

STRUCTURAL ANALYSIS OF SCIENTIFIC DISCOURSE ON PUBLIC-PRIVATE PARTNERSHIP IN DIGITAL EDUCATION USING BIBLIOMETRIC METHODS

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The article examines the specific features of the development of public-private partnerships in digital education through a bibliometric analysis of the scientific discourse. It substantiates that, in the context of the digital transformation of the economy, public-private partnerships serve as an important instrument for consolidating the financial, technological, and institutional resources of the state, business, and the education sector, thereby ensuring the formation of effective models of interaction and the innovative development of education. Contemporary scientific approaches to interpreting the essence of public-private partnerships in education are analyzed, and their key characteristics are identified, including long-term orientation, risk-sharing, and stakeholder synergy. Using bibliometric analysis tools (VOSviewer), a body of scientific publications is examined, which enables the identification of the main thematic clusters in the development of scientific discourse: socio-economic, analytical-evidence-based, socio-demographic, and educational-scientific. The interdisciplinary nature of research in public-private partnerships and its significant role in ensuring the digital transformation of educational systems are established. The key advantages of public-private partnerships are identified, including increased investment efficiency in digital infrastructure, the development of innovative educational platforms, expanded access to educational resources, and the development of digital competencies. At the same time, the main risks are systematized, including technological dependence on global IT companies, the commercialization of the educational environment, and the need to maintain a balance of interests between the state and business. The paper proposes directions for improving the development of public-private partnerships in the field of digital education in Ukraine, in particular, the development of blended financing models, intensifying private sector participation, forming a competitive market for digital educational services, and integration into the European digital education area, which will contribute to improving the quality of education and the competitiveness of human capital.

Key words: public-private partnership, digital education, digitalization, bibliometric analysis, human capital, educational innovations, infrastructure, VOSviewer.

Formulation of the problem in general terms. One of the most promising instruments for implementing such transformations is public-private partnership, which ensures the consolidation of resources, competencies, and the institutional potential of the state, business, and the educational sector. The interaction of these actors creates preconditions for increasing the efficiency of investments in digital infrastructure, modernizing educational programs, developing innovative forms of learning, and forming relevant digital competencies. In particular, private-sector participation enables more prompt attention to labor-market needs, while state institutions provide the regulatory and strategic framework for the development of the educational system.

In the context of the digital transformation of the global economy, the development of digital education is becoming a key factor in the formation of competitive human capital and in ensuring sustainable socio-economic development. According to data from the European Commission, more than 90% of jobs in the countries of the European Union already require basic digital skills, while approximately

42% of the population do not possess them at a sufficient level (Digital Economy and Society Index, 2024) [11]. At the same time, according to UNESCO estimates, more than 244 million children and young people worldwide have limited access to quality education, which exacerbates digital inequality, especially under conditions of crises and armed conflicts [17]. Additionally, the global digital education market demonstrates steady growth: according to HolonIQ's analytical data, its volume exceeded USD 340 billion in 2025 and is forecast to double again by 2030 [12].

For Ukraine, the relevance of the study is significantly intensified due to the impact of military actions: according to the World Bank, more than 5 million pupils and students were forced to change the format of education, which actualizes the need for the accelerated development of digital educational infrastructure and the implementation of innovative models for organizing the educational process [20].

Under such conditions, public-private partnerships become particularly important as an effective mechanism for consolidating financial, technological, and institutional



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resources to ensure the sustainable development of digital education.

Analysis of recent research and publications. This issue is at the center of scholarly research, in particular, Bykov V.Yu. examined the digital transformation of education and the development of its technological platform [1]; Moskvichova O.S. analyzed the mechanisms of public-private partnership in the education sector [2]; Radkevych V.O. studied European trends in the development of partnerships in vocational education [6]; Chernetska T. explored the principles of implementing public-private partnership under conditions of digitalization [7]; Dzhikiya M.K., Karp M.V., Bart T.V., Kukushkin S.N. considered partnership as a tool for education management [10]; Mohamed Hashim M.A., Tlemsani I., Matthews R. investigated strategies for higher education development in the context of digital transformation [13]; Verger A. and Moschetti M. analyzed the nature and risks of applying public-private partnership in education policy [18]; Widjaja G. substantiated the role of partnership in the digitalization of education [19]. In addition, the study by Artyukhova N., Pedchenko N., Strilets V., Franko L., and Perehuda Y. [8] highlights the role of corporate social responsibility of universities in overcoming war-induced educational losses through the application of bibliometric and cluster analysis, thereby complementing the understanding of partnership-based approaches in the digital transformation of education [8].

Formation of the objectives of the article. The aim of the article is to examine the specific features of the development of public-private partnerships in the field of digital education through a bibliometric analysis of scientific discourse and to identify directions for adapting the European experience to Ukraine's conditions.

