Smart Education Concept: A Bibliometric Analysis

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Abstract

   Currently, research in the field of smart education development is one of the dynamically growing scientific fields. At the same time, this field of research is new, opens up new opportunities and has certain limitations, which determines the importance of its further study. The presented article reveals the prerequisites for the development of smart education, as well as the opportunities that the use of intelligent digital technologies in the educational sphere brings. In the paper, based on bibliometric analysis using the built-in Web of Science and Scopus toolkit, core research areas in the conceptual framework of smart education were identified, the thematic areas of smart education research within the field of computer science were studied, types of publications in the conceptual framework of smart education were analyzed, as well as the country distribution of relevant publications. The paper identifies the main universities and publishing houses by contribution to publications on the issues under consideration. With the help of the VOSviewer software product, a network map of keywords on the development of smart education has been built. Based on this, general conclusions are formulated and key directions for the implementation of research in the field of smart education are proposed.

Keywords: smart education, the intellectualization of the educational process, higher educational institutions, intelligent technologies in education, bibliometric analysis
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1. Introduction

   Currently, the subject area of research on smart education and intelligent learning is dynamically developing and expanding [1,2,3]. This is manifested in the growing number of publications, the number of citations, the number of subject areas and institutes that include relevant research issues in their agenda. Special attention is paid to the intellectualization of the educational process in higher educational institutions [4,5]. This is due to the fact that the use of intelligent technologies in higher education institutions makes it possible to simultaneously respond to the big challenges facing the higher education system and use the potential of cutting-edge technologies of Industry 4.0 to improve the efficiency of their activities and development. According to the research results, smart education development can promote learning opportunities to master high-quality education and lifelong learning [6].

   At the same time, this field of research is quite new, it is considered from the positions of different fields of knowledge and is dynamically developing. "Despite decades of the adoption of new technologies in improving education systems, approaches are frequently criticized for lacking appropriate theoretical and technological basis" [2]. This complicates the understanding of what targets and mechanisms should be chosen to create smart learning in universities.

In this regard, research issues are relevant that allow: to determine the dynamics of publications on smart education and intellectual learning in modern universities; to identify the most significant / influential subject areas, publishing houses and institutes in the designated subject field; to trace the evolution of the topic in the scientific field and determine the prospects for its development in the context of interdisciplinary synthesis.

2. Data and methodology

In this paper, the research is carried out on the methodological platform of systemic and evolutionary approaches. Methods of bibliometric, scientometric analysis, and content analysis were used to solve the listed research issues in this paper. The formation of an empirical data for analysis was carried out using the Elsevier ecosystem (Scopus, SciVal and Sciencedirect) and the Web of Science online system with incorporated scientometric tools (Web of Science Core Collection was used to find and collect data). This allowed us to select a high-quality set of publications at the entrance for subsequent analysis. A search query for publications using the keywords "smart learning", "intelligence learning", smart education", "intelligence education" in the Web of science online database showed 84 686 results, 5629 documents were identified in the Scopus system for the similar request, in Sciencedirect - 340234 results. The publications cover the time period from 1987 to 2022. Further, the analysis was carried out using the scientometric tools of SciVal to determine topics, trends in their development and impact. VOSviewer was applied as a visualization tool [7] to generated visualization network maps, including visualization network maps of co-authorship, countries and keywords. Along with this, the built-in Web of Science toolkit was used to analyze the dynamics of publications on the topic of intellectual learning. The results were the determination of the most significant publications in the subject area and conduction the content analysis of these articles. Based on this, a content analysis was carried out further to clarify the current understanding of the concept of smart education and determine the prospects for its theoretical research and practical application.

