Cognitive Technologies and Competence Development: Bibliometric Analysis

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Abstract. The development of cognitive technologies and the formation of competences become an integral part of success in the conditions of a rapidly changing world. This document presents a bibliometric analysis of cognitive technologies and competencies. The dataset was retrieved from the Scopus database, analyzed and presented using VOSviewer. The search equation identified 281 studies. After analysis and application of filters, 60 studies were selected for further analysis. Among the journals that publish research on this topic, the most productive is Ceur Workshop Proceedings (5%). The most cited authors are González-González and Jiménez-Zarco. Authors from Indonesia, Spain and China published the most articles. The top 5 thematic categories include Computer Science; Social Sciences; Engineering; Business, Management and Accounting; Energy. The most cited article is Birjali, M., Beni-Hssane, A., Erritali, M. Research on cognitive technologies and the development of competencies open broad perspectives for improving learning, professional development, and personal growth.

Keywords: Cognitive technologies · Development of competences · Artificial Intelligence · E-learning.

1 Introduction

One of the current areas of research that is attracting more and more attention is the use of cognitive technologies for the formation of competencies. In today's world, where digital innovations are changing all areas of life, these technologies have great potential to influence people's development and learning. Cognitive technologies are based on the use of intelligent algorithms and machine learning to analyze and process large amounts of information, which allows you to understand and use data more effectively. Their application in the field of training and development of competences opens up new opportunities for students, workers and everyone who seeks to improve their skills and acquire new knowledge.

Calışkan et al. [11] conducted research on the competencies of using artificial intelligence. They found that students should understand the role of AI technologies and be able to formulate decisions, taking into account the results of artificial intelligence and their own knowledge and perception in real-world situations. Chao et al. [12] found that knowledge and competence in the field of

artificial intelligence are important for students. The results of the study highlight the need to develop a comprehensive and accessible compulsory course on artificial intelligence for students to prepare them for the role of future users of AI. Huang [22] considers the role of artificial intelligence education in the development of students' key competencies. The need for such education at the stage of fundamental education is proven, which will contribute to the formation of various key competencies of students. Gutierrez et al. [19] investigate the use of artificial intelligence in e-learning and its impact on the new competencies of graduates. They consider it necessary to train programmers specializing in artificial intelligence to achieve social and economic development and offer competencies that graduates should acquire as a result of e-learning. López et al. [29] believe that the integration of cross-cutting competencies in higher education using electronic learning tools is an important task.

Misthou and Paliouras [31] in their article analyzed the importance of artificial intelligence (AI) and found that governments do not fully understand how to implement AI and do not use its potential. They emphasized the need to develop digital skills, particularly in the field of AI, to prepare the future workforce and perform tasks related to artificial intelligence in the economy and society. However, Gaol [15] focuses on the implementation of performance management in an artificial intelligence system using the POAC (planning, organizing, executing and controlling) method in order to improve the competence of human resources. In this context, aspects of the analysis of personnel competencies in the working environment, the interaction of higher education with government structures, the educational budget and the needs of industry and companies in the artificial intelligence system are investigated.

Permana and Pradnyana [35] conducted a study with the aim of developing a recommender system for choosing an internship place by students based on their competencies with the help of artificial intelligence. By processing data collected from questionnaires and tests, an artificial neural network was used to provide accurate recommendations to students on choosing the most suitable place for their internship, ensuring an optimal educational process. Sharma and Manchanda [38] found a correlation between various personality traits related to entrepreneurship and lack of entrepreneurial competence in university students. Using machine learning algorithms, they were able to predict and improve students' entrepreneurial competence, which allows them to propose effective measures to improve this competence.

Lestari et al. [27] investigated the relationship between robot, artificial intelligence and service automation (RAISA), professional competence and perceived career opportunities in hospitality students. They found that awareness of RAISA and the presence of professional competencies positively influence students' perceptions of future career opportunities. Margienė et al. [30] argue that in today's learning environment, e-learning systems and competency-based student portfolios are necessary, but increasing student mobility and the diversity of e-learning systems require a higher level of automated competency integration. Automated matching of e-learning system competencies with competencies ac-

quired by students from other systems reduces workload and increases resource sustainability.

Adinda [1] argues that a competency-based approach is useful for students' self-regulation and self-direction in online learning. The study confirms that such an approach has a positive effect on students and can serve as a valuable contribution to identifying effective strategies for increasing the level of self-regulation and self-direction during e-learning. Chirila [13] found that traditional education systems, which are based on memorizing knowledge, do not meet the modern needs of practical skills, globalization and competitiveness. The author proposed a new educational system based on the concept of competence and the use of a dialog game component, which contributes to the achievement of competences in real-life scenarios. Garad et al. [16] also investigate the role of e-learning infrastructure and cognitive competence in the effectiveness of distance learning. The results of their research confirm the positive impact of e-learning infrastructure and cognitive competence of students, teachers and administrative staff on distance learning.

