Industria 4.0 e innovación educativa: antecedentes y tendencias futuras de las competencias tecnológicas

Industry 4.0 and educational innovation: background and future trends of technological skills

Indústria 4.0 e inovação educacional: antecedentes e tendências futuras das competências tecnológicas

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Resumen

Los avances tecnológicos de las nuevas revoluciones industriales están cada vez más presentes en diferentes áreas de la ciencia, y la educación no es la excepción. Por otro lado, las competencias tecnológicas tienden a especializarse más, con la relevancia de las habilidades blandas y duras en los próximos escenarios futuros. Además, la tecnología y las innovaciones ha avanzado aceleradamente en diferentes sectores y contextos, como por ejemplo el sector industrial o inclusive el sector educativo. Sin embargo, no existe un panorama claro en cuales nuevas tecnologías emergentes y competencias tecnológicas impactaran el sector educativo. Por lo tanto, este trabajo tuvo como propósito estudiar la influencia de las competencias tecnológicas y las tecnologías emergentes de la industria 4.0 en la transformación de la innovación educativa en el desarrollo de la educación 4.0 mediante una bibliometría y una revisión sistémica de literatura. Los resultados muestran a las tecnologías emergentes más estudiadas, como el internet de las cosas, la robótica, la realidad virtual, la automatización, la digitalización y la inteligencia artificial, entre varias. Otro hallazgo es que la tendencia de las competencias tecnológicas está orientada a la educación de la ingeniería, el aprendizaje electrónico, la innovación, la educación computacional, el desarrollo sustentable y los sistemas de aprendizaje entre otros. Se concluye que la cuarta revolución industrial aún está desarrollándose, pero este trabajo sirve de guía para encaminar los esfuerzos de la educación hacia los caminos fructíferos de las tecnologías habilitadoras y las competencias a desarrollar en los individuos.

Palabras clave: penta-hélice, industria 5.0, ingeniero, sociedad 4.0, habilidades duras, habilidades blandas.

Abstract

The technological advances of the new industrial revolutions are increasingly present in different areas of science, and education is no exception. On the other hand, technological skills tend to become more specialized, with the relevance of soft and hard skills in upcoming future scenarios. Furthermore, technology and innovations have advanced rapidly in different sectors and contexts, such as the industrial sector or even the educational sector. However, there is no clear outlook on which new emerging technologies and technological competencies will impact the education sector. Therefore, the purpose of this work was to study the influence of technological competencies and emerging technologies of industry 4.0 on the transformation of educational innovation in the development of education 4.0 through bibliometrics and a systemic literature

review. The results show the most studied emerging technologies, such as the internet of things, robotics, virtual reality, automation, digitalization and artificial intelligence, among others. Another finding is that the trend of technological competencies is oriented towards engineering education, e-learning, innovation, computer education, sustainable development and learning systems, among others. It is concluded that the fourth industrial revolution is still developing, but this work serves as a guide to direct educational efforts towards the fruitful paths of enabling technologies and the skills to be developed in individuals.

Key words: penta-helix, industry 5.0, engineer, society 4.0, hard skills, soft skills.

Resumo

Os avanços tecnológicos das novas revoluções industriais estão cada vez mais presentes em diversas áreas da ciência, e a educação não é exceção. Por outro lado, as competências tecnológicas tendem a tornar-se mais especializadas, com a relevância das soft e hard skills nos próximos cenários futuros. Além disso, a tecnologia e as inovações avançaram rapidamente em diferentes sectores e contextos, como o sector industrial ou mesmo o sector educacional. No entanto, não existe uma perspectiva clara sobre quais as novas tecnologias emergentes e competências tecnológicas que terão impacto no sector da educação. Portanto, o objetivo deste trabalho foi estudar a influência das competências tecnológicas e das tecnologias emergentes da indústria 4.0 na transformação da inovação educacional no desenvolvimento da educação 4.0 por meio da bibliometria e de uma revisão sistêmica da literatura. Os resultados mostram as tecnologias emergentes mais estudadas, como internet das coisas, robótica, realidade virtual, automação, digitalização e inteligência artificial, entre várias. Outra constatação é que a tendência das competências tecnológicas está orientada para o ensino de engenharia, e-learning, inovação, ensino de informática, desenvolvimento sustentável e sistemas de aprendizagem, entre outros. Conclui-se que a quarta revolução industrial ainda está em desenvolvimento, mas este trabalho serve como um guia para direcionar os esforços educacionais para os caminhos frutíferos das tecnologias facilitadoras e das competências a serem desenvolvidas nos indivíduos.

Palavras-chave: penta-hélice, indústria 5.0, engenheiro, sociedade 4.0, hard skills, soft skills.

