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ORIGINAL ARTICLE

# Digitization in Eurasian higher education: A bibliometric analysis of institutional scientific collaboration and thematic trends

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**ABSTRACT**

**Objective.** This study analyzed scientific publications on digitization in higher education in Eurasian countries using bibliometric indicators of term co-occurrence and institutional collaboration. These indicators were used to identify thematic dynamics, collaboration patterns, and the degree of regional scientific articulation in this field.

**Design/Methodology/Approach.** This study employed a bibliometric approach to analyze scientific output related to digitization in higher education within the Eurasian Economic Area. To this end, data were extracted and processed from the Scopus database, including all publications available up to 2024. The bibliometric analysis focused on two main variables: the institutional affiliation of all authors and all keywords recorded in the documents. The first indicator examined intraregional scientific collaboration by analyzing co-authorship between institutions in the same region. The second indicator was the co-occurrence of key terms.

**Results/Discussion.** The results of this study reveal a consolidating research field characterized by wide thematic diversity and an uneven collaborative structure. The analysis of term co-occurrence identified eight clusters, ranging from digital skills and e-learning to technological innovation, institutional automation, and emerging topics such as the digital economy, virtual reality, and vocational training strategies. This thematic variety reflects an expanding scientific agenda that addresses the pedagogical, technological, and organizational challenges of contemporary higher education. However, this conceptual dynamism sharply contrasts with the results of the institutional collaboration analysis. The network is highly centralized in Russia, with its institutions representing over 85% of the nodes on the map.

**Conclusions.** A careful analysis of these results shows that the digitization of higher education in the region is a fragmented area of study, developed under disconnected scientific conditions. This dual fragmentation, both thematic and institutional, presents a significant obstacle to developing effective

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academic integration policies, particularly in a field that inherently requires interdisciplinary collaboration, knowledge sharing, and institutional cooperation.

**Keywords:** digitalization; Eurasian Economic Union; higher education; bibliometric analysis; institutional collaboration; co-word analysis.

## 1. INTRODUCTION

In recent years, we have witnessed and participated in the digital transformation of the global economic system. We have observed the exponential penetration of new digital technologies into all spheres of human life. Today, many countries have identified transitioning to a digital economy as a key development priority. This transformation has impacted various sectors, including ordinary citizens (e.g., online work and education), businesses (e.g., e-commerce), the banking system (e.g., online banking), and the public sector (e.g., online government services). Another significant global development trend is the strengthening of regional international relations. Following the successful example of the European Union (EU), other regional organizations have emerged and evolved, such as the Association of Southeast Asian Nations (ASEAN) and the Eurasian Economic Union (EAEU).

Creating a digital space through an integration association helps break down barriers between participating countries, promotes data exchange and collaboration in scientific and technical fields, and encourages the development of a unified digital infrastructure. Cooperative efforts in cybersecurity, digital literacy, digital platform regulation, and personal data protection are essential. As digital transformation accelerates, the sustainability and competitiveness of integration structures primarily depend on the ability to utilize digital technologies and develop coordinated digital policies effectively.

The processes involved in regional integration during the shift to a digital economy require careful attention. Using the Eurasian Economic Union (EEU) as an example, this article aims to highlight digitalization and the development of a digital space as new aspects of higher education integration. In higher education, students' use of digital technologies has become an integral part of their daily lives. This trend signifies a significant change in how we learn and study, both inside and outside institutional settings. However, digital technologies are still underutilized in educational and training environments (Pan *et al.,* 2024). To stay relevant and successful, higher education and its leaders must strategically incorporate the digital transformation agenda, as other sectors have done (Jakoet-Salie & Kutu Ramalobe, 2023).

Various bibliometric studies have shown the rapid growth of digitization research in higher education worldwide. Analyzing 8,521 documents from Web of Science, Scopus, and PubMed, Zhao and Zhou (2024) identified the most influential authors, leading institutions, key collaboration networks, and emerging topics in this area. The study found that terms like co-creation, digital competence, hybrid teaching, and digital writing are shaping recent research trends. Meanwhile, concepts such as e-learning and blended learning remain fundamental pillars of knowledge in this field. Additionally, they highlighted the evolution of themes over time. They emphasized the importance of strengthening international academic collaborations, particularly in light of the pandemic's impact and the challenges of digital inclusion. Naamati-Schneider and Alt (2023) offered a bibliometric review focused on the subjective dimension of digitization. They analyzed how teachers' digital experiences, perceptions, and competencies are represented. They found that although digitization has become an essential component of academic life, limitations persist in its meaningful integration into higher education institutions.

The disconnect between the potential of technology and its effective use in educational practice raises questions about developing a sustainable digital culture. While both studies acknowledge an expanding thematic agenda and an increasingly active international scientific community, neither addresses how this production is articulated in specific regional contexts, such as the Eurasian space. Thus, this study analyzed scientific publications on

digitization in higher education in Eurasian countries using bibliometric indicators of term co-occurrence and institutional collaboration. These indicators were used to identify thematic dynamics, collaboration patterns, and the degree of regional scientific articulation in this field. Based on this objective, the following research questions (RQ) will be answered:

- RQ 1: What are the main topics addressed in research on digitization in higher education within the EEU, and how are they conceptually structured based on term co-occurrence analysis?
- RQ 2: What patterns of scientific collaboration are evident among institutions in the EEU countries on this topic, and to what extent do they reflect an articulated regional academic system?