Birjali et al. [8] present a new model of adaptive e-learning, which is based on the use of big data and competencies, and also takes into account the social activities of students. In their opinion, the use of Big Data technology in this model allows for the development of new approaches and learning strategies, providing each student with the most appropriate educational content. Hsu and Li [21] propose a new algorithm called "competency-based guided learning algorithm" (CBGLA) that can be used for adaptive management of e-learning. As a result, it was found that the proposed system can provide more effective training than the traditional approach.

Kassymova et al. [23] conducted a study devoted to the role of e-learning in the development of cognitive competence. The results of the study confirm that e-learning has numerous advantages for self-development and improvement of learning conditions, despite its limitations and challenges. Keržič et al. [24] conducted a study aimed at studying the impact of e-learning in a blended learning environment on the development of students' competencies. The researchers found a high correlation between competence in computer skills and the usefulness of e-learning. Zulfiya et al. [42] conducted an analysis and developed a model and methodology for assessing student competencies in the e-learning system. They offer assessment at different levels, including disciplines and modules, as well as checking the achievement of the objectives of the educational program.

Cao and Zhang [10] investigated the use of machine learning to create competency models in human resource management (HRM). These models allow you to quickly and accurately assess the professional competencies of employees and determine the appropriate positions, which gives companies a competitive advantage. In turn, Burkhard et al. [9] propose a new learning structure that takes into account "human-intelligent machine" interaction as a normative orientation for the development of new competencies in the era of artificial intelligence.

Lau [26] consider the role of information competences in the development of cognitive skills for higher education in the context of artificial intelligence. They

emphasize the importance of learning informational competencies that allow students to compete in the new economy. A. Basantes-Andrade et al. [6] confirm that the ability to use tools and aids provided by information and communication technologies is important. Khan et al. [25] also indicate the significant impact of digital innovations on pedagogical digital competence and e-learning system, as well as the mediating role of computer self-efficacy.

Astafieva et al. [5] justify approaches to the effective use of e-learning for the formation of students' mathematical competence. Heba et al. [20] also suggest the use of information and communication technologies, in particular a system of individual learning and an e-learning course, to increase the level of students' competences in mathematics.

Albano and Ferrari [3] believe that students' linguistic competence is important for academic success. Angelis et al. [4] also suggest using an individual approach using information technology and a special platform to improve language competence. Authors Mujiono and Herawati [32] showed a significant difference in the level of sociolinguistic competence between groups of students who used e-learning with sociolinguistic instruction and groups who studied in a traditional face-to-face format.

D'Aniello et al. [14] focus on the development of an e-learning system for the development of intercultural competence. According to them, intercultural competence implies the presence of cognitive, behavioral and affective skills necessary for effective communication and cooperation with representatives of different cultures. The study by Long and Lin [28] is devoted to the empirical study of the development of intercultural communicative competence of students learning English using artificial intelligence. The authors established a significant positive connection with knowledge of foreign cultures, attitudes towards them and skills in intercultural communication.

Al-Sharidah [2] states that the use of e-learning platforms can significantly improve teachers' pedagogical competencies. Thomas et al. [39] identified the needs of teachers in competencies for successful teaching of e-learning. Wu [40] also proposed a model for improving teacher competence using an improved machine learning algorithm. Zhao et al. [41] claim that in the era of artificial intelligence, the systems of professional development of teachers need improvement.

Batko and Szopa [7] claim that in modern organizations, significant attention should be paid to the development of computer technologies, as well as the achievement of new competencies that must be developed in the modern era of robotics and artificial intelligence. Palacios-Marqués et al. [33] determined that the use of Web 2.0 tools in the development of e-learning projects leads to the creation of new opportunities, the modification of traditional competencies and the development of new ones based on knowledge management. Rivera-Kempis et al. [36] investigated entrepreneurial competence and found that the use of machine learning can be useful for classifying entrepreneurs. Sarangarajan et al. [37] found that the use of artificial intelligence and e-learning allows organizations to remain adaptive and competitive, and a learning roadmap setup technique

using a hybrid machine learning-based recommendation system helps managers optimize the necessary skills to execute the organization's business strategy.

The purpose of this article is a bibliometric analysis of cognitive technologies and competence formation. The study aims to answer the following questions regarding cognitive technologies and competence building: (1) Which journals are the most influential? (2) Which authors publish research on this topic? (3) In which countries are the authors interested in this topic? (4) What are the main thematic categories of research? (5) How heavily cited are works on cognitive technologies and competencies? (6) What terminology is used to conduct research on the relevant topic?