3. Results of bibliometric analysis

For quantitative and qualitative analysis of publications on the formation of a smart education system, a search query was conducted in the Web of Science(WoS) Core Collection system. Keyword search "smart learning", "intelligence learning", "smart education", "intelligence education" in the Web of Science online database showed 84,686 results. The dynamics of publications by year is shown in Figure 1.
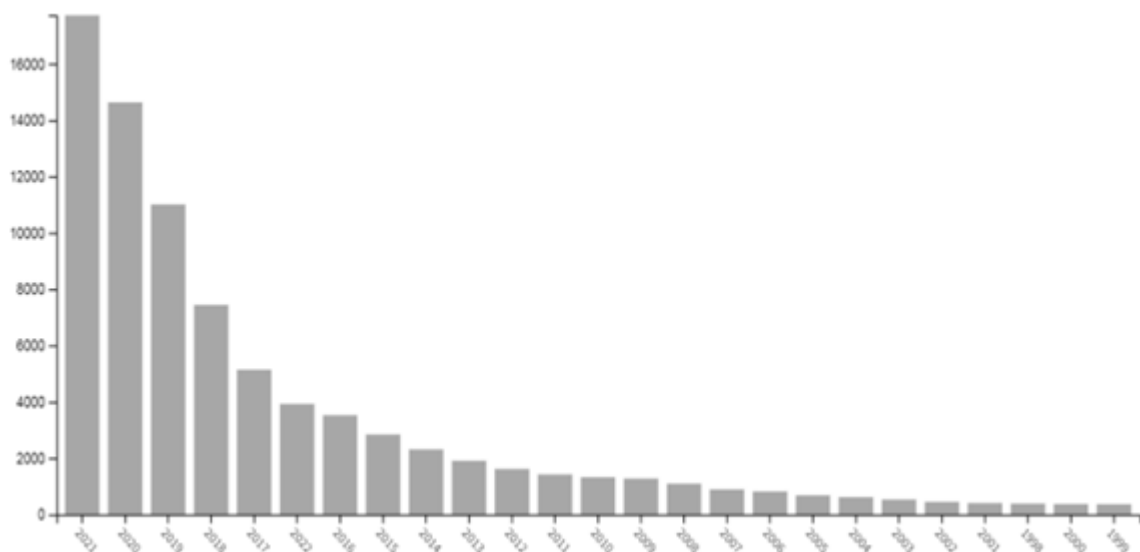

Figure 1. Dynamics of the number of publications on smart education by year in the WoS Core Collection

An analysis of the overall dynamics of publications shows that since 2012, we can talk about an exponential growth in their number, which continues at the present time. The reason for this growth is largely due to three interrelated factors. Firstly, the development of digital technologies and the birth of the Fourth Industrial Revolution, Industry 4.0 (and, accordingly, related cutting-edge technologies and new business models) have significantly expanded the opportunities for the use of digital technologies in the education system. Secondly, Industry 4.0 has led to a transformation of the entire society and the education system, in particular [8,9]. Thirdly, with the processes of new industrialization and the increasing contribution of scientific and technological progress to economic growth, with the digital transformation of society, there is a significant increase in the role of education in economic development. This, in turn, led to the search for new mechanisms to improve the effectiveness of its implementation. The start and explosive growth of the number of studies in the field of the Industry 4.0 coincides with the beginning of an explosive growth in the number of publications on smart education [10].

The coupling of the development of Industry 4.0 and smart education is also confirmed by the analysis of research areas for the above keywords (Fig. 2, Table 1).

In the research areas, Computer Science and Engineering occupy the first two places in terms of the number of publications (66.4 percent of the total number of publications in total). The technical aspect of the development of smart education is also strengthened by the fourth position, which is occupied by research in the field of Telecommunications. It is natural that in the third place in the subject field under consideration are studies in the area of Education (10.3 percent).

**Figure 2. Core research areas in the conceptual framework of smart education**

Further, it should be noted that smart education and training are being studied taking into account the specifics of its implementation in various disciplinary spheres. For example, Ardashkin et al [11] consider modern application trends of smart technologies in higher engineering education. Voskoglou and Salem [12]analyzed benefits and limitations of the artificial with respect to the traditional learning of mathematics.

A deeper dive into the field of publications in computer science shows the leading role of articles in the field of artificial intelligence and system solutions in terms of their application for the development of smart education (Fig. 3).

Table 1. Number of publications on Smart education in scientific research areas

N	Research Areas	Record Count	% of 85 831
1	Computer Science	32,374	37.718%
2	Engineering	24,504	28.549%
3	Education Educational Research	8,750	10.194%
4	Telecommunications	7,583	8.835%
5	Psychology	6,028	7.023%
6	Science Technology Other Topics	3,532	4.115%
7	Neurosciences Neurology	3,124	3.640%
8	Business Economics	3,006	3.502%
9	Automation Control Systems	2,793	3.254%
10	Chemistry	2,577	3.002%
11	Physics	2,209	2.574%
12	Materials Science	2,107	2.455%
13	Environmental Sciences Ecology	2,071	2.413%
14	Energy Fuels	2,048	2.386%
15	Instruments Instrumentation	1,831	2.133%