### 1.1. Literature review

#### 1.1.1. Digital economy as a new trend

The digital economy is a relatively new phenomenon. Emerging at the beginning of the 1990s, its definition has undergone significant evolution due to advancements in digital technology. The digital economy is defined differently in domestic and foreign studies. Some works take Nicholas Negroponte's concept of the "data economy" as a starting point (Zaistev, 2019), while others use Don Tapscott's concept of the "digital economy" (Bukht & Heeks, 2018). These two concepts emerged almost simultaneously. Negroponte, a computer scientist, formulated the concept of a digital economy based on mankind's transition from processing atoms to processing electronic bits in economic activity (Negroponte, 1995), Tapscott, an expert in business strategy, described an economy based on digital technologies as the "Age of Networked Intelligence," where "it is not only about the networking of technology and smart machines, but also about the networking of humans through technology" that "combines intelligence, knowledge, and creativity for breakthroughs in the creation of wealth and social development" (Tapscott, 1995, p. 86).

Since the early 1990s, the term "digital economy" has been a prominent feature in business and research literature. Consequently, by the early 2000s, the term was included in the Oxford English Dictionary. The Oxford English Dictionary (2021) defines a digital economy as "an economy that functions primarily by utilizing digital technology, especially electronic transactions made using the Internet." OECD (2012) experts describe the digital economy as one that enables and executes the trade of goods and services via electronic commerce on the Internet. The digital economy is a substantial driver of economic growth and an increasing source of work for competition authorities.

While the traditional economy relies on physical shops, goods, and cash payments, the digital economy involves economic activity that uses electronic communication and digital technologies to provide goods and services. The internet, email, digital automation, digital payments, artificial intelligence, and social media are the main building blocks of the digital economy (Pettinger, 2020). It is characterized as an economy that utilizes information technology (IT), including hardware, software, applications, and telecommunications, in all aspects: the internal operations of organizations (such as businesses, governments, and nonprofits); transactions between organizations; and transactions between individuals (including consumers, citizens, and organizations). In this regard, IT acts as a driver of economic growth (Atkinson & McKay, 2007). The following key factors highlight the benefits of transitioning to a digital economy in the 21st century:

- For states, digitalization enables more effective security and the systematization and automation of processes within the framework of political and public life.
- For businesses, digitalization will allow them to optimize costs and maximize profits.
- Digitalization enables people to transition to a new level of human culture. It allows them to realize their creative potential and provides the digital economy with effective mechanisms (Khalova & Khalov, 2021).

In the future, a country's economic competitiveness will depend on how deeply digital technology is integrated into production processes. The use of digital technologies is expected to lead to an increase in GDP per capita, as enhanced competitiveness allows countries

to produce more goods and services, thereby boosting total GDP and GDP per capita. Therefore, a successful digital transformation enhances people's well-being (Petersen, 2019).

### 1.1.2. Digitalization and integration

The widespread adoption of information and communication technologies (ICT) and the shift to a digital economy accelerate regional integration processes for several reasons. First, the digital economy boosts trade and employment within the region, shifting the regional development paradigm. Additionally, implementing ICT supports rapid technological progress and innovation, enhancing production efficiency, transforming business models, including the integration of production processes, and reducing barriers between countries. The EU and ASEAN have established comprehensive systems to assess digitalization development at the national and collective levels. The EU introduced the Digital Economy and Society Index (DESI), which includes key digital economy indicators and tracks the progress of EU countries in digital competitiveness. DESI evaluates the effectiveness of digitalization policy and monitors its progress. DESI's primary goal is to evaluate countries' potential to create a single digital market. This potential is evaluated across five key areas: 1) connectivity (fixed broadband adoption, fixed broadband coverage, mobile broadband, and broadband prices); 2) human capital (internet user skills and advanced digital skills); 3) internet use (citizens' engagement with online services and transactions); 4) digital integration (business digitalization and e-commerce); and 5) digital public services (e-government) (European Commission, 2021).

The EU's aggregate DESI score increased from 33.72 in 2017 to 52.28 in 2022 (European Commission, 2022). DESI has been integrated into the Digital Decade Policy Program 2030 since 2023 (European Parliament and the Council of the European Union, 2022). The EU declared that, by 2030, the degree of digitalization of the economy and society would be the most important basis for economic and social sustainability. The EU also noted the need to coordinate joint actions on digitalization. Based on this, one might assume that there is a relationship between digitalization and integration. Currently, the EEU lacks a comprehensive index to assess the level of digitalization among its member states. Despite the strategic importance of digital transformation for deepening integration processes and implementing the EEU Digital Agenda by 2025, a tool to institutionally monitor the digital maturity of member states has yet to be developed. This creates a methodological and analytical vacuum that limits the ability to assess progress in digitalization objectively and makes it difficult to identify imbalances and develop coordinated management decisions. Unlike other regional associations, such as the EU (with the DESI index) or ASEAN (with the ASEAN Digital Integration Index), the EEU lacks a standardized system of indicators to track the dynamics of digital changes from a comparative perspective. Without such an index, the implementation of joint digital initiatives is less effective, the formation of a single digital space is more complicated, and the processes of technological convergence within the union are hindered. Therefore, developing a digital integration index for the EEU is a necessary step to strengthen digital policy coordination, increase transparency, and improve the manageability of integration interactions in the digital sphere.

### 1.1.3. What is the digital space?

In the context of the shift to a digital economy and the rapid digitalization of various sectors driven by the COVID-19 pandemic, many studies have emerged on digitalization issues. However, the topics of digitalizing integration processes and creating digital spaces for integration associations, as well as defining "digital space" from a regional studies perspective, remain underexplored in academia. Currently, a key theoretical challenge is to verify the concept of "digital space". Given the growing importance of spatial and digital factors in the global economy and politics, it is essential to define digital space and assess its influence on these areas. From a theoretical standpoint, Isard (1966) is considered one of the modern pioneers of the spatial approach in regional science. He highlighted the spatial aspect of human activity, describing space not only as territorial relations between people and their

activity areas but also as relationships with the natural and human-altered environment.