Methods of research. The methodological basis of the study is a combination of general scientific and specialized methods that ensure a comprehensive analysis of the development of public-private partnerships in the field of digital education. In particular, methods of theoretical generalization, abstraction, and systematization were used to clarify the essence and key characteristics of public-private partnership and to synthesize existing scientific approaches. A bibliometric analysis of scientific publications indexed in Scopus was conducted using a thematic search query, enabling the formation of a representative empirical sample of 3,014 publications and the identification of the main trends in the development of scientific discourse. The processing of empirical data was carried out using methods of bibliometric and cluster analysis, which revealed structural relationships and key thematic areas of research. To visualize the results and construct a terminological map based on keyword co-occurrence, the specialized software tool VOSviewer was employed. In addition, methods of comparative analysis and logical generalization were used to interpret the identified clusters, determine the interdisciplinary nature of the research field, and substantiate directions for developing public-private partnerships in digital education under conditions of digital transformation.

Results of the study. The involvement of the private sector in the development of digital education is driven not

only by limited public financial resources but also by the need to rapidly implement innovative technological solutions, access advanced digital platforms, and adopt managerial practices. In this context, public-private partnership serves as a complex, multi-level mechanism of interaction that combines the economic, social, and institutional interests of various stakeholders, thereby necessitating a deeper theoretical understanding of its essence and the specifics of its functioning in the field of digital education.

The specific features of public-private partnerships in this field are manifested in the synergy between infrastructure investments and human capital development, the integration of educational platforms and digital ecosystems, and the increasing role of intellectual resources and digital services. At the same time, this form of cooperation is accompanied by several challenges, in particular the risks of technological dependence on global IT companies, the commercialization of the educational space, and the need to balance public interests and business objectives.

Thus, studying the essence and specific features of public-private partnerships in the context of digital education is important for developing an effective model of interaction between the state and the private sector that ensures the sustainable digital transformation of the educational system.

In the scientific literature, the issue of public-private partnerships (PPPs) in the field of digital education is examined through the prism of their potential to accelerate transformation processes, while simultaneously generating a range of structural risks and challenges (Table 1).

In particular, the study by V. O. Radkevych emphasizes that public-private partnerships serve as an important instrument for intensifying educational reforms in the context of digitalization [6]. The author provides an example of cooperation with large technological corporations, in particular Microsoft, whose model involves not only the provision of software but also comprehensive support through educational grants, licensing, and the development of training programs to enhance teachers' digital competencies. Such an approach demonstrates the systemic nature and long-term orientation of the digital transformation of education. At the same time, critical analysis enables identification of the risks of excessive dependence on global IT companies, which may contribute to the monopolization of the educational technology market and a decrease in the technological sovereignty of national educational systems [6].

In the joint report by UNESCO and Worlddidac, public-private partnerships are considered an effective mechanism for crisis response. In particular, an initiative to supply Chromebook devices was implemented in partnership with Google, KPMG, and UNESCO, along with programs for teacher training and the development of digital competencies. Such an approach demonstrates a transition from emergency solutions to the formation of systemic digital skills. At the same time, such initiatives often have a donor-driven nature, which limits their long-term institutional sustainability [15].

Studies by the Joint Research Centre of the European Commission expand the understanding of PPP financial mechanisms, focusing on indirect forms of business partici-

**Interpretations of the essence of public-private partnership in the field of education
in scientific and regulatory sources**

Author / Source	Interpretation
Law of Ukraine "On Education" [4]	Public-private partnership in the field of education and science provides for: joint financing of educational institutions; establishment and/or joint financing and development of practical training bases and innovative enterprises based on educational institutions; development of modern learning technologies; implementation of joint specialist training programs, as well as measures for the social protection of participants in the educational process.
Law of Ukraine "On Public-Private Partnership" [3]	PPP is defined as cooperation between the state (its territorial communities represented by state authorities or local self-government bodies) and legal entities (except state and municipal ones) or individual entrepreneurs (private partners), carried out on the basis of a relevant agreement.
V. O. Radkevych [2]	Defines PPP in the field of vocational education as a system of long-term, mutually beneficial contractual economic and organizational relations between public and private entities aimed at attracting additional investments in the development of education, increasing the level of shared responsibility for socially significant decisions, and achieving pedagogical, social, and economic effects.
O. S. Moskvichova [2]	Considers PPP as an effective distribution of roles, which implies that the private sector clearly controls the targeted use of invested resources, while the state prevents excessive commercialization of education by business, which together should lead to the maximum possible socio-economic effect.
A. Verger, M. Moschetti [18]	Interpret public-private partnership in education as long-term contractual relations between the government and a private provider for the full or partial provision of educational infrastructure and services; it ensures a structure in which the public and private sectors complement each other's strengths in financing and delivering educational services.
M. K. Dzhikiya, M. V. Karp, T. V. Bart, S. N. Kukushkin [10]	Consider PPP as a mechanism of education management that allows simultaneously increasing investment support for higher education (through joint financing) and improving the efficiency of university governance by combining the flexibility of private investors with effective state control.
G. Widjaja [19]	Defines PPP as a crucial instrument for supporting initiatives of digitalization of education, which, by combining the financial and technical resources of the private sector with government efforts, helps to provide educational institutions with vital technological infrastructure and promotes innovation.
T. Chernetska [7]	Interprets PPP as a form of cooperation between public authorities and private enterprises aimed at the joint implementation of projects (in particular under conditions of digitalization and innovative development) that have significant economic, social, or infrastructural impact through the effective combination of resources, knowledge, and experience of both sectors.