The manuscript is organized as follows: chapter 2 presents the methodology of document search and their selection. Section 3 presents the results of the analysis. For this, journals, authors, countries, subject categories, types of publications, citations, terminology related to cognitive technologies and competencies were analyzed. Section 4 provides conclusions, limitations, and future research.

2   Materials and Methods

This study proposes a bibliometric analysis focusing on the study of publications related to the development of competencies in the context of the use of cognitive technologies. Within the framework of this article, an analysis will be conducted to identify cooperation between authors, organizations and countries. The main source of data for the study is the Scopus database, which is a recognized and authoritative resource for scientific research with significant global weight. This article proposes the use of bibliometric analysis for the identification of scientific publications corresponding to the topic of the implementation of cognitive technologies for the acquisition and development of competences.

The following equation was used for the search - TITLE ("Cognitive technolog?" OR "Artificial intelligenc?" OR "Artificial Intelligence Technolog?" OR "E-learning" OR "Innovation Education" OR "Machine Learning") AND TITLE ("Competenc? Development" OR "Competenc? Design" OR "Competenc?" OR "Competenc?-oriented education" OR "Competenc?-Based" OR "Modeling competence?" OR "Professional Competence") AND (EXCLUDE (AFFILCOUNTRY,"Russian Federation")) AND (LIMIT-TO (LANGUAGE,"English")) AND (LIMIT-TO (DOCTYPE,"ar") OR LIMIT-TO (DOCTYPE,"cp") OR LIMIT-TO (DOCTYPE,"ch") OR LIMIT-TO (DOCTYPE,"bk")) AND (LIMIT-TO (PUBYEAR,2022) OR LIMIT-TO (PUBYEAR,2021) OR LIMIT-TO (PUBYEAR,2020) OR LIMIT-TO (PUBYEAR,2019) OR LIMIT -TO (PUBYEAR,2018) OR LIMIT-TO (PUBYEAR,2017) OR LIMIT-TO (PUBYEAR,2016) OR LIMIT-TO (PUBYEAR,2015) OR LIMIT-TO (PUBYEAR,2014) OR LIMIT-TO (PUBYEAR, 2013) with the replacement of the last letters with the symbol "?" to search for all possible word endings.

Two hundred and eighty-one (281) documents were retrieved from the Scopus database search. Certain documents were selected for research and analysis using 4 stages.

At the first stage, studies related to the Russian Federation were excluded. The removal of these publications is due to the war and aggression that Russia has launched against Ukraine. As a result, 11 studies were excluded.

In the next step, all publications except articles, conference papers, book chapters and books are excluded. As a result, 33 studies were excluded and 237 documents were obtained.

As a result of the third stage, articles published in 2023 and before 2013 and not in English were removed (84 such documents were found). 153 documents were received.

At the fourth stage, articles were analyzed by title, abstract and main overview. As a result, the materials of 60 studies related to the specified direction will be used for the research.

The received articles are loaded into MS Excel for analysis and information visualization using the VOSviewer software.

3   Results

3.1   Journals

A total of 60 documents were published in 36 resources. This indicates a certain interest in publications related to the development of cognitive technologies, artificial intelligence, as well as the development of competencies as a result of their implementation. Out of 36 resources, 86.1% published only one document on this topic, the rest - 13.9% published from two to three documents.

In addition, the top journals were highlighted based on the number of published articles related to cognitive technology and competency development.

Table 1 presents the top 5 most productive journals, including publisher and indexing information such as number of publications, SJR 2021 indicator, CiteScore 2021 and SNIP 2021.

Table 1. Top 5 most productive magazines regarding cognitive technologies and competence development.

N	Journal	Publisher	№ of Publ	SJR-2021	Cite Score 2021	SNIP 2021
1	Ceur Workshop Proceedings	Conference Proceeding	3	0.228	1.1	0.317
2	Journal Of E Learning And Knowledge Society	Italian e-Learning Association	2	0.251	1.6	0.705
3	Journal Of Physics Conference Series	Conference Proceeding	2	0.251	1.6	0.705
4	Journal Of E Learning And Knowledge Society	Italian e-Learning Association	2	0.210	0.8	0.395
5	Sustainability Switzerland	Multidisciplinary Digital Publishing Institute	2	0.664	5	1.310

These top 5 journals published 18.3% of the total number of publications. The Ceur Workshop Proceedings conference published the most research, namely 3 articles (5.0%).

3.2 Authors

The five most productive authors in terms of number of publications, citations and publications as first author are presented in Table 2 . Inés González-González is in first place, with two publications, both of which are first author. Ana Jiménez-Zarco, who has 2 publications, but is not a co-author in any of them, ranks second in terms of citations. Next, the authors of one publication: as the first author - Adinda, not the first authors - Adeyanju, Adilbayeva.