In the context of the spread of information and communication technologies within the framework of the Theory of Large Multidimensional Spaces, the concept of an "information space" is distinguished as a space that acquires special significance in the modern era of the information revolution, due to the global mobility of information, capital, qualified personnel, and technological progress. Digital infrastructure has become a strategic resource in highly developed countries (Dergachev, 2011). The author of this theory also identifies "cyberspace" as the virtual realm of the World Wide Web where intellectual products can be transported without customs, tax, or other restrictions (Dergachev, 2011).

As the Internet and new technologies have grown in importance, the Spanish researcher of the information society, communication, and globalization, Manuel Castells, has presented the Theory of Flow Space. This theory identifies a new spatial process based on the flow of information. Telecommunication systems disperse these flows and integrate regions into international networks that link their most dynamic sectors. These flows erase geographical, historical, economic, and cultural boundaries, creating new functional networks (Castells, 2000). Based on a study of the theoretical features of space formation as the primary category of regional studies, the authors have systematized the main types of spaces, considering the space-forming phenomenon from the perspective of integration processes (see Table 1).

| Space | Space-forming phenomenon |
|---|---|
| Cultural | A space based on material and spiritual culture (Ehrhardt, 2015) |
| Economic | A space based on the free movement of goods, capital, labor and information (Achkasova, 2019) |
| Social | The implementation of social functions by human groups, the measurement of human behavior in space (Buttimer, 1969) |
| Political | The degree of convergence of states when it comes to their interests in regional projects, focusing on the coherence of various institutional mechanisms, countries have common political goals (Cossio Rodriguez & Haag, 2022) |
| Informational | The totality of information flows and institutions that produce and regulate these flows within the boundaries of a region (Achkasova, 2019) |
| Digital | Digital space is the result of the convergence of information spaces of states (Yachmeneva & Yachmenev, 2020) |

**Table 1.** Characteristics of spaces formed in the process of regional integration. **Source:** Compiled by the authors.

Digital integration encompasses the establishment and development of digital platforms and ecosystems, the creation of a conducive environment for digital innovations to flourish and disseminate, and the support of digital start-ups and other initiatives. According to Kutsenko (2019), the following methods are employed in the execution of digital integration:

- Firstly, the term "vertically" refers to the movement or development within the industry and among its enterprises.
- Secondly, integration of processes must be considered horizontally. This involves establishing cross-industry, interstate, and transnational processes.
- Thirdly, within the framework of digitalization, products, services, business models, and customer access to the ecosystem are being impacted.

### 1.1.4. Digitalization of higher education as part of the digital economy

The digitalization of higher education is a key driver of overall digital transformation in the EU. Universities, research centers, and other educational institutions play a crucial role in developing digital skills, creating innovative solutions, and training personnel for the digital economy. Pan-European strategies such as the Digital Compass 2030 and the European Education Area focus on integrating digital technologies into educational processes, creating online platforms, and expanding access to open digital resources. The growth of online programs and hybrid learning formats, as well

as the increasing use of artificial intelligence in academia, contributes to the widespread adoption of digital practices among the general population. Thus, higher education institutions are becoming generators of digital innovations, including cybersecurity, big data, and research on digital platforms.

The collaboration between universities and EU digital policy enhances the region's technological independence, reduces digital disparities among member states, and promotes the development of a unified digital space. In this context, the digitalization of higher education is a vital part of the EU's sustainable digital development. "Human capital" (including "internet user skills" and "advanced skills and development") is one of the main indicators of the EU Digital Economy and Society Index. In 2022, the human capital indicator was 45.75, compared to 42.25 in 2017. Meanwhile, the "Advanced Skills and Development" marker increased significantly, rising from 18.19 to 20.40 (European Commission, 2022).

While in ASEAN, the digitalization of higher education has a significant impact on the formation and development of the region's digital environment. The implementation of regional initiatives, such as the ASEAN Digital Masterplan 2025 and the ASEAN Higher Education Space, has prioritized the development of online learning, digital platforms, and cross-border educational programs. This not only enhances the accessibility of higher education but also accelerates the adoption of digital practices among young people and teachers, thereby increasing digital literacy. As a result, the digitalization of education is becoming a key part of ASEAN's strategic plan to create an integrated, sustainable, and innovative digital space. Therefore, the higher education system plays a crucial role in shaping the region's digital future.

One of the key components of the ASEAN Digital Integration Index is "Digital Skills and Talent." In 2021, the score was 48.21 out of 100, which is below the median level. Therefore, it is recommended that ASEAN enhance its efforts to promote the development of digital skills and capabilities, as well as formal employment opportunities that utilize digitalization. It is essential to prioritize and allocate educational resources toward STEM courses to ensure equal learning opportunities and to expand digital skills programs beyond urban centers, better enabling the upskilling of resources in rural areas. Collaborating with the private sector to develop necessary labor policies that address the digital skills gap and identify the skill sets needed for domestic market demands is also important (ASEAN & USAID, 2021).

As the authors previously noted, the EEU lacks a single mechanism for assessing the state of digitalization. However, according to the EEU's official statistical data, the correlation between the digital economy and the education system is assessed at the state level, not the EEU level (Eurasian Economic Commission, 2023). In other words, initiatives for the digitalization of education and the development of human potential for the digital economy are implemented separately by EAEU member states. This approach makes it challenging to determine the average level of exposure to digitalization processes among the EEU population.

In 2021, the Eurasian Economic Commission's headquarters in Moscow hosted a discussion about the prospects of creating a unified information environment for the scientific community of EAEU member states. The project aims to synchronize the development of digital technologies in science and education among EAEU member states, thereby increasing the overall scientific potential of the Eurasian integration association. To do this, the first stage of practical implementation involves creating a unified scientific and educational network infrastructure that provides access to the information systems and knowledge bases of universities and scientific institutions, as well as digital science and education services. This includes projects for developing artificial intelligence technologies for EEU members (CNews, 2021). However, a unified, fully functional information environment for EEU scientists has yet to be established.