Introduction

Since the beginning of history, human beings have been witnesses and makers of their own destiny. In this sense, it was the deep questioning of the reality that surrounds them that motivated them to follow their own path in favor of their progress, to create tools, devices and machines that will facilitate your day-to-day activities. Thus, the presence of technology in man's life was consolidated, understood as that knowledge that is possessed to create an artifact that must be useful to solve everyday problems, so it can be said that technology always has been present in the development of humanity (Baygin et al., 2016; Zhang, 2019)**.**

In this same order of ideas, the same evolution of scientific knowledge brought transformations at much higher levels, impacting the way of producing all types of products. Such is the case of the industrial sector, where these transformations are notably evident through industrial revolutions. However, it is from the beginning of the industrial revolutions that changes occur massively, expanding throughout the world and opening the way to modernity. These changes at the time implied a certain fear in society and resistance to change, modifying the way of thinking, adapting, responding and generating knowledge (Xu, David & Kim, 2018). In this way, throughout history different industrial revolutions have been marked, going through the first, the second, the third, the fourth (I4.0), and there are even those who are already investigating the topic of the fifth industrial revolution (I5 .0).

In this regard, the pillars on which the new trends in technology are based constitute a very important part on which the new paradigms of economic growth of different countries of developed, emerging and undeveloped economies are based, since they focus all their efforts to lead on technological innovation issues and remain at the forefront. In this regard, among the countries that lead the development of these emerging technologies, countries such as Germany, China and the United States stand out. However, it must be recognized that they are not the only ones, since the interest is immersed in all countries on all continents (Ghobakhloo, 2020).

In addition to the above, the influence of globalization of developed countries increasingly impacts emerging and developing economies, such as Latin American countries, which are also making an effort to introduce emerging I4.0 technologies, although without much success due to the collaborative work necessary to create synergy, transform and enhance innovations (Stachová et al., 2019).

So, the technological skills that this new era of industry 4.0 will demand regarding technology (and its applications such as multimedia and simulation), will be extremely important for future professionals, especially for graduates of engineering education profiles (Angeli, 2005;

Grodotzki, Ortelt & Tekkaya, 2018), since it will depend on achieving a standardized status, unlike those who do not have them, especially because the industrial sector is where the engineer works in work practice and it is also the same where technological transformations and digital skills impact both for political and educational areas (Ilomäki et al., 2016). In this same order of ideas, the automation of processes and the technological incorporations contemplated by I4.0 represent today the main challenge to be resolved in the coming years by the educational system, new graduates must be able to respond to the new technological requirements and adaptations through relevant training and qualification of the individual according to the needs of the social environment and the new industrial revolutions (Alvarez-Aros & Bernal-Torres, 2021; Benešová & Tupa, 2017; Hariharasudan & Kot, 2018). That said, education 4.0 (mainly focused on the future of the labor market through technological innovations) must redouble efforts in updating curricular plans that include classes or seminars in which knowledge for the use and management is imparted. of these new technologies (Corzo & Alvarez-Aros, 2020).

Starting from the previous points and now contrasting this technological issue, it can be stated that over time society has evolved through technological changes and these, in turn, mark changes in different areas of science such as the educational sector. This is how the different industrial revolutions have changed the world through their technological advances and applications in the educational area (Corzo-Ussa, Alvarez-Aros & Chavarro-Miranda, 2022).

In this regard, the advances that improved the educational area, in the first industrial revolution, were largely due to the great importance that was placed on mechanical tools related to printing and paper manufacturing, the typewriter, in addition to the use of graphite pencil and the use of the ballpoint pen, for example. That time was called education 1.0, considering the issues of the time, learning focused on the teacher (Alvarez-Aros & Bernal-Torres, 2021).

Later, the era of education 2.0 is considered to be the beginning of the 19th century, where the technological protagonists were industrialization and electricity, and the first electronic devices. In the educational sector it was improved by printers, calculators. Learning continued to be based on the teacher as the center of the educational process, although some practices of correspondence education and broadcasting emerged.

Then, at the end of the 21st century, it was considered the beginning of education 3.0, which was characterized by the extensive use of computers and information and communication technologies (ICT), the automation of processes and the emergence of Internet access (Villegas-Valle, Walle-Vazquez & Alvarez-Aros, 2021). At this stage, the rise of access to online material and the exchange of information by electronic means arises. Learning in this stage begins with

some processes focused on the student and no longer on the teacher as in previous stages, since learning initiatives and learning methods such as computer-based are even perceived (López-López, Rodríguez-Cotilla & Alvarez-Aros, 2022).

However, currently, the world is experiencing the acceleration of technological changes with education 4.0 and society is also experiencing it from different areas of science. This can be contrasted with emerging applied technologies such as the presence of ICT competencies, regardless of the age of the employees (Guo, Dobson & Petrina, 2008), the internet of things (IoT), big data, cloud computing and virtual reality. For example, virtual reality in surgical education is a growing fact that will positively impact the medical field (Ota et al., 1995). Other contrasting technologies are augmented reality, artificial intelligence, robotics, quantum computing, and cyber-physical systems. The latter are conceptualized as the fusion of sensors and actuators connected by high fidelity with equipment that share, monitor and analyze performance and adaptation data (Mourtzis et al., 2018).