Table 2. Top 5 most productive authors regarding cognitive technologies and competence development.

No.	Authors	Country of Author	Number of Publications	Number of Publications as the First Author
1	González-González, I. [18]	Spain	2	2
2	Jiménez-Zarco, A.I. [17]	Spain	2	0
3	Adinda, D. [1]	France	1	1
4	Adeyanju, J. [39]	Nigeria	1	0
5	Adilbayeva, U.B. [23]	Kazakhstan	1	0

Fig. 1 presents the analysis of Co-authorship by Authors obtained using VOSviewer.

3.3 Countries, Organizations

The number of publications on cognitive technologies and competencies, according to countries, was determined according to the Scopus database. Fig. 2 shows the top 5 countries with the largest number of publications.
Overall, the country with the highest number of publications is Indonesia, which with 9 papers accounts for 15.0% of the total number of published articles.

In second and third place are China and Spain, which each have 8 documents and 13.3%. In fourth place is Taiwan - 4 documents, 6.7%. Also in the Top 10 are: Finland, Greece, Kazakhstan, United States – 3 documents each (5.0%); India, Italy – 2 documents (3.3%).

Fig. 3 shows the top 4 Organizations with the largest number of publications. With the results of the research of Organizations, the leading place is occupied by Spain: Universitat Oberta de Catalunya (3 publications), Universitat Politècnica de València (2 publications). In the second place among the number of Organizations as a result of the analysis is Indonesia (Universitas Negeri Yogyakarta, 2 publications).
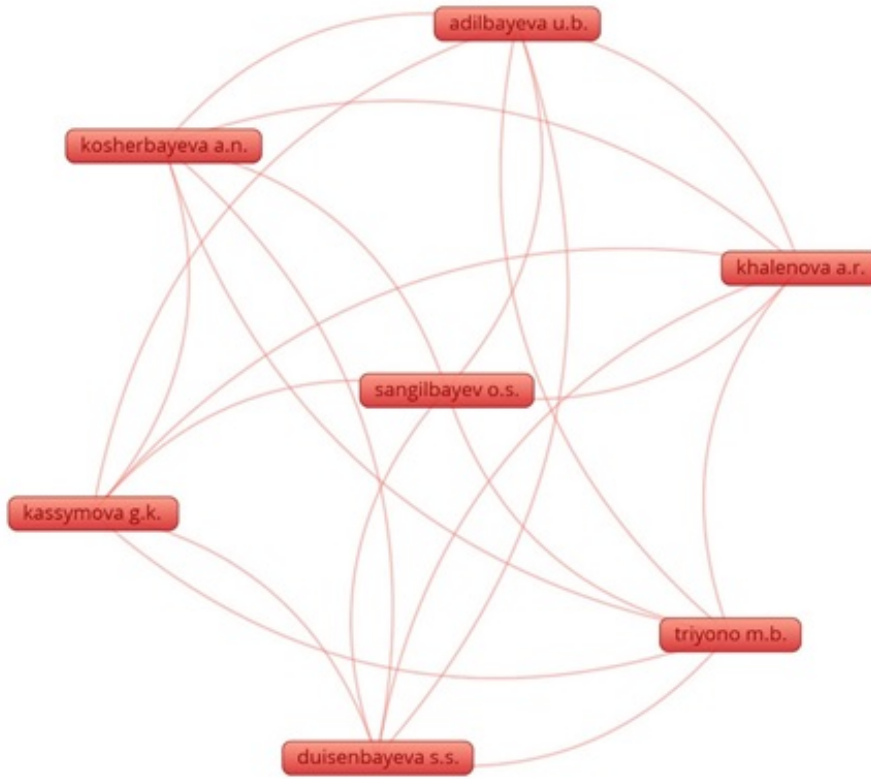
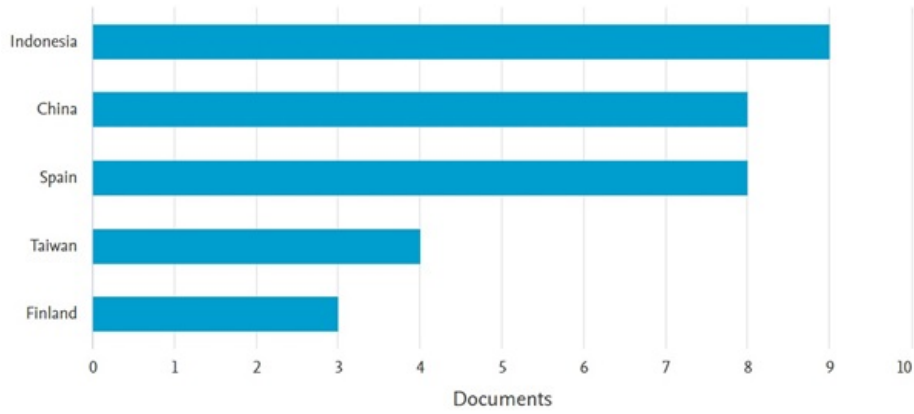**Fig. 1.** Co-authorship by Authors (created using VOSviewer).