## 2. MATERIALS AND METHODS

This study employed a bibliometric approach to analyze scientific output related to digitization in higher education within the EEU. To this end, data were extracted and processed from the Scopus database, including all publications available up to 2024. The search strategy was

constructed in two stages. First, the Boolean operator OR was used to incorporate the term "digitalization" and some conceptual variants (e.g., "digital technology," "automation," "digital device," and "digital divide") to capture studies focused on different aspects of digitization. This part of the search was applied exclusively to the title field to ensure a high degree of thematic relevance. Second, the AND operator was used to restrict the results to the field of higher education. The terms "university" and "higher education" were searched in the title, abstract, and keyword fields to allow for the inclusion of publications that addressed digitalization and made explicit reference to the university or higher education sector.

Once the initial results were obtained, the analysis corpus was filtered. First, the records were limited to those that included at least one institutional affiliation from one of the countries in the Eurasian Economic Area: Armenia, Belarus, Kazakhstan, Kyrgyzstan, and Russia. This geographical delimitation allowed the analysis to focus on intraregional scientific dynamics. Next, a filter was applied by document type to select only publications classified as scientific articles, reviews, book chapters, conference articles, or conference reviews. This ensured the inclusion of documents that had undergone substantive editorial or academic review.

The bibliometric analysis focused on two main variables: the institutional affiliation of all authors and all keywords recorded in the documents. Both variables underwent a normalization process involving the creation and application of a customized thesaurus. This process unified terminological, orthographic, and typographical variants, resolving ambiguities and inconsistencies in the database. Based on the normalized variables, two key indicators were developed. The first indicator examined intraregional scientific collaboration by analyzing co-authorship between institutions in the same region. To ensure the maps' representativeness and clarity, only institutions that published two or more documents within the analyzed corpus were included. The final institutional collaboration map included 55 institutions and clearly visualized the most relevant collaborative dynamics among institutional actors in the region.

The second indicator was the co-occurrence of key terms. The analysis of these terms revealed the main topics studied in the field. Only terms that co-occurred at least twice in the records were included, resulting in a map with 351 terms. The association strength index was used to measure the intensity of relationships between terms. This normalization method is commonly used in co-occurrence analysis because it adjusts the strength of connections based on how often the terms appear. We used VOSviewer software to visualize the collaboration and thematic co-occurrence networks. This software is widely used in bibliometric studies due to its ability to visually represent complex relationships between entities. Finally, we subjected the resulting maps to qualitative interpretation based on the analysis of the formed clusters, the relationships between nodes (whether institutions or key terms), and the identified connection density.

## 3. RESULTS

### 3.1. Thematic analysis using co-word maps

Using the parameters defined in the article's methodology, we identified eight thematic clusters (see Figure 1 and Table 2), described below.

#### 3.1.1. Cluster 1: Digital skills and technological literacy in higher education

The first cluster contains 67 terms and stands out for its density and thematic cohesion. The cluster focuses on digital skills, technological literacy, and the integration of emerging technologies in higher education. The most representative node is "digitalization (71)," which confirms its role as the central theme of the research grouped in this cluster. It is closely connected to "ICT (20)," "digital literacy (15)," "digital competences (13)," and "digital environment (5)." Together, these terms form a semantic core that focuses on understanding, acquiring, and implementing technological skills in university educational contexts. The term "ICT (20)" is a key node that connects to concepts such as "online learning (10)," "blended learning (10)," "online courses (7)," and "e-learning environment." This reflects a direct association between digital skills and technology-mediated educational

modalities. These relationships suggest that digital literacy is understood as more than just tool mastery; it is also a prerequisite for active participation in hybrid and virtual educational models.

Similarly, terms related to pedagogical and technological innovation, such as "innovation (8)," "augmented reality (6)," and "artificial intelligence (8)," indicate a growing interest in the use of cutting-edge technologies in teaching and learning processes. The links with "Industry 4.0" and "manufacturing" point to an approach that transcends the university classroom and extends to the productive and industrial environments. This reinforces the idea that digital skills prepare individuals for careers in technologically advanced sectors. Conversely, terms such as "professional training (8)," "sustainable development (8)," and "science (7)" broaden the cluster's thematic scope to include cross-cutting dimensions, linking digital literacy to continuing education, sustainable development, and scientific production. The presence of "competition (5)," "model (5)," and "industrial economics (6)" suggests that some research addresses the economic, strategic, or institutional implications of digitization in educational contexts.

### 3.1.2 Cluster 2: Structural transformations and challenges of the higher education system

The second cluster may reflect concerns about structural, organizational, and pedagogical changes in higher education in the context of digitization. The most representative term in the group is "higher education (55)," which, together with "educational process (42)" and "education (38)," serves as the unifying theme of the group. Together, these three terms suggest a systemic view of higher education as a complex social process transforming, not just an institutional sphere.

A central aspect of this cluster is the attention paid to distance learning modalities, as suggested by terms such as "distance education" (13), "online education" (7), and "internet" (6). These concepts are interrelated with others, such as "quality of education" and "efficiency," suggesting that the research in this cluster describes the transition to virtual modalities and reflects on its implications in terms of quality, institutional performance, and access. The prominent presence of the term "Russia (20)" indicates a strong concentration of studies with a national or institutional focus on that country, which likely serves as a reference or main case study within the corpus. This focus may also be linked to the presence of terms such as "higher education system (5)," which refer to institutional or educational policy approaches.