pation. In particular, the model of private-sector investment in the creation of telecommunications infrastructure with the right to its subsequent commercial use is considered. This approach ensures mutual benefit from cooperation; however, it simultaneously increases the risks of commercializing the educational environment and the dependence of the quality of educational services on business interests [9].

In the works of V. Yu. Bykov and other researchers of digitalization in education, public-private partnerships are mainly seen as instruments for financial and resource provision. The implementation of digital platforms and technologies requires significant investments, which necessitate cooperation with IT companies. At the same time, such an approach narrows the essence of PPP to a compensatory financing mechanism, failing to sufficiently account for its potential as a platform for co-creating innovative educational content and learning models [1].

Thus, the generalization of scientific approaches indicates that public-private partnership in the field of digital education has significant transformational potential; however, its effectiveness is determined by the ability to ensure a balance of interests between the state and business, minimize technological dependence, and guarantee the long-term sustainability of implemented initiatives [5; 6; 15; 9].

A public-private partnership is defined as long-term cooperation between the state and private entities on a contractual basis, involving the joint implementation of projects, the investment of resources, and risk-sharing [5]. The key features of PPP include the long-term nature of coopera-

tion (5–50 years), the participation of private capital, and the transfer of part of the financial and technical risks to the private partner. In the field of education, this may include modernizing educational infrastructure, creating digital educational platforms, and developing EdTech solutions.

Within the framework of this study, a bibliometric analysis of scientific publications indexed in the international scientometric database Scopus was conducted using a thematic query on public-private partnerships in education. The study period covers the contemporary stage of scientific discourse, enabling reflection on current trends in the transformation of the studied issue.

The empirical sample comprised 3,014 scientific publications, ensuring an appropriate level of representativeness and reliability for the results. Bibliometric and cluster analysis methods were used for data processing, enabling the identification of structural patterns in the development of scientific research in this field. To visualize and cluster terms, the specialized software tool VOSviewer was used, which is based on keyword co-occurrence analysis. The use of this toolkit enabled the identification of semantic clusters and the determination of the thematic structure of scientific discourse (Fig. 1).

As a result of the analysis, a term map structured into four clusters emerged, each reflecting a distinct thematic dimension of research on public-private partnerships in the educational sphere.

The first cluster can be interpreted as the socio-economic and institutional-managerial dimension of partnership.

Thus, the constructed terminological map demonstrates that contemporary research on public-private partnerships in education has a pronounced interdisciplinary character, spans a wide range of directions, and provides a holistic understanding of the instruments, mechanisms, and outcomes of interaction between the public and private sectors. At the same time, the obtained results confirm the expediency of using the bibliometric approach as an effective tool for identifying scientific trends and substantiating strategic directions for the development of digital education.

For Ukraine, the development of public-private partnerships in the field of digital education is becoming particularly relevant amid structural transformations of the economy and the need to integrate into the European digital space. At the same time, the effectiveness of its implementation depends on the ability to maintain a balance among economic feasibility, social orientation, and the technological independence of the educational system. Based on the results, it is advisable to propose directions for improving the development of public-private partnerships in digital education in Ukraine (Table 2).

