

THE DIGITALISATION IMPACT ON EDUCATION LEVEL - A BIBLIOMETRIC ANALYSIS

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Abstract: *In the era of accelerated digitalisation, the field of education has been profoundly influenced by technological advances, transforming the way pupils and students learn and teachers teach. This study aims to conduct a critical and constructive bibliometric analysis of a set of scholarly papers published between 2009 and 2024, with a focus on the impact of digitization on education. To carry out this study, 256 relevant documents were identified through the keywords “digitalisation”, “impact” and “education” using the Web of Science (WOS) database. Subsequently, after processing and filtering these documents, a set of 238 documents was used as the basis for the study. The analysis was done using R statistical software, with the Biblioshiny bibliometric extension. The research design was a mixed-method, combining quantitative and qualitative data to achieve a comprehensive descriptive analysis. The findings of the study show the trends identified in research on the impact of digitalisation in education and the predominant topics or areas of interest.*

Keywords: digitalisation impact, education, bibliometric analysis

1. Introduction

The digitalisation process has brought both significant challenges and opportunities, fundamentally shaping the contemporary educational landscape. Digitalisation means much more than simply using the technology in the classroom. It is a paradigm in which information is accessed, stored, distributed and processed in a digital way [1]. This fundamental change in the way the educational process itself takes place has a profound impact on the entire educational system [2].

One of the most obvious transformations is the increased accessibility to educational resources. Through online platforms, courses and educational materials can be accessed at any time and from anywhere, removing geographical and time barriers.

This opens doors to education for those who would otherwise have difficulty accessing traditional learning resources [3]. Digitalisation is not just about providing educational content online. It is also redefining the way we teach and learn. Emerging technologies, such as virtual and augmented reality, enable interactive and immersive learning experiences that can improve comprehension and retention. Data analytics tools can also provide valuable insights into individual student progress and needs, allowing teachers to better personalize learning [4].

2. Literature Review

It is important to recognize the challenges and benefits of digitalization in education. Although the benefits are often discussed,

access to education can pose a major problem and some communities may be marginalized due to lack of access to technology or insufficient digital skills [3]. Also, throughout this educational process, it is essential to address data security and privacy issues to protect sensitive student and teacher information.

Digitalization in education can either reduce or widen existing gaps between socio-economic and geographical groups in Chakraborty opinion [5]. While efforts have been made to address educational disparities, the recent shift to online learning during the pandemic has highlighted the importance of access to technology in reducing inequality [6],[7]. Studies show that access to technology improves academic outcomes and can help mitigate disparities, particularly related to socioeconomic status. However, digital resources may not significantly benefit lower-income students due to issues such as unequal access, circumstances, and self-regulation [8]. Differences in internet access, device ownership, and technology use exist across different age groups, rural and urban areas, and income levels, highlighting the need for interventions such as technology resource centers and public-private partnerships to bridge the digital divide in education [9].

The integration of digital technologies, including e-learning platforms, educational apps, and online resources, has a significant impact on how students learn and assimilate information [10]. These technologies offer flexibility, customization, and adaptability, allowing learners to access educational content anytime, anywhere, and at their own pace [11]. They facilitate interaction and collaboration between learners and teachers, enhancing the learning experience [12]. Digital tools enable effective assessment, and progress tracking, providing immediate feedback to students. In addition, the use of digital technologies ensures objectivity in the assessment of knowledge, promotes active student participation, and motivates learners to

engage more effectively in the learning process. Overall, the use of e-learning platforms, educational apps, and online resources revolutionizes education by meeting the diverse needs of learners in the digital age [13].

Another aspect that we consider important is that the impact of digitalization in education starts with the learning process, moves on to the knowledge process, and then extends to the assessment process. Digital technologies can provide more diverse and accurate ways of assessing students' knowledge and skills [14]. For example, online assessment tools can provide immediate and personalized feedback to point students in the right direction.

As we move into the digital age, it is essential to continually explore ways in which technology can improve the quality and accessibility of education [15]. Educational platforms provide tools for flexibility, personalisation and assessment, enabling learning anytime and anywhere [16]. Teachers are adapting to digital transformations by redesigning courses and assessments, and focusing on accessibility and flexibility [17].