As expected, this era is different from others due to important advances such as ICT and the birth of new learning didactics that are based on these technological advances. In addition to the above, at this stage emerging technologies begin to mature and develop (Alvarez-Aros & Bernal-Torres, 2021; Miranda et al., 2019). The previous stages of education and its evolution can be summarized in the following Table:

Table 1. Background from education 1.0 to education 4.0

Education	Characteristics	Examples
Education 1.0 (Late 18th century)	Mechanization systems Teacher-centered	paper making machine Mechanical printing graphite pencil dial point pen, typewriter
Education 2.0 (Early 20th century)	Industrialization and electricity correspondence education broadcast education Teacher-centered education	electronic devices such as printers, calculators and early computers
Education 3.0 (Late 20th century)	automation and the birth of internet access teacher-centered education first students focused on initiatives	Extensive computer use, access to online material, and exchange of information learning methods such as computer-based training, blended learning and hybrid learning
Education 4.0 (21st century)	Information technologies which are powered by the Internet of Things more student-centered education	Information technology innovative facilities or facilities new learning methods based on technologies development of core competencies

Source: Miranda *et al.* (2019)

After analyzing the Table, it is reaffirmed that the technological advances of the new industrial revolutions are increasingly present in different areas of science, and education is no exception. In this sense, technological skills tend to be complemented by the relevance of soft skills in the upcoming future scenarios. However, there is no clear consensus on how new emerging technologies will affect the educational sector through technological competencies (Corzo-Ussa, Alvarez-Aros & Chavarro-Miranda, 2022). What are the emerging technologies and key technological competencies to develop in the educational sector?. For these reasons, this work aimed to study the influence of technological competencies and emerging technologies of industry 4.0 in the transformation of educational innovation towards education 4.0. through bibliometrics and a literature review. This work follows an IMRD structure, that is, it is integrated from the

present introduction, then the methodology, results and discussion are shown, and at the end the conclusions are presented.

Methodology

The methodological design was made up of eight stages. In them, firstly, as the first or initial stage, the objectives to be pursued by the research were defined, then, as a second stage, the search criteria referring to the words or terms with which to obtain documents related to the research were established. At this stage the search equation used was: (TITLE (educati*) AND TITLE-ABS-KEY ("industry 4.0") OR TITLE-ABS-KEY ("tech* compet*")). From the previous search, it is observed that the research focused mainly on the title of the documents related to education, and then an opening is made to the search for technological competencies and the fourth industrial revolution, not only in the title of the documents. documents, but also the search includes summaries and keywords of the same documents.

Then, in the third stage, the sources or platforms for obtaining documents were determined, which in this particular case were obtained from the Scopus database. It is important to clarify that the Scopus database is one of the largest international scientific platforms that lead among the most prestigious databases. In addition, it contains a large number of documents of the highest quality from scientific, technological and educational journals (Alvarez-Aros & Bernal-Torres, 2021; Cruz-Manzo et al., 2023). Later, in the fourth stage, the entire collection of documents to be studied and analyzed or separated in the following phases was selected. In the fifth stage, the analysis of collected documents and their content was carried out; That is, a systematic literature review (SLR) was carried out to discern between the research to be studied and the research to be excluded. At this stage, 1072 total documents were selected.

SLR play a vital role in both supporting further research effort and providing unbiased synthesis and interpretation of findings in a balanced manner (Kitchenham et al., 2010). This type of review attempts to gather relevant evidence that fits prespecified eligibility criteria to answer specific research questions (Moher et al., 2009).

It should be noted that the review process was divided into three steps proposed by Kitchenham & Charters (2007), that is, planning, conducting and reporting the systematic review. Reporting of the review was guided by the principles of the PRISMA acronym (Preferred Reporting Items for Systematic Reviews and Meta-Analyses). In particular, the PRISMA methodology was used to guide the description of eligibility criteria, information sources, data collection process, data elements, and synthesis of results (Moher et al., 2009).

Furthermore, as a sixth stage, a classification system for said documents was developed. Also, as the seventh stage, the quantification of key elements was carried out. In this phase, a content analysis was carried out that allowed us to identify the relevant emerging technologies of Industry 4.0 and the outstanding technological competencies in the area of education (Alvarez-Aros & Bernal-Torres, 2021). Finally, in the eighth stage, the results and findings were presented, processed through the R, Bibliometrix and Biblioshiny software. It is important to mention that SLR is a method that is characterized by being orderly, structured and objective in the selection of documents and quantification of key elements (Arballo et al., 2019; Manterola et al., 2013). The stages of the methodology are presented in the following Figure:

Figure 1. Stages of the research methodology
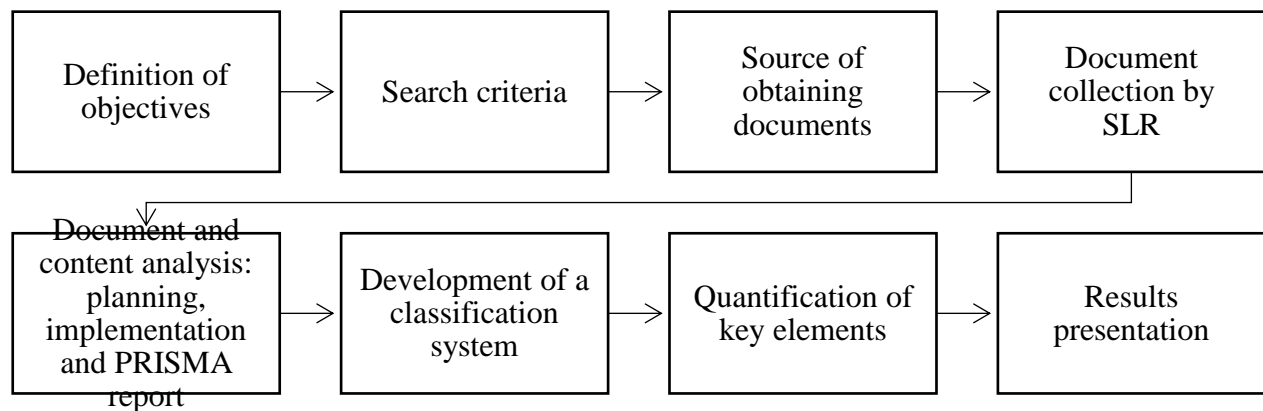
Source: Preparation from Alvarez & Bernal (2021)

From the previous stages, some main data was obtained regarding relevant information and types of documents, which are shown in the following Table:

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Table 2. Main information and types of documents analyzed

| Main information	Result	%
Year range	1952:2023	100
Sources	622	100
Documents	1,072	100
Documents type		
Article	468	43.66
Book	10	0.93
Book chapter	61	5.69
Conference article	469	43.75
Conference review article	13	1.21
Editorial articles	4	0.37
Erratum documents	1	0.09
documents letter	1	0.09
Notes	5	0.47
Retraction documents	1	0.09
Review articles	38	3.54
Short surveys	1	0.09
Totals	1,072	100.00

Source: Scopus

From the previous Table, it is shown that research on technological competencies in education covers a range of 71 years of scientific study. In that period of time, 1072 works have been published, which belong to 622 magazines or sources. Also, it is observed that the research concentrates only on two types of documents with the total 87.41%, these are conference articles (43.75%) and research articles (43.66%). Then, other types of documents are seen other than conference articles and research articles that represent the minority (book, book chapter, conference review article, editorial articles, erratum documents, letter documents, notes, retraction documents, articles review, short surveys, etc.).

Results

Derived from the methodological procedure, Tables, Graphs and Figures related to industry 4.0 in educational innovation were obtained, resulting in elements of technological competencies as findings. Among the main findings are the annual scientific production of technological competences in education, the Figure of the three fields (list of countries, universities and thematic trends), and the thematic groupings, the top 20 authors with the most publications, the top of countries with the most publications, and ends with the top of emerging technologies and technological competencies of industry 4.0 in educational innovation.

Figure 2. Annual scientific production of Industry 4.0 and educational innovation
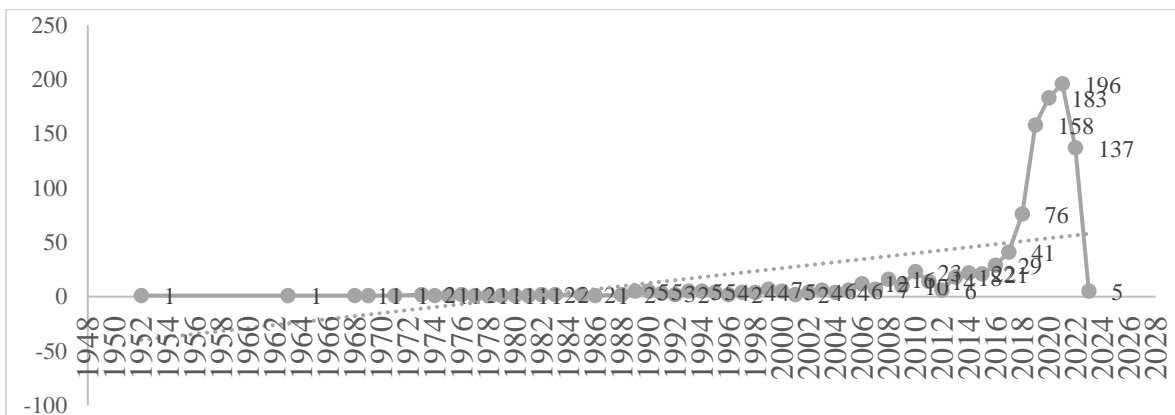
Source: Scopus