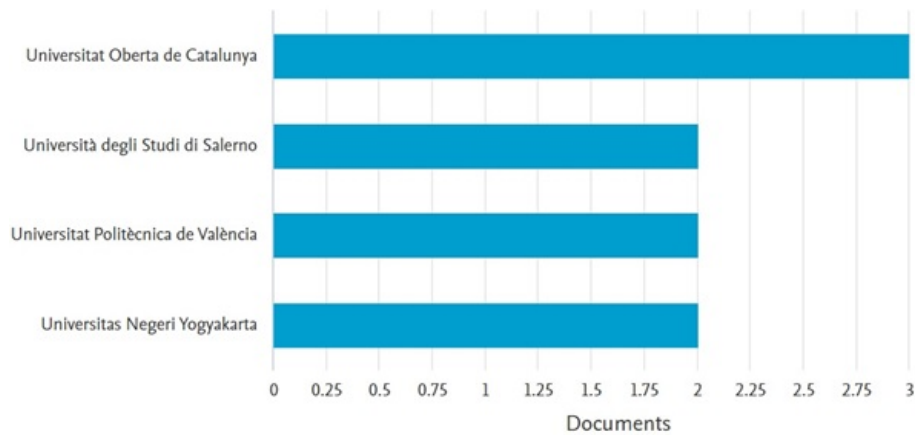**Fig. 2.** Top 5 countries by the number of publications.

Fig. 3. Top 4 organizations by number of publications.

3.4   Analysis of Subject Categories, Type of Publications

As a result of the research, certain thematic categories were defined, in which the researched articles were published. They are presented in Fig. 4 .

The top 5 categories are: Computer Science (35 articles, 31.8%); Social Sciences (25 articles, 22.7%); Engineering (16 articles, 14.5%); Business, Management and Accounting (5 articles, 4.5%); as well as Energy (5 articles, 4.5%). The analysis of the type of publications is shown in Fig. 5.

As a result of the analysis of the type of publications, the following was found: Article (30 articles, 50.0%); Conference Paper (23 documents, 38.3%); Book Chapter (5 documents, 8.3%); Book (3 documents, 3.3%).

3.5   Analysis of Citations

A corresponding study was conducted on the citation of authors and organizations among the selected articles. The results of the analysis of the top 5 cited authors are presented in Table 3 .

As a result of the analysis, it was found that the most cited article is Birjali, M., Beni-Hssane, A., Erritali, M. on the topic "A novel adaptive e-learning model based on Big Data by using competence-based knowledge and social learner activities ". As a result, this study currently has 43 citations, which is 29.7% in the top 5. The next most cited article is Palacios-Marqués, D., Cortés-Grao, R., Lobato Carral, C. These authors received 22.1% of the top 5. The following results were as follows: Garad, A., Al-Ansi, A.M., Qamari, I.N. – 19.3%; Huang, X. – 15.9%; Parkes, M., Reading, C., Stein, S. - 13.1%.

Analysis of Citation by Authors is shown in Fig. 6.

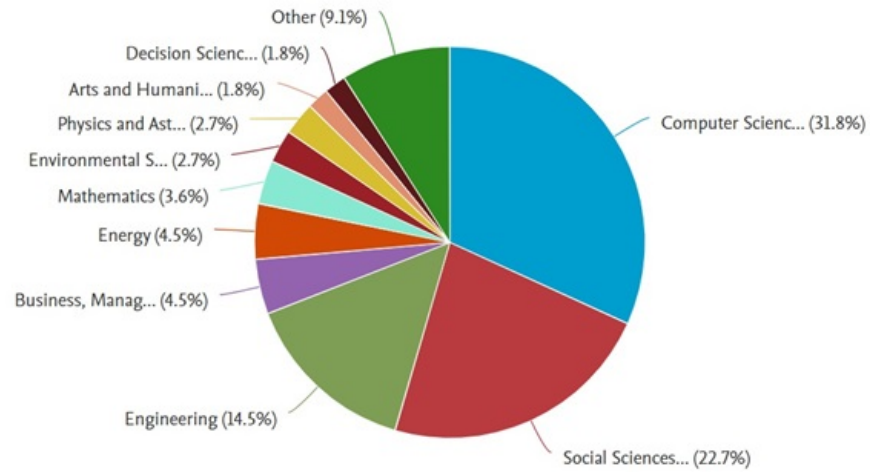Fig. 7 shows Citation by Authors from Density Visualization by Clusters for clarity.