However, the implementation of digital technology in assessment practices can lead to challenges, such as an unintentional shift to closed assessments, which could hinder transparency in student understanding [18]. The modern education system is moving towards lifelong learning and self-education, highlighting the need for innovative teaching methods and the development of teachers' ICT skills to effectively navigate the digitalised educational landscape [19]. Online learning apps are used for instructional delivery and assessment, with gender differences observed to the extent of their use by lecturers [20].

Educational institutions can support the development of digital competence by integrating information and communication technologies (ICT) into the educational process, focusing on improving digital

competence among students and teachers [21], [22].

To align with sustainability goals, higher education institutions should revise curricula to include interdisciplinary skills for the digital age, with an emphasis on technology and management skills [23].

3. Methodology

The fundamental objective of this research is to gain a detailed, analytical and critical understanding of the implications of technologies in the educational process through content analysis of relevant papers. The data used in the analysis were extracted from the Web of Science database and were processed with the econometric software R using the Biblioshiny extension. We identified a total of 256 relevant articles, based on specific key terms such as Impact of digitalization in education.

The reason for choosing these terms was

their relevance in the context of the field and area of interest. We did not intend to apply a broader approach as we tried to have as few errors as possible. The period analyzed was January 2009-February 2024. The mode of analysis is descriptive by interpreting the data emerging from the bibliometric analysis. The research design is mixed because quantitative and qualitative data were combined and statistical software was used to process the data.

4. Results and Discussion

4.1. General Data

Given the above, Table 1 illustrates the distribution of articles in the most significant WOS categories in which at least 5 record count, considered to be the most important for the field of research addressed, were identified before being processed.

Table 1: Distribution of articles in the most significant WOS categories
(Source: Authors' processing using WoS data)

Web of Science Categories	Record Count	% of 256
<i>Education Educational Research</i>	69	26.95
<i>Management</i>	30	11.71
<i>Economics</i>	26	10.15
<i>Environmental Sciences</i>	23	8.984
<i>Green Sustainable Science Technology</i>	22	8.594
<i>Business</i>	17	6.641
<i>Environmental Studies</i>	14	5.469
<i>Multidisciplinary Sciences</i>	9	3.516
<i>Public Environmental Occupational Health</i>	8	3.125
<i>Computer Science Interdisciplinary Applications</i>	6	2.344
<i>Forestry</i>	6	2.344
<i>Information Science Library Science</i>	6	2.344
<i>Medicine General Internal</i>	6	2.344
<i>Social Sciences Interdisciplinary</i>	6	2.344
<i>Engineering Environmental</i>	5	1.953
<i>Engineering Industrial</i>	5	1.953

From this Table, it is evident that areas such as Management and Educational Research attracted the attention of the majority of researchers, obtaining high scores (69 and

30 respectively), suggesting an increased interest in these topics. On the other hand, Engineering Environmental and Industrial obtained the minimum score of 5 record

count, indicating a lower involvement or relevance in the academic discussions analysed. This analysis highlights the importance and diversity of concerns in education in the context of interaction with

evolving technology.

4.2. Citation and Publication over Time

Figure 1 provides with an overview of the period analysed but also with important data for this study.