From the previous Figure, there is a horizontal axis of years and a vertical axis with frequency scales of documents published in each year. It can be seen that the topic, since its beginnings in the 1950's, has not had great relevance in terms of the interest of the scientific community, and it was not until before 2010 that it began to have some relevance, but until 2016 is when this topic is taking off exponentially and is expected to continue increasing in the coming years. It is important to clarify that the trend is perceived to have decreased in 2023 and 2024, but this is because when the analysis was carried out, the year 2023 had not yet ended. The main finding of the annual scientific production is that this topic is beginning to have a trend exponential rise, and it will have to be followed up within the scientific community and in different areas.

Figure 3. Three fields: Countries, universities and thematic trends
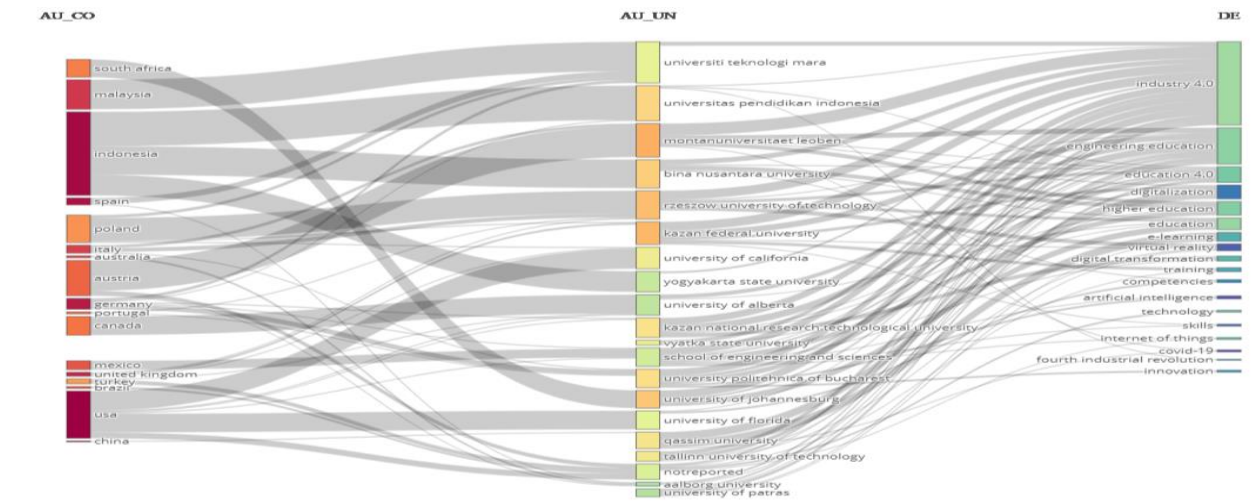
Source: Scopus

From the previous Figure, a top 20 elements are observed in three columns with higher or lower colored boxes according to the frequency of the count of the analysis of the elements found under the criteria of the search equation carried out in Scopus. On the left is the column of countries, in the center the affiliations or universities and on the right the thematic trends through keywords, and how each of these elements are related through gray lines.

Among the most notable countries are Indonesia, the USA and Malaysia. In this regard, in Latin America, Mexico and Brazil are identified within the top. On the other hand, regarding universities, the MARA University of Technology of Malaysia stands out (*Universiti Teknologi Mara*), Indonesian University of Education (*Universitas Pendidikan Indonesia*), Leoben University (*Montanuniversität Leoben*), Binus University of Indonesia (*Bina Nusantara University*), Rzeszow University of Technology in Poland (*Rzeszow University of Technology*) among other.

It is worth mentioning that participation from educational institutions from countries such as the United States, Kazan, Russia, Romania, South Africa, Saudi Arabia, Estonia, Denmark, and Greece among others also stands out. On the other hand, regarding the last column of keywords or themes, the interest of the scientific community is mainly focused on topics such as industry 4.0 and engineering education, education 4.0, digitalization, higher education, e-learning, virtual reality, transformation digital, training, skills, artificial intelligence, technology, skills, internet of things, COVID-19, fourth industrial revolution, and innovation.

From all of the above, it is interesting to note that Indonesia and the United States are the countries that have the most Universities and Research Centers present in the study of the technological competencies of Industry 4.0 in higher education. Also, those related to the

technological competencies of Industry 4.0 in educational innovation also highlight some emerging technologies that are already in the research spotlight, such as digitalization, virtual reality, digital transformation, artificial intelligence, internet of things, and innovation.