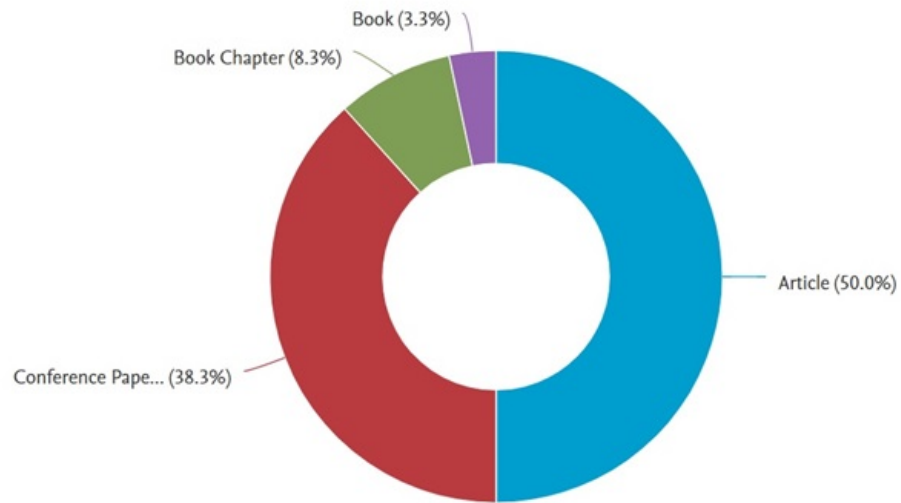**Fig. 4.** Thematic categories in which the researched articles are published.
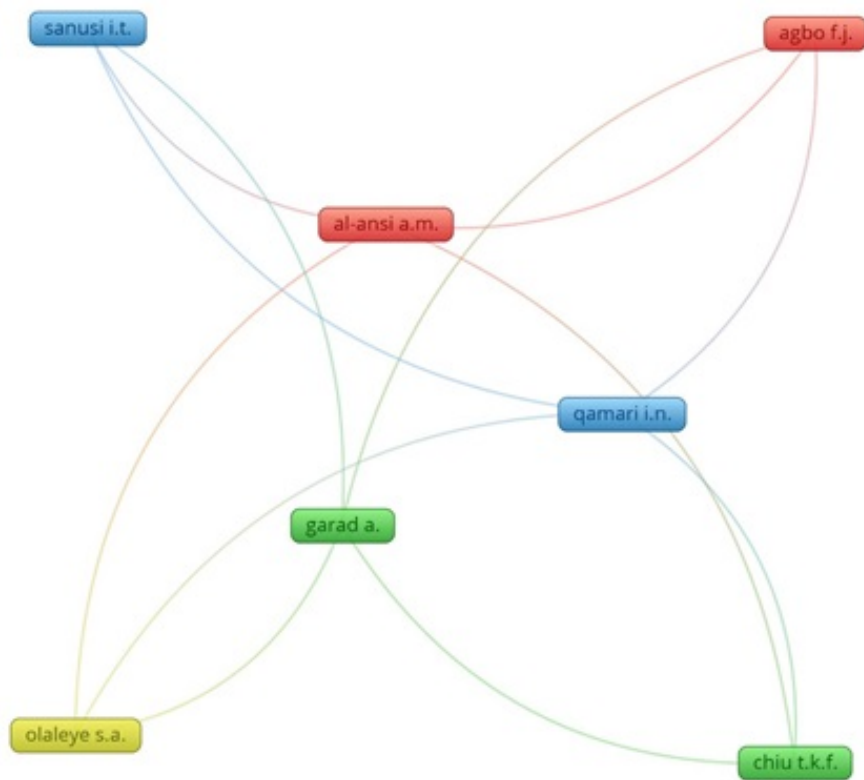

Fig. 5. Type of documents analyzed.

Fig. 6. Citation by Authors (created using VOSviewer).

Table 3. Top-5 publications with most citations.