Conceptually, this cluster is a space for reflecting on the reconfiguration of higher education amid accelerated digitalization, particularly in contexts like the pandemic, as indicated by the term "pandemic (6)." Incorporating "economics (10)," "economic and social effects (5)," and "training (10)" introduces an economic and labor dimension. This suggests that the transformations are perceived as phenomena with broad social implications, encompassing employability, the sustainability of university systems, and equity, rather than merely as pedagogical or technological changes. Terms such as "vocational education (5)," "educational platforms (4)," and "digital skills (4)" reinforce this practical and institutional perspective, viewing higher education as a space for professional training and technological infrastructure deployment.

### 3.1.3. Cluster 3: Digitization of training processes and professional development in virtual environments

The third cluster focuses on the digitization of teaching and learning processes, emphasizing the educational, technological, and professional aspects related to higher education. The most prominent node in the group is "e-learning (107)," followed closely by "digital technologies (93)." This indicates a clear focus on research regarding the use and implementation of digital learning platforms, resources, and strategies. These concepts are directly linked to "digitalization of education (36)," which serves as an overarching category for the entire cluster.

The cluster also incorporates dimensions related to professional and pedagogical development, as reflected in terms such as "personnel training (43)," "professional competence (10)," "teacher (10)," "curricula (12)," and "professional aspects (13)." These connections suggest that digitization is addressed not only from a

technical perspective but also in terms of its impact on teacher training and curriculum redesign. Together, these concepts point to a comprehensive reconfiguration of the educational process in which digital technologies transform the means and ends of higher education.

Terms such as "distance learning" (26), "learning systems" (17), "education systems" (10), and "learning processes" (8) reinforce this systemic perspective. These terms indicate that the studies analyze digital learning ecosystems and their institutional implementation conditions, not just isolated tools. The presence of "computer-aided instruction" (10), "education computing" (10), and "information technology" (18) suggests an approach oriented toward designing technology-assisted learning environments with a possible software development or educational platform component. The cluster also reveals sensitivity to the recent pandemic-forced transformation, as reflected in the term "Covid-19 (10)," which is conceptually associated with the emergence of new virtual teaching forms and accelerated technology adoption processes. Finally, terms such as "university students (15)," "educational activity (13)," and "professional activity (8)" suggest that although the emphasis is on institutional and teaching processes, students are also subjects of study regarding their adaptation, participation, and skill development in digital environments.

#### 3.1.4. Cluster 4: Digital educational environments in technical universities and student training

The fourth cluster focuses on the transformation of university educational environments, particularly the role of students and the use of technology in institutional contexts. The most frequent term is "student" (62), which positions students at the center of the group's analysis. This student focus is linked to other key terms, such as "engineering education" (41), "higher education institutions" (10), and "technical university" (6). Together, these terms allow this cluster to be interpreted as oriented toward studies developed or applied in technical or engineering institutions.

One of the conceptual nuclei of this cluster is the term "digital transformation" (34), which is connected to "digital educational environment" (17), "educational environment" (16), and "digital education technologies" (6). This network of terms reflects concern about how digital transformation redefines educational content and tools as well as the architecture of the learning experience, including the spaces, platforms, services, and resources that support it. Notably, the terms "digital devices (8)," "digital services (5)," and "electronic information (5)" point to the technological infrastructure that supports these digital environments. Additionally, terms such as "Moodle (6)" and "electronic information educational environment (3)" refer specifically to educational platforms used for learning management, which reinforces the technical dimension of the cluster.

Another relevant aspect is the connection to "Foreign Language Teaching (7)" and "Foreign Language (5)," suggesting that the digital environment is being examined as a space for foreign language learning, likely in contexts of curriculum internationalization or cross-curricular training. The presence of "qualified personnel (5)" and "information services (5)" indicates research examining the human and organizational resources needed to implement these digital ecosystems effectively. Finally, the inclusion of "globalization (5)" broadens the scope to include global trends in higher education, particularly in technical disciplines requiring constant updates and international collaboration.

#### 3.1.5. Cluster 5: Information management, automation, and digital services in educational institutions

The fifth cluster contains a total of 39 terms and is characterized by its focus on the technical, administrative, and organizational aspects of digitization within the higher education system. The most representative node is "Automation (13)," which is strongly linked to "Information Management (11)," "Information Systems (9)," and "Information Use (6)." This network of terms reflects research focused on automating the management of data and processes within educational institutions as part of a digital transformation aimed at improving operational efficiency and enabling informed decision-making.

A second conceptual core forms around "educational organizations (8)," "educational services (6)," and "state technical university (5)," suggesting that research in this cluster focuses on how universities, particularly technical ones, implement digital solutions for academic and administrative management. This idea is reinforced by the presence of "class schedule (3)" and "scheduling (3)," which refer to specific applications of automation in planning teaching activities.

This cluster also includes an applied technological dimension, as evidenced by terms such as "computer-aided design (4)," "software (3)," and "education technology (3)," indicating the integration of advanced IT tools into institutional processes. Added to this are concepts such as "smart education" and "modern education," which refer to educational models based on intelligent technologies with the potential to optimize personalized learning, automated assessment, and resource management. The relationship with specific geographical contexts, such as "Kazakhstan (4)," suggests that some of the analyzed studies have a particular contextual or institutional focus in which local technology adoption models can be observed. Furthermore, terms such as "strategy (4)," "public administration (5)," and "rating (3)" introduce dimensions of institutional planning, educational governance, and evaluation or classification systems. This broadens the focus from technology to politics and strategy.