Figure 4. Thematic groups
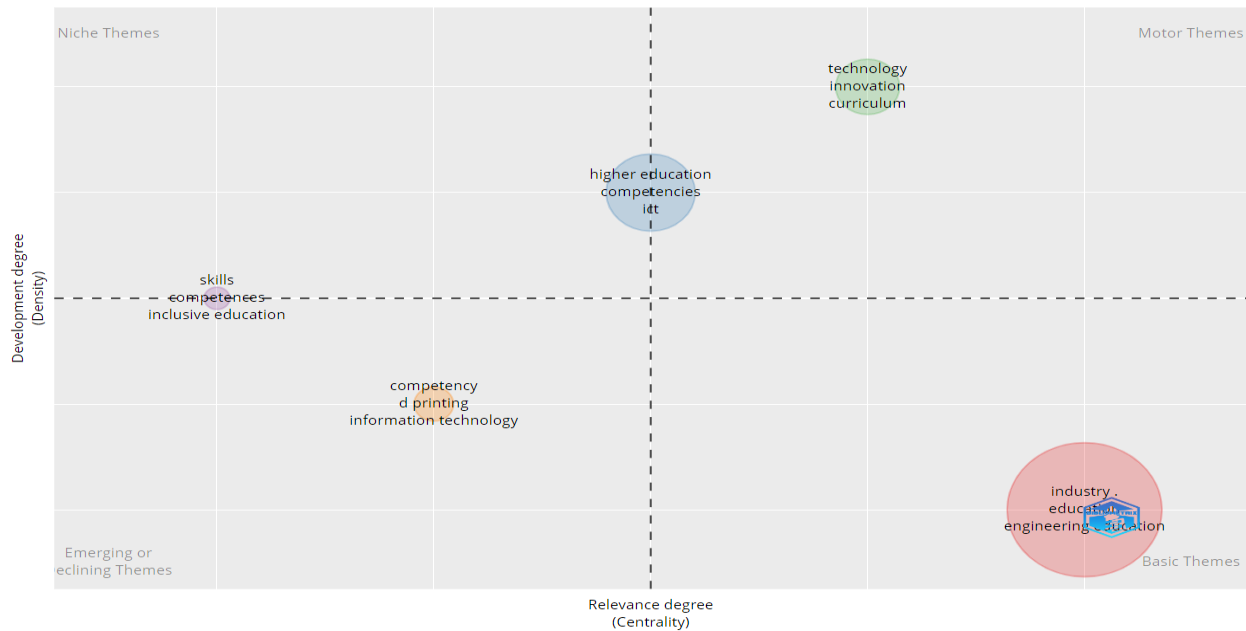
Source: Scopus

From the previous Figure, it is observed in the quadrant that the horizontal axis is governed by the centrality of the themes or their degree of relevance, while the vertical axis is governed by the density of the themes or their degree of development. The thematic map is made up of four quadrants, in these quadrants are the motor themes of the first quadrant, with density and positive centrality, the second quadrant with the highly developed and isolated themes or niche themes (located by their negative density and positive centrality). , the emerging or declining themes of the third quadrant (density and negative centrality), and finally a fourth quadrant, of basic and transversal themes of positive density and negative centrality.

From this Cartesian plane, the topics that are the driving force, in a first group, are technology, innovation and the curriculum, while at the limit as highly developed topics with opportunities for growth are found in another group, skills, the Internet of things, higher education and also to a lesser extent the third made up of skills, competencies and inclusive education. For its part, well-defined emerging topics are additive printing, while skills and information technologies would be considered declining topics. Finally, the transversal or basic themes would be the industry, education in general and specifically engineering education, where disruptive

advances and digital transformation mark the characteristics of the next industrial revolutions, such as the stage of the fifth industrialization (Broo, Kaynak & Sait, 2022).

Table 3. Authors with the most publications

#	Author	Publications	#	Author	Publications
1	Pacher, Corina	10	11	Doost	4
2	Woschank, Manuel	10	12	Molina, Arturo	4
3	Makarova, Irina	7	13	Mukhametdinov, Eduard	4
4	Mourtzis, Dimitris	6	14	Putnik, Goran	4
5	Rauch, Erwin	6	15	Shubenkova, Ksenia	4
6	Gorshenina, Svetlana N.	5	16	Adnan, Airil Haimi Mohd	3
7	Ciolacu, Mónica	4	17	Alves, Cátia	3
8	Gupta, Kapil	4	18	Anshari, Muhammad	3
9	Kondratyev, Vladimir V.	4	19	Assante, Dario	3
10	Mavrin, Vadim	4	20	Bonnaud, Oliver	3

Source: Scopus

From the previous Table, the authors Corina Pacher from the Resource Innovation Center of Austria, and Manuel Woschank from the University of Leoben in Austria stand out, they remain in the top with 10 publications, then they are followed by other authors in very consecutive climbing in the top 20.