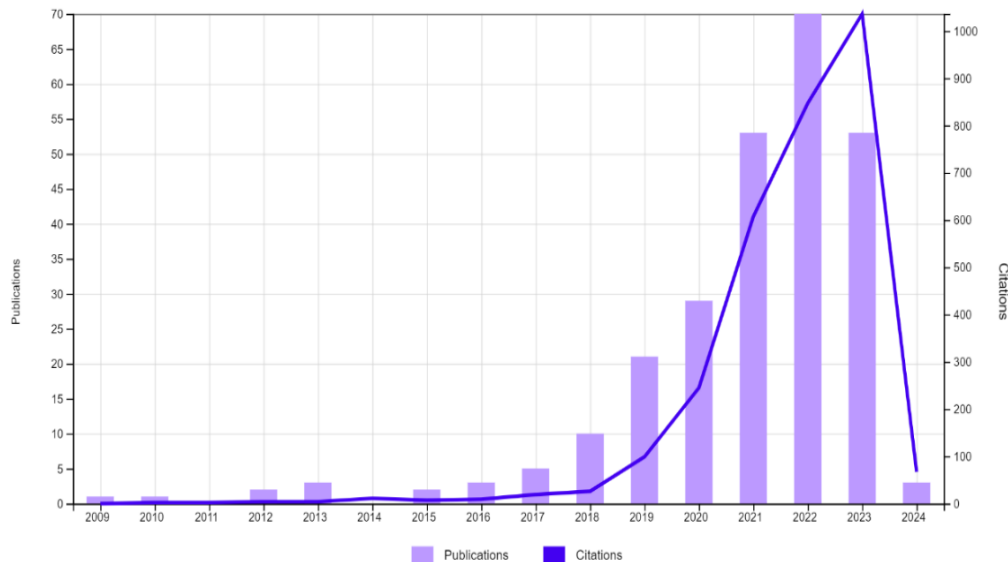


Figure 1: Times Cited and Publications Over Time
(Source: Authors' research using WoS data)

The publications are represented by bars, and peaked in 2022, when the coronavirus pandemic was coming to an end and recorded 1000 publications. The line shows that the maximum number of citations in this direction, which also represents interest in the topic, was reached in 2023. It should be noted that the trend is upwards, the decrease being due to the period when we extracted the database, which is the

beginning of 2024, more precisely 10 February.

From the total of 256 articles extracted, those that were published in languages other than English have been removed, as there could be errors in the study in terms of data accuracy.

4.3. Data Extracted

Table 2 therefore gives a detailed picture of the data on which the study itself was based.

Table 2: Total of 238 documents extracted from 2009-2024
(Source: Authors' research from WoS database analysis)

Bibliographic sources	2009:2024
Sources (Journals, Books, etc)	200
Documents	238
Annual Growth Rate %	11,33
Document Average Age	3
Average citations per doc	12,37
References	0
DOCUMENT CONTENTS	
Keywords Plus (ID)	555
Author's Keywords (DE)	1059
AUTHORS	
Authors	799

<i>Authors of single-authored docs</i>	26
AUTHORS COLLABORATION	
<i>Single-authored docs</i>	26
<i>Co-Authors per Doc</i>	3,53
<i>International co-authorships %</i>	25,63
DOCUMENT TYPES	
<i>article</i>	166
<i>article; book chapter</i>	2
<i>article; early access</i>	14
<i>editorial material</i>	2
<i>proceedings paper</i>	37
<i>review</i>	15
<i>review; early access</i>	2

Table 2 is an essential element of our analysis, providing a complete and detailed of the situation of our study. By analyzing the specified period, we can gain a deeper understanding of the evolution of research over time and emerging trends in the field under study. Through the number of documents included, we can assess the extent and intensity of academic discussions related to the topic under

discussion, thus reflecting the level of interest and importance attributed to it by the academic community.

4.4. Relevant Sources

Figure 2 shows the most 10 relevant sources witchd provided most relevant documents in the analized field. Sustainability publication ranking includes environmental, economic and social in the search for sustainable solutions to current problems, it has a total of 10 documents.