| No.	Authors	Journal	Citations in Scopus	SciVal Topics
1	Birjali, M., Beni-Hssane, A., Erritali, M. [8]	Applied Soft Computing Journal	43	Computer-Aided Instruction; Adaptive Hypermedia; Intelligent Tutoring Systems
2	Palacios-Marqués, D., Cortés-Grao, R., Lobato Carral, C. [33]	International Journal of Project Management	32	Examiner; Education; Attendance
3	Garad, A., Al-Ansi, A.M., Qamari, I.N. [16]	Cakrawala Pendidikan	28	Blended Learning; Learning Management System; Distance Education
4	Huang, X. [22]	Education and Information Technologies	23	Computer Science; Education Computing; Computational Thinking
5	Parkes, M., Reading, C., Stein, S. [34]	Australasian Journal of Educational Technology	19	Internet Of Things; Transatlantic; Training and Development
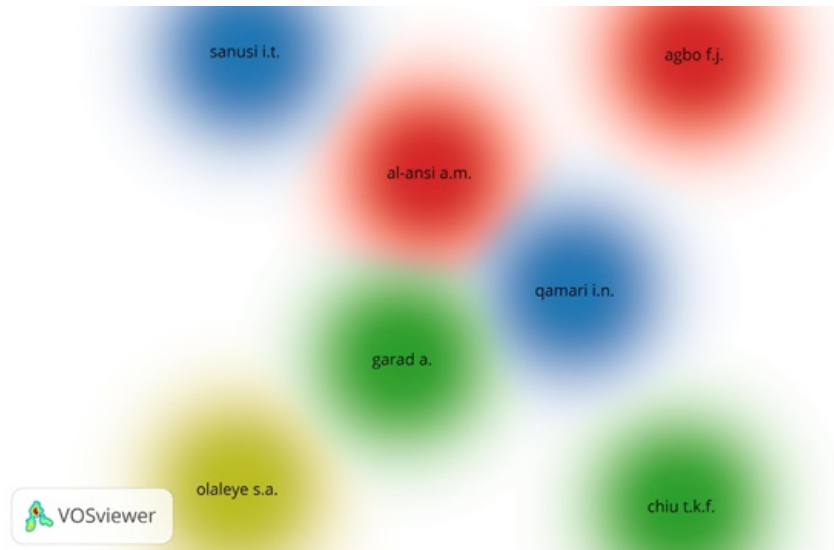
Fig. 7. Citation by Authors Density Visualization by Clusters (created using VOSviewer).

Fig. 8 shows the results of the citation analysis of organizations whose authors published articles on the given topic.
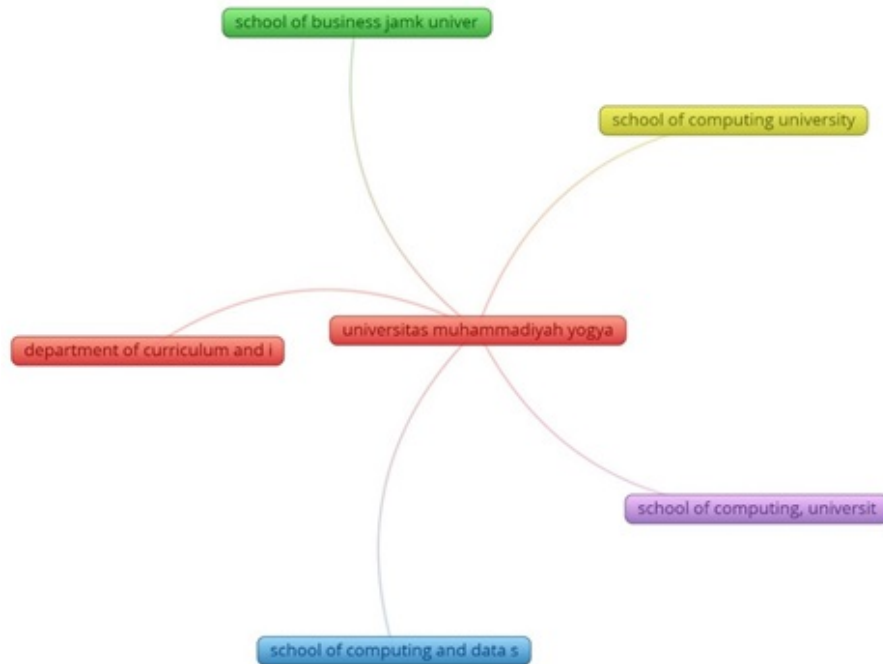

Fig. 8. Citation by Organization (generated using VOSviewer).

3.6   Term Analysis

The analysis of all the terms used in the articles is shown in Fig. 9. In particular, 2 main clusters are highlighted, which are formed by all keywords.
The main cluster is formed by such keywords as Artificial intelligence, E-learning, Teaching, Machine learning.

Fig. 10 shows the analysis of word sharing with overlay visualization.
This visualization makes it easier to see certain periods when keywords were used in research. For example, the use of the phrases "artificial intelligence", "learning systems", "machine learning", and "e-learning" appeared in 2020-2022.