Table 4. Top countries

#	Country	Publications	#	Country	Publications
1	USA	145	11	India	33
2	Russia	104	12	Australia	32
3	Germany	61	13	Brazil	28
4	United Kingdom	55	14	South Africa	28
5	Spain	53	15	Austria	26
6	Indonesia	49	16	Poland	26
7	China	46	17	Portugal	26
8	Malaysia	41	18	Canada	25
9	Italy	36	19	Türkiye	25
10	Mexico	34	20	Colombia	18

Source: Scopus

From the previous Table of the top 20 countries that publish the most about the technological competencies of Industry 4.0 and educational innovation, it is observed that developed economies such as the United States in America and Russia in Asia maintain the leadership in terms of the publication of the topic with 145 and 104 documents respectively. Then other countries such as Germany, the United Kingdom, Spain, Indonesia, China and Malaysia follow further down. Finally, another group of countries is visualized consisting of India, Australia, Brazil, South Africa, Austria, Poland, Portugal, Canada and Turkey. From the above, it is perceived that the European continent is the one that maintains the most interest in continuing to develop research related to the topic with 8 investigations, then followed to a lesser extent by the Asian continent with 6 publications, the American continent with 5 publications, and Africa one.

Figure 5. Trend of emerging technologies and technological competencies
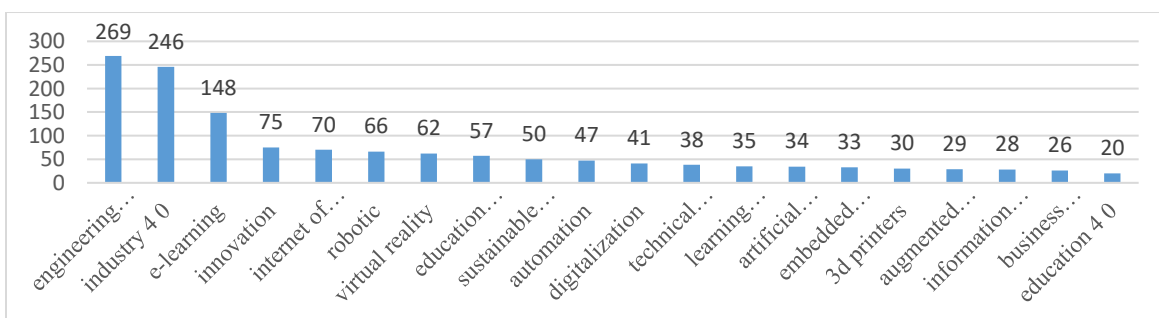
Source: Scopus

From the previous Figure, two types of main findings are observed, one that has to do with the most prominent emerging technologies in the educational field, and another that has to do with the orientation of technological competencies. Regarding the findings of emerging technologies, the following can be seen: Internet of things, robotics, virtual reality, automation, digitization, artificial intelligence, embedded systems, 3D additive printing, augmented reality, information and communication technologies, etc. Regarding the findings of the orientation of technological competencies, the following are observed: engineering education, e-learning, innovation, computer education, sustainable development, learning systems, technological education, business models, education 4.0.

In general, engineering education represents the largest topic of research and interest in different economies and countries of the world with 269 works. Then follows the term industry 4.0 (with 246 counts), which is not surprising, since it was part of the search equation and has 246 results. Later in third place is e-learning, as a trending topic with 148 documents. In this regard, autonomous learning techniques make it possible to evaluate learning through virtual environments and develop technological skills necessary for the next industrial revolutions (Ciolacu et al., 2017).

Of these three themes, the focus of different countries on improving their technological and engineering skills stands out, that is, seeking to continue improving the mechanisms that allow the learning of such hard sciences of the next industrial revolutions. In this same order of ideas, at a lower level than the previous trend topics, we can place terms such as innovation (75), internet of things (70), robotics (66), virtual reality (62) and computing (57).

Finally, there are topics such as sustainable development, automation, digitalization, technical skills, learning systems, artificial intelligence, embedded systems, additive printing, augmented reality, information technologies, business model and education 4.0.

It is important to mention that, although not directly present, practices such as big data and cloud computing are implicit in many of the technologies found as a discovery. Expanding on the previous point, cloud computing has been growing a lot in industrial environments, and has taken on different widely practiced aspects, such as, for example, software as a service (SaaS) in CAD or computer-aided design applications. computer (Gaha et al., 2021). In this regard, the latter represent a challenge to overcome in developing economies (Sánchez, Alvarez & Croda, 2021).

Discussion

The findings allowed us to identify different key points to take into account for the development of the topic in different sectors. These points deal with annual scientific production, the relationship between countries with universities and trending topics, thematic groupings, the countries that study the topic the most, the universities that are delving deeper into the topic, authors and thematic trends. Regarding the findings of the incremental growth of annual scientific production, the interest in exploring the topic of emerging technologies of industry 4.0 agrees with the results of other research (Corzo-Ussa, Alvarez-Aros & Chavarro-Miranda, 2022; López-López, Rodríguez-Cotilla & Alvarez-Aros, 2022), in which it has been identified how the accelerated changes in the industry are impacting to that extent the development and use of new technologies.