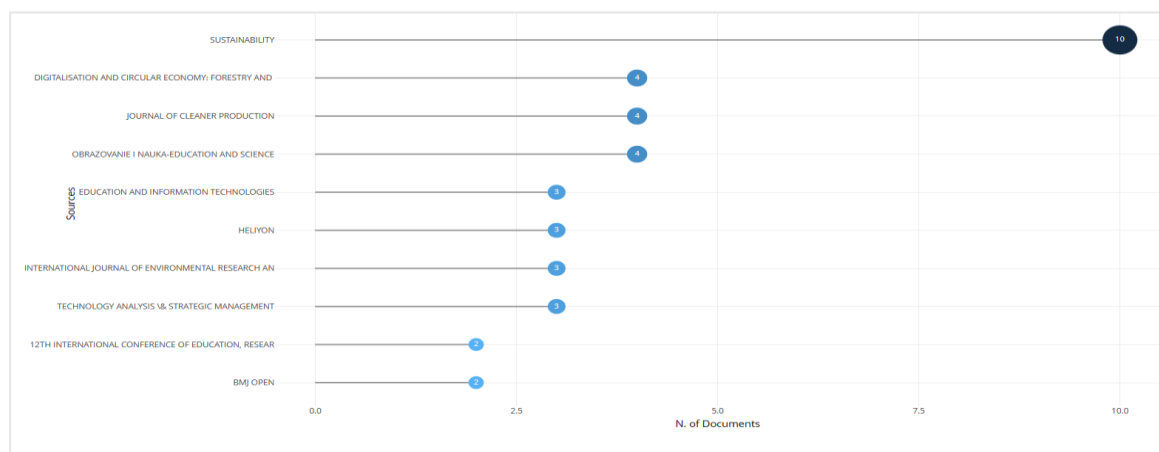


Figure 2: The most 10 relevant sources
(Source: Authors' research based Biblioshiny results)

The publication „*Digitalisation and circular economy: forestry and forestry based industry implications*”, comprises 4 documents focusing on digitalization and circular economy with specific implications for the forestry and forestry based industry. This seems to be an area of increased interest given the significant number of articles. Also 4 documents, but exploring

issues related to clean and innovative production, focusing on methods and technologies for reducing environmental impact belong to the Journal of cleaner production journal. The other publications such as *Education and information technologies*, *Heliyon*, *International journal of environmental research and public health*, *Technology analysis & strategic management* have 3 documents.

12th international conference of education, research and innovation and Bmj open, each have a smaller number of documents, and covering various aspects of technology, education, and environmental and public health impacts.

4.5. Most Cited Countries

Another aspect is the average number of citations per document. This metric provides insight into the impact and influence of papers within the research field, indicating their recognition and relevance in the scientific community. Thus, a higher average number of citations per paper may suggest a significant contribution and stronger influence within

academic discussions. Taken together, these aspects present a more complete and informed perspective on the current state of research in the field under analysis, allowing us to assess not only the quantity but also the quality and impact of papers within the academic community. Citations reflect the intellectual links between publications, which are formed when one publication cites another. Figure 3 shows a taxonomy of country through citation analysis. The analysis makes it possible to determine the most influential country in a field of research.