In general, it is important to note a very high level of interdisciplinary research. But at the same time, it is worth noting that the dominance of technical publications, insufficient attention paid to organizational, economic, educational, institutional aspects of the development of smart learning limits the possibilities of theoretical research and deploying of smart education(SE) in practice, even if there are significant technical results and theoretical developments obtained [4,13].
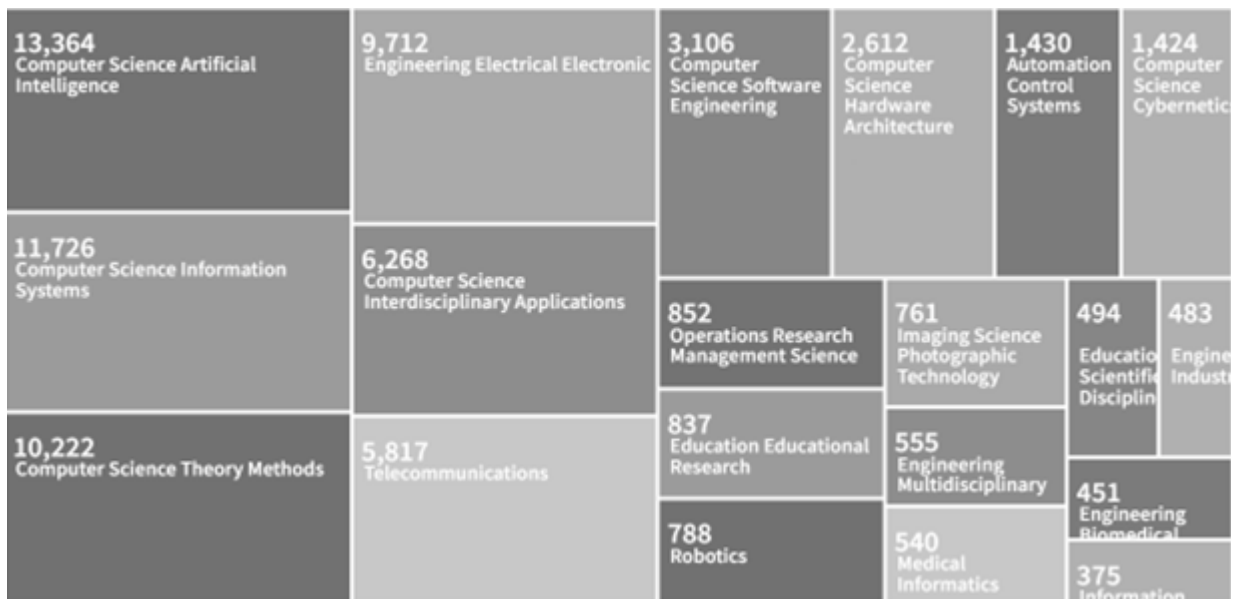

Figure 3. Detailing the thematic areas of SE research within the field of computer science

According to the type of publications, research in the field of smart education is mainly represented by Articles, Proceedings Papers or Review Articles (Fig.4).

Figure 4. Types of publications in the conceptual framework of SE

In turn, the analysis of the country dimension of publications shows the leading positions of the USA and China in the total volume of relevant scientific papers indexed in the Web of Science Core Collection in the time horizon under consideration (Fig. 5). It should be noted that this fully corresponds with the leading positions of these countries in the development and capitalization of digital economy technologies in terms of working with data [14].
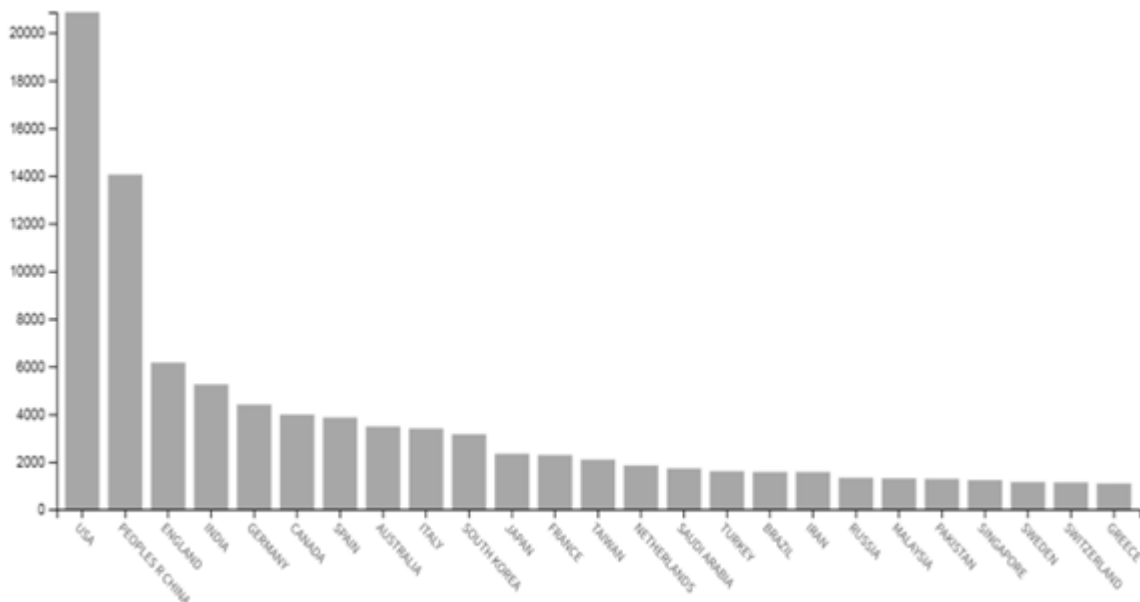
Figure 5. Country distribution of publications on SE