### 3.1.6. Cluster 6: Digital economy, employability, and vocational training standards

The sixth cluster focuses on analyzing higher education as a driver of the digital economy. It highlights the link between university education, the labor market, and the new skills required in digitized economic environments. The dominant term is "digital economy (56)," which structures the cluster's semantic field, demonstrating a cross-cutting approach that connects education with macroeconomic and productive transformations in the Eurasian region. One internal nucleus of this cluster consists of terms such as "educational program (15)," "curriculum (4)," "educational standards (3)," and "professional standards (3)." These terms refer to curricular and regulatory frameworks that align higher education with the demands of the digital economy. These terms are complemented by "competence (13)," "professional development (3)," and "lifelong learning (3)," which reinforce the idea that the training process should foster adaptive, permanent, and employment-oriented skills.

This approach is linked to the economic and labor dimensions of the cluster, as expressed through the terms "employment (8)," "labor markets (5)," "commerce (8)," "economic analysis (5)," and "personnel (4)." These connections reflect a body of research analyzing the role of higher education in economic revitalization, particularly in strategic sectors of the digital economy, as well as in academic contexts. The presence of "engineers (4)" and "computer science (4)" suggests an interest in training areas with high professional demand in this new economic environment.

Additionally, the incorporation of concepts such as "communication technologies (4)," "knowledge management (4)," and "control systems (3)" points to the development of the applied technical skills necessary for training and professional practice in technology-intensive industries. Finally, the inclusion of "research universities (3)" and "educational systems (3)" extends the focus to institutional environments that promote innovation and talent development in these areas.

### 3.1.7. Cluster 7: Transformation of university teaching and institutional evolution in digital environments

The seventh cluster comprises 31 terms and focuses on research related to changes in university teaching from both pedagogical and institutional perspectives in digital contexts. The most frequent term, "university" (25), serves as the conceptual core of the set, followed by "teaching" (16) and "digital education" (11). These three concepts define a space for analyzing how teaching is carried out, what is taught, and the institutional conditions under which it occurs within the framework of digital transformation. This approach is reinforced by terms such as "teaching methods," "teaching experience," and "teaching and

learning," which highlight the importance of teaching processes, pedagogical innovation, and the continuous improvement of teaching practices. The term "information and educational environment (7)" indicates that these processes occur within specific institutional ecosystems that mediate access to resources, technologies, and teaching and learning models.

Along these lines, concepts such as "digital communication systems (3)," "digital resources (3)," "digital communication technology (2)," and "modern information technologies (2)" appear. These concepts highlight the technological tools that enable and shape educational dynamics. The presence of "smart universities (3)" reinforces the idea of institutions that incorporate technologies and redefine themselves based on them by adopting intelligent, adaptive, and interconnected management, infrastructure, and teaching models.

This cluster incorporates a strategic and organizational dimension, as indicated by terms such as "management (8)," "strategic development (2)," and "comprehensive analysis (2)." These terms suggest that universities are the subject of study not only in terms of teaching practices, but also in terms of governance, planning, and institutional response to digitization. The appearance of "high school (5)" may suggest a transition between educational levels and indicate that research could address the connection between secondary and university education in digital environments. Similarly, terms such as "social sciences computing (2)," "Russian Academy of Sciences (2)," and "modern Russia (2)" provide a broader contextual and institutional dimension, possibly pointing to case studies or specific developments in the Russian context.

### 3.1.8. Cluster 8: Educational innovation, immersive technologies, and emerging digital skills

The eighth and final cluster comprises only 33 terms, focusing on the intersection of technological innovation, emerging educational tools, and the development of new digital skills. This cluster particularly emphasizes immersive environments and advanced teaching resources. The most frequent term is "educational technology (16)," which marks the group's orientation toward using specific technologies for pedagogical purposes. This node is closely linked to "digital competence (10)," indicating that the analysis of technologies extends beyond their mere presence to include the ability to use them critically in educational contexts.

A distinctive aspect of this cluster is its focus on immersive technologies, as evident in the terms "virtual reality (8)," "digital tools (6)," "digital space (5)," and "learning environments (2)." These relationships suggest an interest in extended learning environments that incorporate immersion, simulation, and digital interaction, thereby transforming the educational experience. Finally, "educational resources (5)" and "information environment (2)" complete the conceptual map by referring to the material and informational infrastructure that enables this innovation. The presence of terms such as "key competencies (2)," "professional knowledge (2)," and "learning motivation (2)" suggests that these technologies are linked to complex training processes that motivate, train, and update students' professional knowledge through innovative methods. Concepts such as "innovative education" and "innovative approaches" reinforce the exploratory and experimental nature of many of the initiatives studied.

Notably, this cluster includes terms linked to specific disciplinary areas, such as "mining (3)," "geology (2)," and "laboratory (3)." This suggests that some studies apply advanced educational technologies in specific professional or technical contexts, particularly in fields related to the applied sciences or engineering, where the simulation and virtualization of environments add value. Additionally, "information security (2)" introduces concerns about data protection and digital environments, particularly in educational contexts where personal and academic information circulates extensively. Finally, the appearance of "Central Asia (2)" as a geographical term suggests that some of these studies are contextualized in specific regions within the Eurasian space. This may reflect institutional interests or national priorities regarding the use of innovative technologies in higher education.