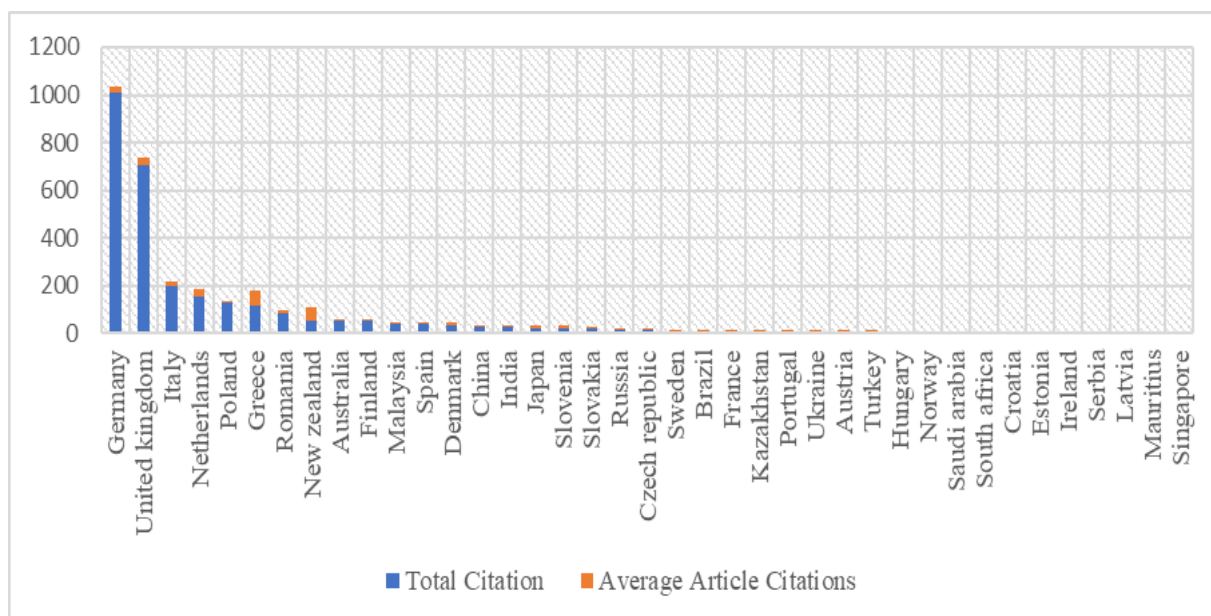


Figure 3: Most cited countries
(Source: Author's research)

Out of the total of 42 countries that had publications in the analysed direction, we selected only 38 countries, the limit being a minimum of 1 citations. Figure 3 highlight the most cited countries, and as we can see the first and most highly cited countries are Germany and the United Kingdom, which together have 1715 citations. Thus, papers with researchers from the first two countries generate more than 80% of all citations.

Romania has made significant progress in the research placing itself ahead of countries such as New Zealand, Australia and Finland with 87 citations, but also behind countries such as Poland and Greece with 127 and 119. Moderate citations were registered by the Czech Republic and Sweden, with only 14 and 10 citations respectively. Fewer citation are Serbia, Mauritius, Latvia, and Singapore.

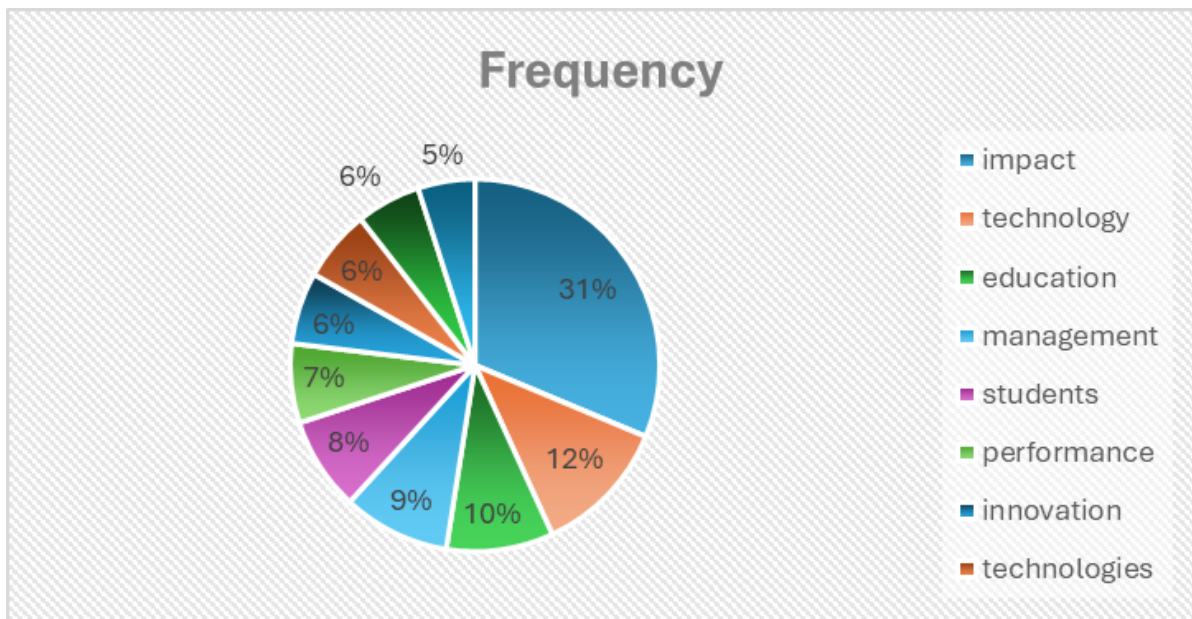


Figure 4: Words found most frequently in documents analyzed
(Source: Authors' research)

4.6. Most Frequently Words

The highest weight we see in Figure 4 is impact and has a frequency of (50), which indicates the importance of analysing the effects that digitalisation has on the educational process as a whole. This can be seen both through positive aspects, such as improved access to education, and challenges and negative effects, such as digital polarisation or uneven digital development. Technology and Tehnologies, with frequencies of (19) and (10) indicate the importance of technology in the digitalisation of education and suggest that the analysis focuses on technological tools and how they influence and transform the educational environment. They are correlated with innovation(10), an element that indicates increased interest in innovation in education through the implementation of digital technologies. It can explore how technological innovations can stimulate change and improvement in the educational process.