Whereas in the context of universities, it can be seen that the leading position in published research on smart education belongs to European universities, first of all, the League of European Research Universities (Fig. 6). However, in general, it should be noted that there is a more uniform distribution of publications by universities compared to the country distribution

(according to the data provided for 25 universities with the largest number of publications on smart education).
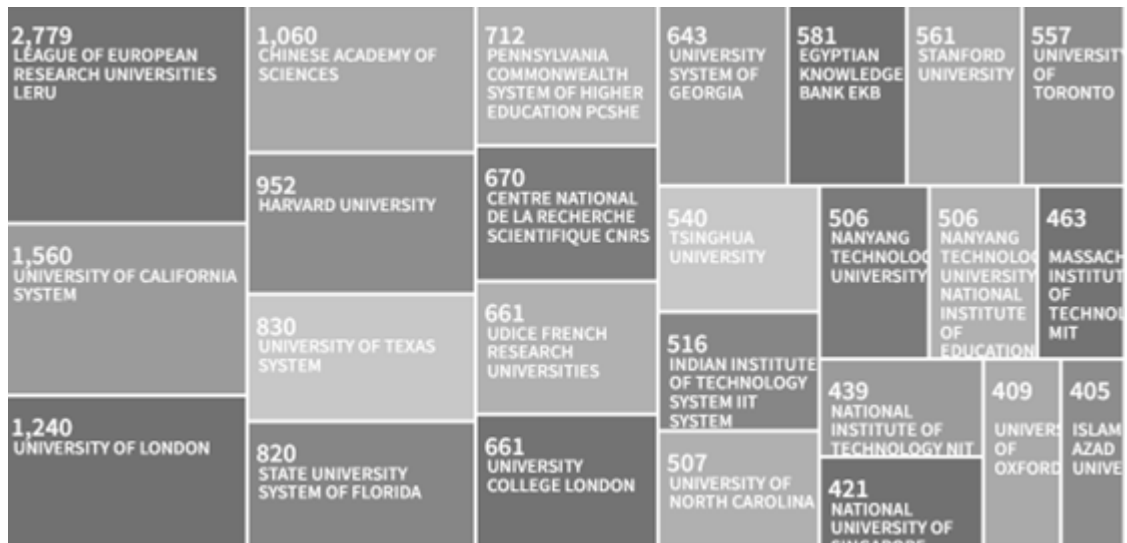
**Figure 6. Distribution of publications on SE among universities**

The most influential publishing houses, judging by the number of publications, include both publishing houses specializing in technical and engineering issues, and publishing houses of a wide thematic profile (Table 2). It should be sad that publications on smart education are concentrated in the leading scientific publishing houses of the world.

Table 2. Distribution of publications on smart education by publishers

| N	Publishers	Record Count	% of 85 831
1	IEEE	18,471	21.520%
2	Elsevier	12,075	14.068%
3	Springer Nature	11,378	13.256%
4	Mdpi	5,119	5.964%
5	Wiley	3,870	4.509%
6	Taylor & Francis	3,030	3.530%
7	Assoc Computing Machinery	1,955	2.278%
8	Sage	1,721	2.005%
9	Frontiers Media Sa	1,363	1.588%
10	Lippincott Williams & Wilkins	827	0.964%
11	Inst Engineering Technology-Iet	816	0.951%
12	Oxford Univ Press	797	0.929%
13	Emerald Group Publishing	767	0.894%
14	Ios Press	760	0.885%
15	Iated-Int Assoc Technology Education & Development	726	0.846%
16	Spie-Int Soc Optical Engineering	598	0.697%
17	Hindawi Publishing Group	552	0.643%
18	Iop Publishing Ltd	481	0.560%
19	Cambridge Univ Press	472	0.550%
20	Atlantis Press	461	0.537%

In turn, to analyze the influence of authors and for content analysis, it is necessary to take into account not only the number of publications, but also citations, as well as other scientometric indicators. To solve this research objective, the search was limited to the keywords smart education, which reduced the number of selected papers to 6,145 (the limit of the number of publications to 1000 for constructing a citation report was set by Web of Science).