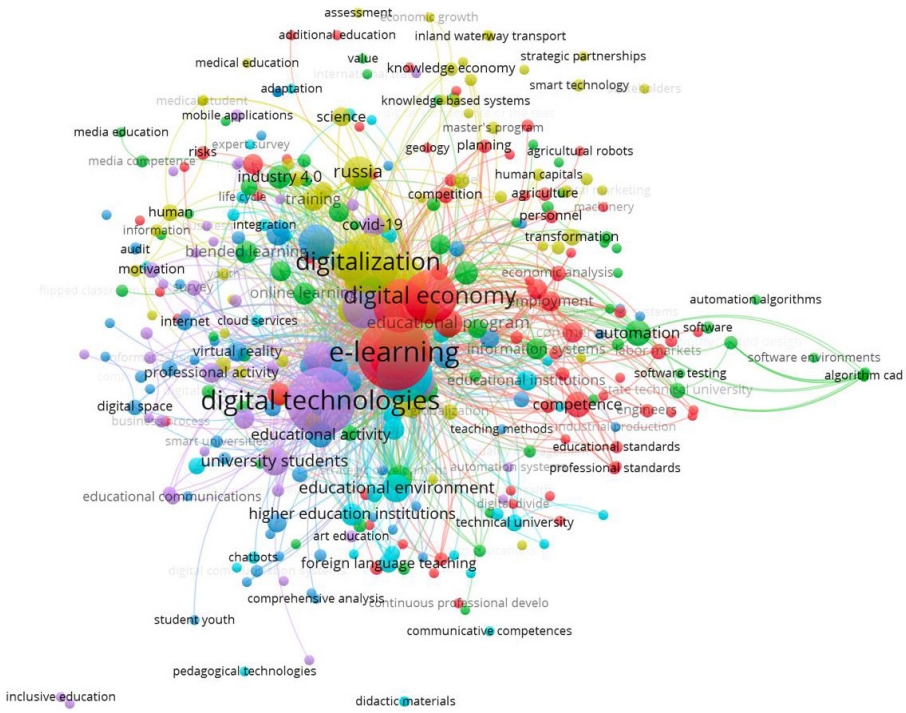


**Figure 1.** Co-word map of the digitalization research in Scopus produced by the Eurasian countries.

| Cluster | Number of terms | Cluster topic | Top co-occurring terms |
|---|---|---|---|
| 1 | 67 | Digital competencies and technological literacy in higher education | digitalization, ict, digital literacy, digital competences, industry 4.0 |
| 2 | 60 | Structural transformations and challenges in higher education systems | higher education, educational process, education, russia, distance education |
| 3 | 56 | Digitization of learning processes and professional development in virtual environments | e-learning, digital technologies, personnel training, digitalization of education, distance learning |
| 4 | 40 | Digital educational environments in technical universities and student training | student, engineering education, digital transformation, digital educational environment, educational environment |
| 5 | 39 | Information management, automation and digital services in educational institutions | automation, information management, information systems, educational organizations, information use |
| 6 | 38 | Digital economy, employability and professional training standards | digital economy, educational program, competence, commerce, employment |
| 7 | 26 | Transformation of university teaching and institutional evolution in digital contexts | university, teaching, digital education, management, information and educational environment |
| 8 | 25 | Educational innovation, immersive technologies and emerging digital skills | educational technology, digital competence, virtual reality, digital tools, digital space |

**Table 2.** Summary of the clustering results.

### 3.2. Institutional collaboration

The institutional collaboration map comprised 128 institutions, 106 of which had at least one co-authorship link with other entities within the same set (See Figure 2 and Table). Although it is a relatively high-degree network in structural terms, it is also marked by notable asymmetries in the geographical distribution and intensity of collaborative relationships.

Geopolitically, the map shows almost absolute dominance of institutions from the Russian Federation, representing 110 of the 128 institutions. This equates to 86% of the nodes in the network and reaffirms that scientific production and collaboration in higher education digitization in the Eurasian region are highly concentrated in Russia. Kazakhstan follows with 10 institutions, Kyrgyzstan with two, and Belarus with one. Armenia is not represented on the map, indicating a lack of scientific collaboration in this area from that country. Three institutions from Uzbekistan, one from Ukraine, and one from the Czech Republic were also identified despite not belonging to the Eurasian Economic Area, introducing a slightly more heterogeneous composition in terms of scientific collaboration.

Regarding intraregional collaboration, the results show that there are no co-authorship links between institutions in different Eurasian countries. Almost without exception, connections are developed between Russian universities. Entities in Kazakhstan and Kyrgyzstan, although present, remain disconnected or collaborate only with institutions in their own country. Consequently, the map reveals an absence of an integrated regional scientific network, contradicting the frequent aspirations for transnational academic cooperation within the Eurasian Economic Area framework. Several Russian universities stand out in terms of productivity and collaboration, with notable output and a central position in the network. These include Kazan Federal University (15 documents, connection strength 14), Moscow City University (10 documents, strength 9), and Moscow State Pedagogical University (9 documents, strength 7). These institutions lead in both the number of publications and collaborative links and represent strategic nodes within the network, acting as bridges between multiple academic entities.

In Kazakhstan, the most productive institution is Abai Kazakh National Pedagogical University, which has six documents and a connection strength of two. Next is Al-Farabi Kazakh National University, which has three documents but no collaborative links within the network. In Kyrgyzstan, the two institutions, I. Arabaev Kyrgyz State University and Kyrgyz National University have low productivity levels (two documents each) and no collaborative links with the rest of the network, which reinforces their peripheral status. As for Belarus, only one institution, Belarusian State University, has a marginal presence with one document and no visible connections.