Regarding the findings regarding the relationship of countries with universities and trends, it is interesting to note that Indonesia and the United States are the countries that have the most universities and research centers present in the study of the technological competencies of industry 4.0 in higher education. . In this order of ideas, within the trends, some emerging technologies that are already in the focus of research stand out, such as digitalization, virtual reality, digital transformation, artificial intelligence, the internet of things and innovation. The latter agree with the findings of other researchers (Alvarez-Aros & Bernal-Torres, 2021; Villegas-Valle, Walle-Vazquez & Alvarez-Aros, 2021), that emphasize the need to continue with the maturity of industry 3.0 technologies in developing economies, as it represents a pending agenda in said governments to continue technological advancement.

Regarding the findings of emerging technologies, the internet of things, robotics, virtual reality, automation, digitalization, and artificial intelligence, among others, can be seen as the most prominent enabling technologies globally, however, other studies diverge in terms of these priorities, finding technologies such as big data or blockchain as fundamental elements to develop in industry 4.0 scenarios (Cruz-Manzo et al., 2023; Sánchez, Alvarez & Croda, 2021). This may be due to the fact that there is currently a very dynamic and changing environment regarding technological issues, which means that priorities may be different, depending on the moment, the delimitations and the regions where said technological changes are studied.

Within the topic of Industry 4.0 technologies in education, a point to discuss of equal interest is to visualize some myths and truths and negative aspects of technology in the educational sector, since excessive use of technology and learning electronic, could cause different types of problems in individuals, arguing for techno-skepticism as a possible result of technological changes (Sultany & Halford, 2013). The new convergence of technologies impacts all disciplines of science,

in addition to raising ethical principles in relation to correct management, as it is influencing the use of ICT, changes in renewable energy, and health. In addition, it promises a better expectancy and quality of life and in areas such as education it could improve its quality, as well as favorably influence professional development, among other aspects (Navalpotro & Pastor, 2024).

Conclusions

This research was able to investigate the influence of technological competencies and emerging technologies of industry 4.0 in the transformation of educational innovation towards education 4.0 through bibliometrics and a systemic review of literature. The results allowed us to identify the most studied emerging technologies on the planet, such as the internet of things, robotics, virtual reality, automation, digitalization and artificial intelligence, among several. Another finding is that the trend of technological competencies is oriented towards engineering education, e-learning, innovation, computer education, sustainable development and learning systems, among others. In addition to the above, it is necessary to clarify that the issue is immersed in technological change that is growing exponentially without precedent. In this sense, it is seen that the next jobs will not even be related to the existing trades and jobs of today. That is why the fact that education advances gradually along with technological advances is a latent need from any latitude, since today's human resources with job skills need to be updated.

In a synthetic way, it can be stated that the convergence of emerging technologies of industry 4.0, future technological skills and education 4.0 is shaping a new paradigm in the workplace and education. In this way, the interconnection of Emerging Technologies of Industry 4.0 is marked by technologies such as the Internet of Things (IoT), artificial intelligence (AI), advanced robotics, virtual/augmented reality and additive manufacturing. And, furthermore, the integration of these technologies allows for more efficient and connected systems, creating intelligent and productive work environments. On the other hand, it is important to highlight that covering the need for technological skills is essential to make the most of Industry 4.0. Skills in programming, data analysis, cybersecurity, technology management, among others, are required. And also, the ability to quickly adapt to new technologies is required and continuous learning becomes crucial.

 In another order of ideas, treating the point of education 4.0 as a facilitator, it can be stated that it focuses on innovative and technological teaching methods. Project-based learning, the use of online platforms, virtual reality and other digital tools are integrated into the educational process.

Education must be aligned with the demands of the labor market, providing students with the skills necessary to succeed in technological work environments. In addition, flexibility and adaptability to technological evolution, interdisciplinary collaboration and without ceasing to emphasize socio-emotional skills must be taken into account. In summary, the successful integration of emerging technologies, technological competencies and Education 4.0 requires a holistic perspective that encompasses both technical and social and emotional aspects. The ability to adapt and continually learn becomes crucial in this dynamic and technological environment. Within the limitations of the study, it is important to highlight that although systematic literature reviews supported by software allow the authors' inferences to be significantly reduced, there are still no automatic methods to successfully integrate different databases, which is why this work I only look at the Scopus database.

Future lines of research

As future lines of research, it is suggested to carry out future research that contemplates other databases such as Web of Science or Dimensions, in addition to carrying out studies contemplating the industry 5.0 scenario in depth, society 4.0, the immersion of new technologies in an integral field of the penta-helix, since these future trends could complement and detail more specifically the path to continue in the implementation of enabling technologies. It is also suggested to expand the topic towards the ethical and social dimensions that new technological developments imply, as well as the digital divide or the gender gap, to mention some additional topics.

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