With this in mind, the dynamics of the number of publications and citations are shown in Figure 7. The analysis of the dynamics of citations of publications on smart education confirms the growth of research attention to this area of research.
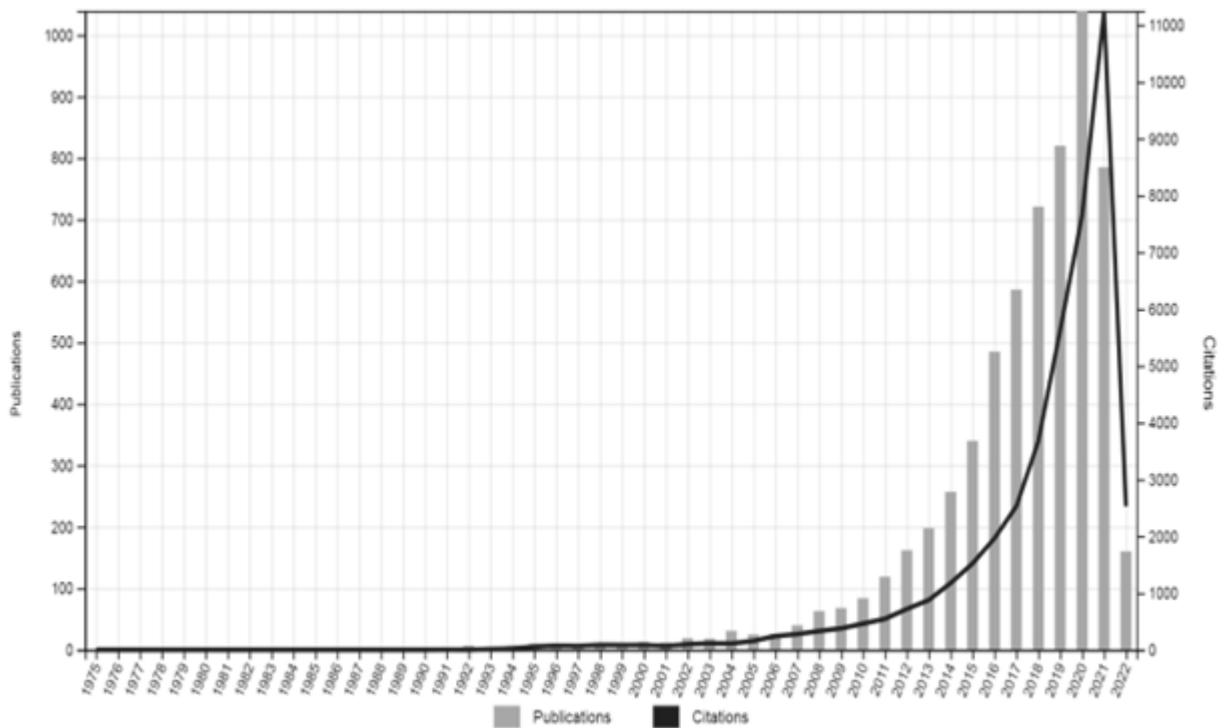
**Figure 7. Dynamics of publications and citations on smart education**

With the help of VOS viewer, network map of co-authorship by country was built based on Web of Science data (Fig. 8). For the analysis, the papers were sorted by the highest citation rates (the technical limit is 500 publications for aysis).
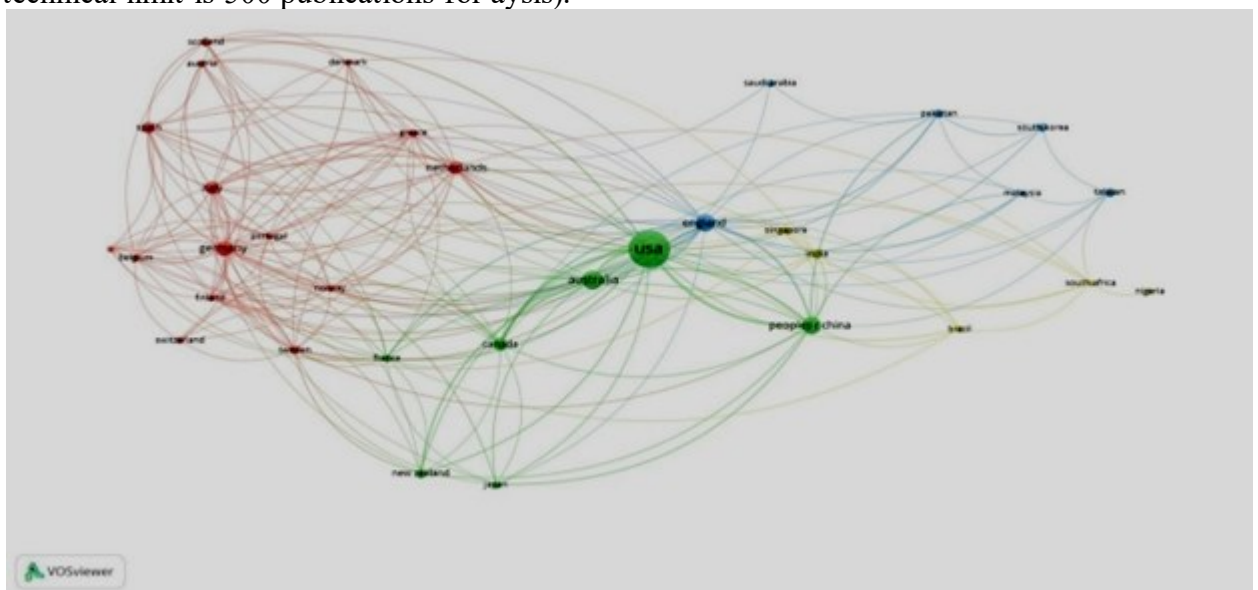
Figure 8. Co-authorship by country on WoS publications on smart education