4   Conclusions

The study analyzed the Scopus publication database from 2013 to 2022 to analyze cognitive technologies and competencies. It was found that cognitive tech-
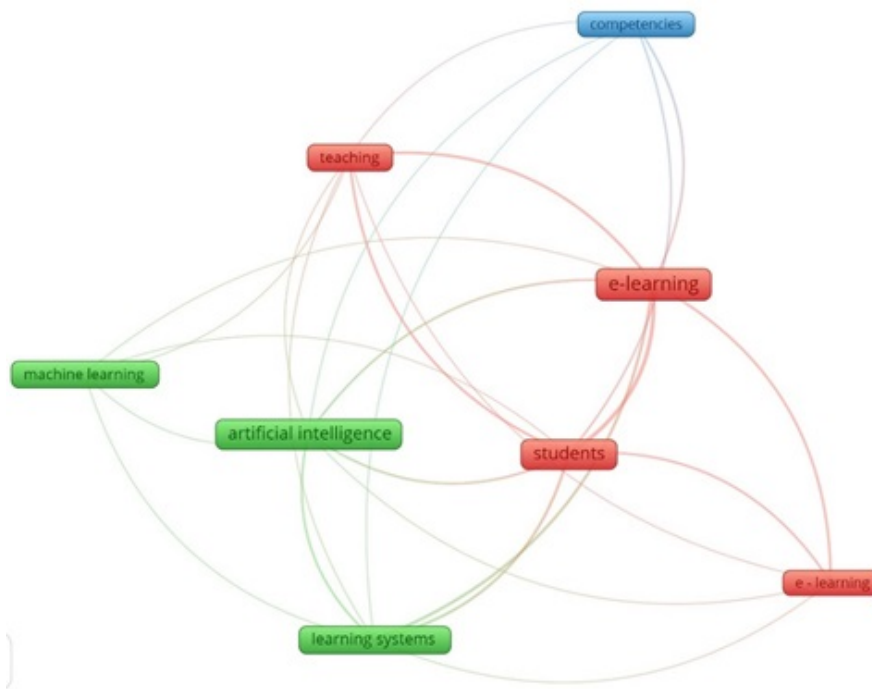
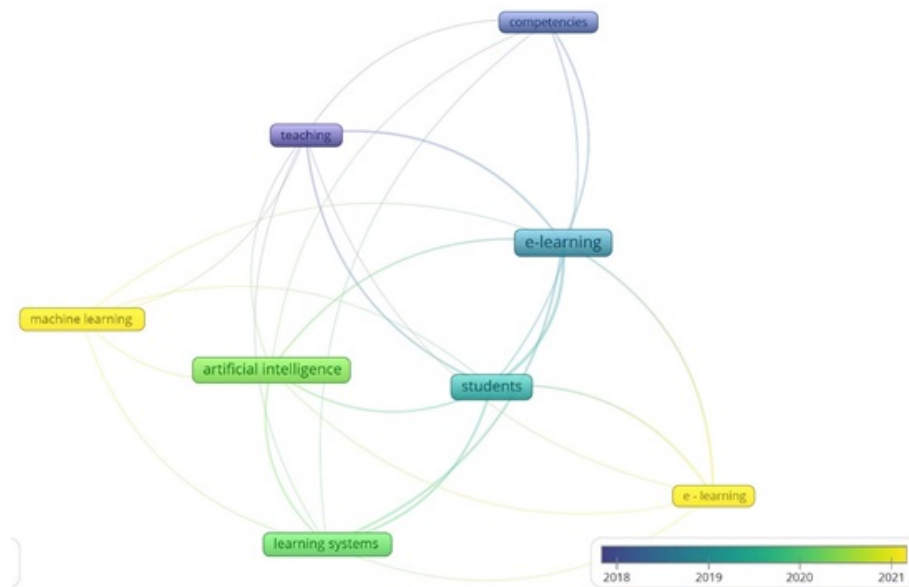**Fig. 9.** Co-occurrence for All keywords (created using VOSviewer).

Fig. 10. Co-occurrence for All keywords with Overlay visualization (created using VOSviewer).

nologies show significant potential in improving learning processes and developing competencies, providing access to innovative methods and tools. They enable students and employees to develop critical thinking, problem-solving and creative thinking, communication skills and other important competencies. Also, cognitive technologies can be successfully used in various spheres of life, including education, business, medicine and others. They allow personalizing the educational process, adapting it to the individual needs and abilities of each participant.

A limitation of this study is the consideration of only publications from the Scopus database. Another limitation is the exclusion from the sample of publications from the Russian Federation, which is related to the war it started against Ukraine.

The possibility of using virtual and augmented reality for the formation of competencies can be a topic for further research. Secondly, the development of innovative methods of assessment and certification of competencies using cognitive technologies. It is also important to investigate the ethical aspects of using cognitive technologies in the formation of competences, in particular the issues of privacy, security and risks associated with the use of data in the learning process.

In general, the study of the role of cognitive technologies in the formation of competences opens wide prospects for improving the process of learning and development of people. Understanding their potential, limitations and prospects

will allow us to make the most of these technologies for the training of competent specialists able to function effectively in today's digital society.

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