University Physical Education Course Support System Under Streaming Media Technology. In *2024 5th International Conference on Big Data and Informatization Education (ICBDIE 2024)* (pp. 488–496). Atlantis Press. https://doi.org/10.2991/978-94-6463-417-4_45

[65] Yu, J. E. (2022). Exploration of educational possibilities by four metaverse types in physical education. *Technologies*, 10(5), 104. https://doi.org/10.3390/technologies10050104

[66] Zhang, J., & Huang, Y. S. (2023). Augmented reality in sports and physical education. B *Springer Handbook of Augmented Reality* (pp. 355–368). Springer International Publishing. https://doi.org/10.1007/978-3-030-67822-7_14

[67] Zhang, X., & Ma, C. (2024). Intelligent Development of College Physical Education Teaching Mode Based on "Internet+". *International Journal of Web-Based Learning and Teaching Technologies (IJWLTT)*, 19(1), 1–13. https://doi.org/10.4018/IJWLTT.340724

[68] Zhu, J. (2024). Application of MOOC mixed teaching model in college physical education teaching-taking track and field teaching as an example. *International Journal of Embedded Systems*, 17(1–2), 126–137. https://doi.org/10.1504/IJES.2024.143769

[69] Zulkifli, A. F., & Danis, A. (2022). Technology in physical education: Using movement analysis application to improve feedback on sports skills among undergraduate physical education students. *Social Sciences & Humanities Open*, 6(1), 100350. https://doi.org/10.1016/j.ssaho.2022.100350

Yefremenko Andrii, Candidate of Sciences in Physical Education and Sports, Associate Professor; Associate Professor in the Department of Athletics; Kharkiv State Academy of Physical Culture, Kharkiv, Ukraine;
ORCID ID: 0000-0003-0924-0281
Address: Kharkiv State Academy of Physical Culture, Klochkivska St., 99, Kharkiv, 61022, Ukraine.
E-mail: literasearchukr@gmail.com

Shutieiev Illia, PhD student, recipient of the third (educational and scientific) level of Doctor of Philosophy in the Department of Athletics; Kharkiv State Academy of Physical Culture, Kharkiv, Ukraine;
ORCID ID: 0009-0008-0594-6467
Address: Kharkiv State Academy of Physical Culture, Klochkivska St., 99, Kharkiv, 61022, Ukraine.
E-mail: ay3.09.2022@gmail.com

Poltoratska Hanna, Senior Lecturer in the Department of Informatics, Biomechanics and Cybersport; Kharkiv State Academy of Physical Culture, Kharkiv, Ukraine;
ORCID ID: 0000-0002-0076-4727
Address: Kharkiv State Academy of Physical Culture, Klochkivska St., 99, Kharkiv, 61022, Ukraine.
E-mail: anna15kaya@gmail.com

Melnyk Alina, Candidate of Sciences in Physical Education and Sports, Associate Professor; Associate Professor in the Department of Sports and Outdoor Games; Kharkiv State Academy of Physical Culture, Kharkiv, Ukraine;
ORCID ID: 0000-0001-5612-0333

Address: Kharkiv State Academy of Physical Culture, Klochkivska St., 99, Kharkiv, 61022, Ukraine.
E-mail: alina.melnik1987@ukr.net

Dolhopolova Nataliia, Candidate of Technical Sciences; Senior Lecturer in the Department of Informatics, Biomechanics and Cybersport; Kharkiv State Academy of Physical Culture, Kharkiv, Ukraine;
ORCID ID: 0000-0002-4326-2284
Address: Kharkiv State Academy of Physical Culture, Klochkivska St., 99, Kharkiv, 61022, Ukraine.
E-mail: natasha.dlgplva@gmail.com

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У сучасних умовах цифровізації освіти електронне навчання у фізичному вихованні визначається як перспективний напрям трансформації освітнього процесу, особливо в контексті дистанційного та змішаного навчання. Однак відсутність системного аналізу дослідницького ландшафту ускладнює розробку та організоване впровадження цифрових інструментів. Мета дослідження: здійснити комплексний аналіз дослідницького ландшафту електронного навчання у фізичному вихованні за період 2020–2025 років. Матеріали та методи. Ми використовували бібліометричний підхід з аналізом даних Google Scholar за допомогою програм Publish or Perish, Zotero та Vosviewer. Остаточний аналіз включав 414 наукових джерел після ретельного відбору. Ключові терміни були картографовані, згруповані в тематичні групи, а також оцінена сила зв'язків між поняттями. Бібліометричні дані були доповнені емпіричним опитуванням 24 фахівців у галузі фізичного виховання, які оцінили своє ставлення до основних напрямів розвитку електронного навчання за допомогою авторської анкети. Аналіз відповідей респондентів продемонстрував узгодженість анкети на рівні α–Кронбаха = 0.92. Результати. Міцні концептуальні зв'язки між термінами засвідчують про формування сталих напрямів досліджень. Аналіз ключових слів умовжливив виявлення 27 релевантних термінів, згрупованих у п'ять кластерів: 1) мобільні технології та гейміфікація; 2) онлайн та змішане навчання; 3) передові технології (штучний інтелект, віртуальна/доповнена реальність); 4) великі дані та масові відкриті онлайн-курси; 5) відео та навчальні платформи. Найбільш часто вживаними термінами були "додаток", "платформа" та "інтернет", що свідчить про домінування досліджень прикладних мережевих технологій. Результати опитування показали, що більшість вчителів позитивно сприймають ідею впровадження цифрових технологій у фізичне виховання. Найбільшу підтримку отримали такі напрями, як: створення національних платформ (пов'язане з кластерами 4 та 5), адаптація цифрових ресурсів до вікових і фізіологічних особливостей учнів (пов'язане з кластером 1) та необхідність професійної підготовки вчителів (пов'язане з кластерами 1–5). Водночас респонденти наголосили, що традиційні форми навчання не можуть бути повністю замінені цифровими інструментами, підкреслюючи важливість моделей змішаного навчання (пов'язане з кластерами 2 та 3). Висновки. Отримані результати свідчать про те, що дослідницький ландшафт електронного навчання у фізичному вихованні структурований навколо ключових технологічних концепцій, де найвищий рівень займають цифрові платформи, мобільні додатки й мультимедійний контент. Водночас, імерсивні технології (віртуальна і доповнена реальність) та аналітичні інструменти менш поширені в дослідженнях, що свідчить про потенціал їх розвитку. Очікується, що визначені кластери будуть використані для побудови ефективних навчальних платформ, орієнтованих на фізичне виховання. Адже педагогічна спільнота демонструє готовність до цифровізації, але потребує методологічної підтримки, навчання та інституційної допомоги. Подальші дослідження мають бути зосереджені на експериментальній перевірці ефективності імерсивних технологій, розробці українських систем управління навчанням і вивченні впливу електронного навчання на освітні та практичні результати студентів.

Ключові слова: електронне навчання, мобільні додатки, фізичне виховання, цифрові технології, освітні інновації.