To identify the most influential authors in the subject field under consideration, search queries were implemented in Sciencedirect and Scopus.

When constructing a search query in Sciencedirect using smart education keywords, 73,992 results were obtained for 1999-2023, 11,664 publications were obtained in Scopus. The leading authors are shown in Figure 9.
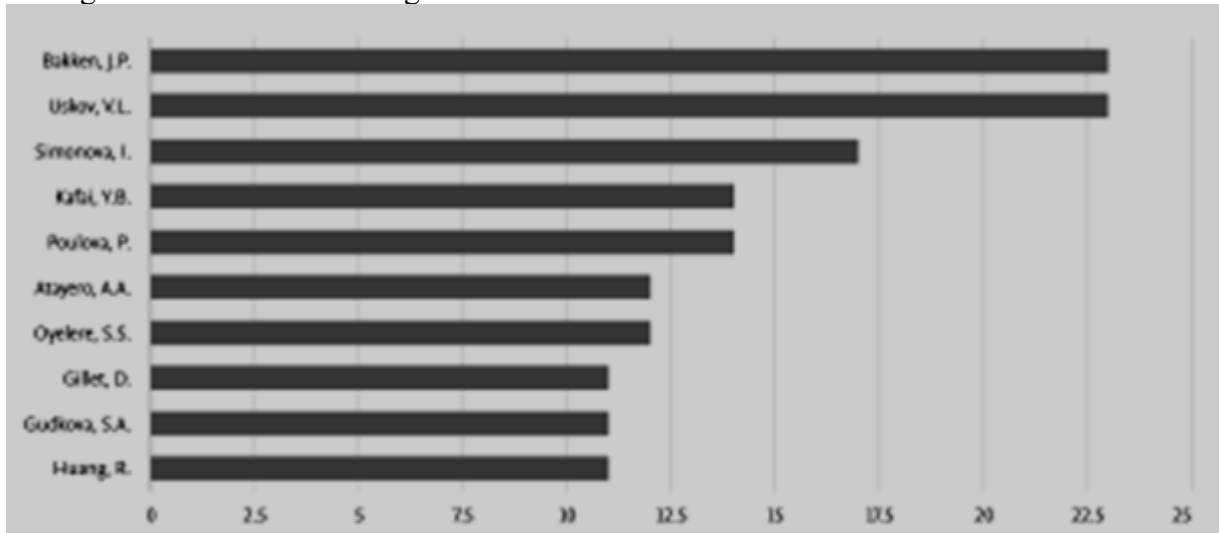
Figure 9. Top 10 authors by publications on smart education in Scopus

Further, a content analysis of publications was carried out, on the basis of which the publications most relevant on the topic of the development of the smart education system at universities were identified. According to them, the topic of Scival was determined and their subsequent analysis was carried out.

Publications on the topic of smart education are presented, for example, in SciVal Topics:
Design Science Research; Information Systems; Blockchain
Moodle; Learning Management System; Dashboards
University Rankings; China; Higher Education
Lectures; Video Indexing; E-Learning
Computer-Aided Instruction; Adaptive Hypermedia; Intelligent Tutoring Systems
Data Mining; School Dropout; Moodle
Computer-Aided Instruction; Tutor; Computer-Based Learning

All topics are characterized by high indicators of topic prominence (above 98-99), Field-Weighted citation index and positive dynamics in the number of publications and citations. At the same time, publications on a variety of topics, clusters of topics, and areas of knowledge are recorded. This significantly complicates the general analysis of the topics of smart education. In particular, the concept of smart education is considered by researchers from different theoretical, conceptual and methodological positions of different disciplines.