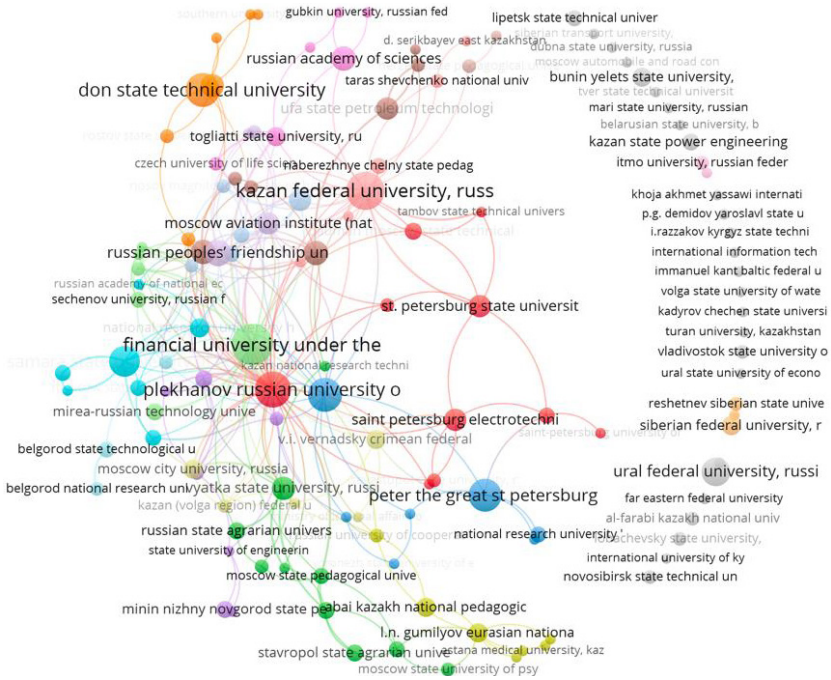


**Figure 2.** Institutional collaboration map.

| Country | Institutions | Connected institutions | # of documents | Total conexiones | Total link strenght |
|---|---|---|---|---|---|
| Russian Federation | 110 | 93 | 524 | 485 | 581 |
| Kazakhstan | 10 | 6 | 29 | 15 | 16 |
| Uzbekistan | 3 | 3 | 7 | 6 | 9 |
| Kyrgyzstan | 2 | 0 | 4 | 0 | 0 |
| Belarus | 1 | 0 | 2 | 0 | 0 |

**Table 3.** Statistical data derived from the institutional collaboration map.

## 4. DISCUSSION AND CONCLUDING REMARKS

The results of this study show a growing research area with broad thematic variety and uneven collaboration. The analysis of term co-occurrence identified eight groups, covering topics from digital skills and e-learning to technological innovation, institutional automation, and emerging areas such as the digital economy, virtual reality, and vocational training strategies. This thematic diversity reflects an expanding scientific focus on the pedagogical, technological, and organizational challenges faced by modern higher education. However, this conceptual energy contrasts sharply with the findings on institutional collaboration. The network is heavily centered in Russia, with institutions making up over 85% of the nodes on the map. In contrast, countries like Kazakhstan, Kyrgyzstan, and Belarus have minimal representation, and Armenia is not present at all. Additionally, there were no recorded collaborations between institutions from different countries within the Eurasian region, nor any connections with universities outside the region. This highlights the lack of a regional scientific community dedicated to the digitization of higher education.

This institutional disconnect is particularly paradoxical when analyzed in relation to the Eurasian Economic Union's (EAEU) political framework for regional digitization. Since the 2016 signing of the Declaration on the EAEU Digital Agenda, and especially since its 2017 formalization by the Supreme Council, the EAEU has promoted a strategic vision aiming to consolidate a common digital infrastructure, strengthen system interoperability, and synchronize digital transformation processes in economic, social, and educational sectors (Eurasian Economic Commission, 2017).

Key pillars of this digital agenda include the digital transformation of economic sectors, harmonization of public management processes, integration of digital labor markets, and development of common digital skills (Decision, 2016; Eurasian Economic Union, 2021). Additionally, the EAEU has implemented supranational projects, including the "Work Without Borders" information system, digital transport corridors, and industrial cooperation and technology transfer platforms. The success of these projects largely depends on the existence of a critical mass of regional scientific knowledge and collaborative academic networks. However, the data from this study indicate that the regional academic system has not yet adopted the digital integration initiatives promoted by political leaders. Each country has developed national digitization strategies, such as Armenia's Digital Strategy (2021), Belarus's State Program (2021-2025), Kyrgyzstan's Digital Conceptualization (2024-2028), Kazakhstan's National Development Plan (2024), and Russia's "Digital Economy" program (2019). Nevertheless, there is no systematic coordination between their scientific communities. There is no systematic coordination between their scientific communities.

This reflects multi-scale fragmentation: epistemological (due to thematic dispersion without conceptual integration), institutional (due to a lack of co-authorship between universities), and regional (due to a concentration in a single country). Consequently, the field of digitalization in higher education is currently characterized by a structural imbalance between thematic dynamism and relational weakness. This gap between the political agenda for digital integration and the reality of collaborative scientific production

limits the Eurasian region's ability to develop sustainable, innovative educational solutions adapted to the regional context. While Russia has powerful institutional nodes, the absence of transnational collaboration reduces the potential for knowledge transfer, epistemic diversity, and coordinated responses to common challenges.

As United Nations experts have pointed out, digitization has the potential to transform all economic and social sectors by generating value, efficiency, and new opportunities (United Nations, 2019). For this transformation to occur in education, it is essential to establish a true Eurasian digital scientific space. In this space, knowledge production is supported by active, stable institutional networks that are oriented toward common goals. A critical reading of these results reveals that the digitization of higher education in the region is a fragmented subject of study and is produced under fragmented scientific conditions. This dual fragmentation, both thematic and institutional, poses a significant challenge to the development of academic integration policies, particularly in a field that inherently demands interdisciplinary collaboration, knowledge dissemination, and institutional synergy.

Looking ahead, it will be crucial to foster intraregional scientific collaboration initiatives, create platforms for academic exchange, and promote transnational funding for joint projects. Only through denser networks of academic and institutional relationships can we move toward a comprehensive, contextualized, and cooperative understanding of digitization in higher education in Eurasia.

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## Conflict of interest

The authors declare that there are no potential conflicts of interest.

## Contribution statement

Conceptualization, research, methodology: Gulmira Mussina, Aigerim Ospanova, Akbota Zholdasbekova.

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## Statement of data consent

The data generated during the development of this study have been included in the manuscript. ●

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