Table 2

System of measures for improving public-private partnership in the field of digital education in Ukraine:

Direction	Implementation
1. Development of blended financing models for digital education	It is advisable to introduce hybrid financial mechanisms that combine public investment, private capital, and international technical assistance. Such an approach will reduce the fiscal burden on the state budget while ensuring the stability of financing for educational innovations.
2. Stimulating private sector participation through economic instruments	It is recommended to introduce tax incentives, grant programs, and state-guarantee mechanisms to encourage companies to invest in the development of digital educational infrastructure. An important role in this process may be played by international technology companies, particularly Microsoft and Google, which have significant experience implementing educational projects.
3. Formation of the digital education services market	It is necessary to develop a competitive EdTech market by supporting national developers of digital educational platforms, stimulating startups, and creating conditions for the export of educational technologies. This will increase value added in the economy and reduce dependence on imported technologies.
4. Integration into the European digital education space	It is advisable to actively involve Ukraine in European Commission initiatives to develop the Digital Single Market, which provides access to financial resources, technologies, and partnerships. This will help harmonize educational standards and enhance the international competitiveness of Ukrainian education.
5. Management of economic risks of public-private partnership	It is important to implement risk-minimization mechanisms, in particular: diversification of partners; development of local technological solutions; and prevention of monopolization of the digital education market. This will ensure economic security and resilience of the educational system in the long term.
6. Focus on human capital development as an economic resource	Investments in digital education within the framework of public-private partnerships should be considered strategic investments in human capital that ensure long-term economic growth, innovative development, and increased labor productivity.

Source: compiled by the author based on [21; 16; 14; 13; 7]

Conclusions. As a result of the conducted research, it has been established that public-private partnership in the field of digital education is one of the key instruments for ensuring its sustainable development under conditions of the digital transformation of the global economy. Based on the generalization of theoretical approaches, it has been determined that public-private partnership is evolving from an instrument of financial support for the educational system into a comprehensive mechanism for the formation of innovative educational ecosystems that combine infrastructural, technological, and intellectual resources.

It has been established that European experience demonstrates a high level of effectiveness in the use of public-private partnerships as a mechanism for the development of digital education, particularly through the integration of educational systems into digital markets, the active participation of technology companies, and the application

of innovative financing models. At the same time, a number of risks have been identified, associated with potential technological dependence on global IT companies, the commercialization of educational services, and unequal access to digital resources.

The prospects for further research lie in deepening the analysis of the economic efficiency of public-private partnerships in digital education, particularly through the evaluation of returns on investment in human capital and digital infrastructure. It is also advisable to conduct comparative studies of PPP models in EU countries and Ukraine, taking into account their impact on the development of the digital education services market. Particular attention should be paid to analyzing the roles of technology companies, particularly Google and Microsoft, as well as to the application of bibliometric tools, including VOSviewer, to identify key trends in the digital transformation of education.

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СТРУКТУРНИЙ АНАЛІЗ НАУКОВОГО ДИСКУРСУ ЩОДО ПУБЛІЧНО-ПРИВАТНОГО ПАРТНЕРСТВА У ЦИФРОВІЙ ОСВІТІ З ВИКОРИСТАННЯМ БІБЛІОМЕТРИЧНИХ МЕТОДІВ

У статті досліджено особливості розвитку публічно-приватного партнерства у сфері цифрової освіти на основі бібліометричного аналізу наукового дискурсу. Обґрунтовано, що в умовах цифрової трансформації економіки публічно-приватне партнерство виступає важливим інструментом консолідації фінансових, технологічних та інституційних ресурсів держави, бізнесу й освітнього сектору, забезпечуючи формування ефективних моделей взаємодії та інноваційного розвитку освіти. Проаналізовано сучасні наукові підходи до трактування сутності публічно-приватного партнерства у сфері освіти та визначено його ключові характеристики, зокрема довгостроковість, розподіл ризиків і синергію інтересів учасників. Із застосуванням інструментарію бібліометричного аналізу (VOSviewer) досліджено масив наукових публікацій, що дало змогу виокремити основні тематичні кластери розвитку наукового дискурсу: соціально-економічний, аналітично-доказовий, соціально-демографічний та освітньо-науковий. Встановлено міждисциплінарний характер досліджень у сфері публічно-приватного партнерства та його вагомий вплив на забезпечення цифрової трансформації освітніх систем. Визначено ключові переваги використання публічно-приватного партнерства, зокрема підвищення ефективності інвестицій у цифрову інфраструктуру, розвиток інноваційних освітніх платформ, розширення доступу до освітніх ресурсів і формування цифрових компетентностей. Водночас систематизовано основні ризики, пов'язані з технологічною залежністю від глобальних ІТ-компаній, комерціалізацією освітнього середовища та необхідністю забезпечення балансу інтересів держави і бізнесу. Запропоновано напрями вдосконалення розвитку публічно-приватного партнерства у сфері цифрової

освіти в Україні, зокрема розвиток змішаних моделей фінансування, активізацію участі приватного сектору, формування конкурентного ринку цифрових освітніх послуг та інтеграцію до європейського цифрового освітнього простору, що сприятиме підвищенню якості освіти та конкурентоспроможності людського капіталу.

Ключові слова: публічно-приватне партнерство, цифрова освіта, цифровізація, бібліометричний аналіз, людський капітал, освітні інновації, інфраструктура, VOSviewer.

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