The concept of smart education in scientific research is considered as the most relevant and important stage of digitalization of the educational sphere. In contrast to the previous stages (distance learning, e-learning, m-learning), smart education involves the provision of student-centered learning through interaction with learning materials using intelligent information systems, as well as the inclusion of non-formal learning opportunities and professional communities [15,16]. Smart education involves a comprehensive modernization of all educational processes, as well as methods and technologies used into this process. Фактически речь идет о переходе от традиционного обучения к умному обучению [16].

Kadir Alpaslan Demir defines smart education as the "effective and coherent use of information and communication technologies to reach a learning outcome using a suitable pedagogical approach" [1].

Zhu and He think that "the essence of smarter education is to create intelligent environments by using smart technologies, so that smart pedagogies can be facilitated as to provide personalized learning services and empower learners to develop talents of wisdom that have better value orientation, higher thinking quality, and stronger conduct ability"[17].

Smart education entitles applications of latest or smart technologies in collaboration with advanced pedagogical practices, tools and techniques [18].

Bajaj, R. and Sharma, V. think that "smart education is about providing personalized learning, anywhere and anytime." [16]

Iqbal, H.M.N. et al. write that "smart education is a unique learning concept that entitles and facilitates the overall learning process and credentials in the digital age" [19].

According to Xing-Rong Guo , Xiang Li and Yi-Ming Guo, "smart education should not only be smart "implements", but also smart "education" and "learning". Education itself is far more important than technical tools" [20].

From the technological point of view, smart education can be considered as technology-enhanced learning. Technologies can play role of media or tools for accessing learning content, communication and collaboration, construction, expression and evaluation [21]. Technologically, artificial intelligence and other intelligent solutions play a key role in the development of smart education [16,22,23,24,25]. From the organization point of view, smart learning is considering as Self-directed, Motivated, Adaptive, Resource-enriched, and Technology-embedded [26].

Accordingly, considering smart education from technological, educational, psychological, managerial, and institutional positions, various authors identify various structural components and determinants of smart education in their publications. In addition, the specifics of smart education for different levels are highlighted. In this research, we focus on the development of smart education in higher education, which is an important direction in research in this area [27]. This was a key reflection when conducting content analysis and selecting papers for detailed analysis.

According to IBM smart education is "the multidisciplinary student-centric education system; linked across institution of learning and workforce training using adaptive learning application, collaborative technologies, online learning resources and better information to the learners for learning anywhere at any time" [28].

O. A. Shvetsova proposed framework of smart education system which consist of four components: smart campus (Wi-Fi, cloud, mobile, Internet of things & security); smart classroom (smart classroom & eLearning); Smart assessment (personalised learning objects, collaborative learning object & learning management) and Smart bags (laptops and other personal learning devices) [29].

Yusufu Gambo and Nachandiya Nathan defines smart education as "a studentcentric intelligent learning environment enriched with digital learning resources to provide smart pedagogies that support smart learners' personalised learning experiences anywhere at any time using smart portable device and linked across educational institution or training workforce through the advancement and superiority of smart and wireless technologies" [30]. Four component-based model of smart education was proposed be researches. These components include smart pedagogy, smart learning environment, smart technologies and smart learners with each contributing to the development of smart education system initiatives.

Zhi-Ting Zhu , Ming-Hua Yu and Peter Riezebos, defined a research framework of smart education with three essential elements in smart education (smart environments, smart pedagogy, and smart learner), four-tier architecture of smart pedagogies and ten key features of smart learning environments for foster smart learners [21].

Based on the results of the analysis using VOSviewer, a keyword cloud was built based on bibliometric data on smart education. To build this network map, Web of Science publications

were sorted by relevance. Accordingly, 500 publications indexed in the Web of Science Core Collection were selected. The results are shown in Figure 10.
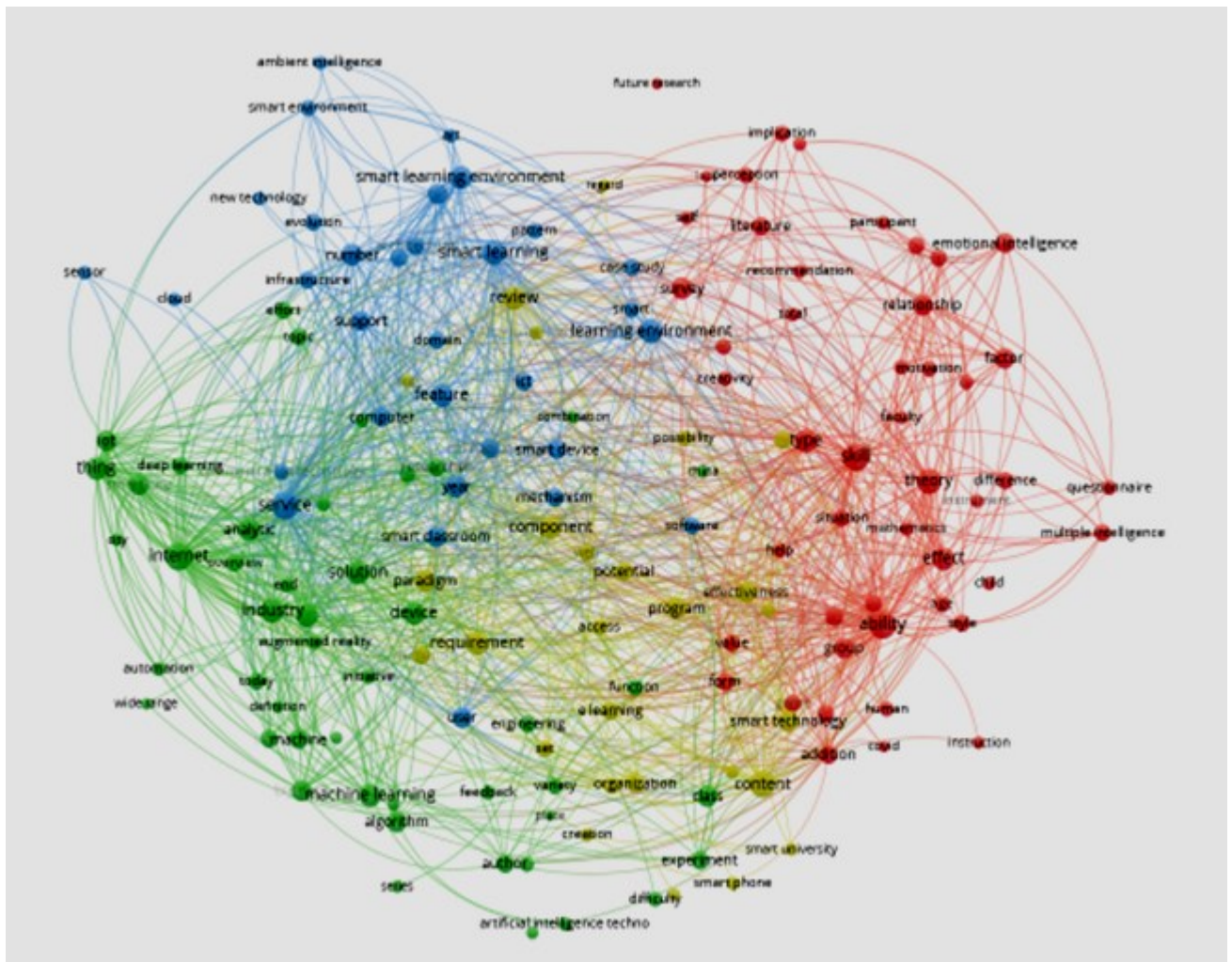
Figure 10. Network visualization of keywords on Smart education

4. Challenges and Discussion

Currently, despite the great attention to the problems of smart education in scientific research, the further development of the topic is complicated by several circumstances. Firstly, most of the research on smart learning is concentrated in the countries leading in the global education market. Despite the logic of this situation, it is necessary to take into account the risk of increasing the existing gaps between the leading countries in the education market and other countries. In fact, we can say that this is another dimension of the digital divide. Secondly, research in the field of smart education is largely focused on technical and pedagogical aspects, while institutional and organizational-economic work in this subject area is much less represented. This limits the deployment, dissemination and scaling of the results already obtained in the area under consideration. Thirdly, the dispersion of scientific works on smart education on a variety of topics in scientometric systems (like SciVal) leads to the fact that the search for new solutions is not always sufficiently based on the results already obtained.

5. Conclusions and Future Work

The conducted research has shown that the subject of smart education is characterized by high positive dynamics of development. This is manifested in the growth in the number and variety of publications, exponential growth in the number of citations, a very high level of prominence of

all key topics, which include publications on smart education. The study of the content of publications made it possible to trace the evolution from the study of the technical aspects of the use of intelligent digital technologies in educational processes to the study of the transformation of learning models and the entire educational system using smart technological solutions. This allowed determining the prospects for its development in the context of interdisciplinary synthesis. The unifying block of research integrating technical and pedagogical aspects of the development of smart education can be the synthesis of institutional and organizational-economic study of the introduction of smart education as a concept, model, and set of technologies. In addition, the evaluation of the effectiveness of smart education in the modern digital economy should be indicated as an important area of future work.

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