Words such as Education (15) and Students (13): highlight the focus of the analysis on the educational process and the impact of digitalisation on it. It emphasises the

importance of understanding how technology affects both teaching and learning and the experience of pupils and students.

Management indicates the emphasis on leadership and organisational aspects of implementing technology in education and has a frequency of (15).

Big data (9) and the Internet (8): These words suggest that the analysis also focuses on the use of data and the Internet in the context of the digitalisation of education. Methods of collecting, analysing and using big data and the internet to improve learning and teaching processes can be explored.

Together, these weights presented in Figure 4 indicate a comprehensive analysis of the impact of digitalisation on the education process, covering technological, management, performance and innovation aspects, with a focus on the use of technology and data in education.

4.7. Factorial Analyses

Continuing the links between the words used in the literature another interesting aspect can be seen in Figure 5.

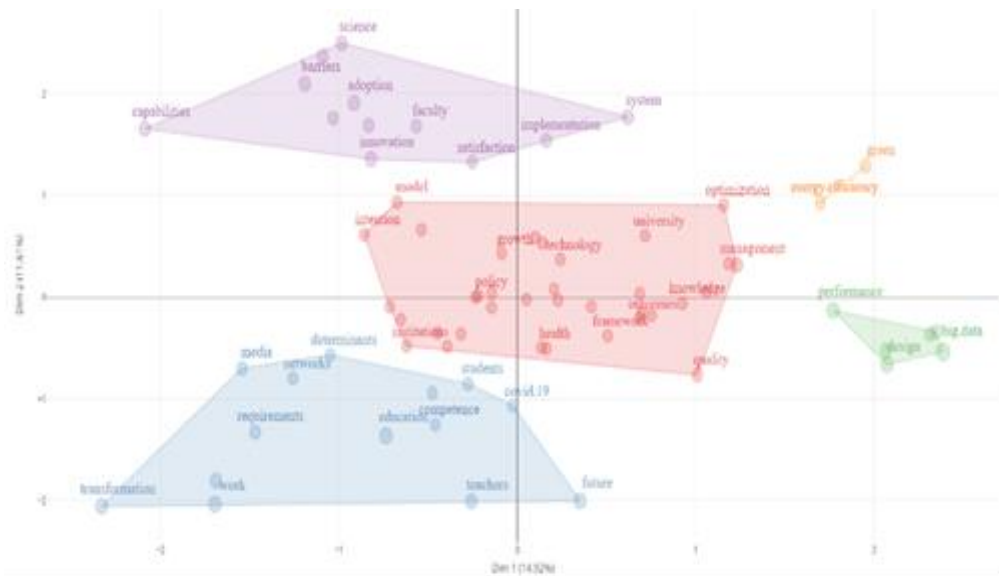


Figure 5: Factorial analysis of the most used terms
(Source: Authors' research by biblioshiny)

To simplify the data and to better understand the underlying relationships between variables, we believe that the factor analysis used examines the complex relationships between several observed indicators or variables and identifies the hidden structures or factors that contribute to these relationships. This presents an interesting situation of the terms grouped within the documents analysed according to the central tendency by five factors. Thus in Figure 5, the most representative terms that constitute the main factor (red) close to the central tendency are: growth, policy technology and health, and those furthest from the central tendency that belong to the same red area are: optimisation, management and quality. This points to a high significance of causality between growth, policy, technology and health in various contexts because health variables such as health care expenditure, human development index, life expectancy and mortality have a substantial impact on economic growth. Improved health also leads to economic growth, indicating that health acts as a transmission mechanism through which education drives economic progress. Understanding the causal

relationships between growth, policy, technology and health is vital for formulating effective strategies to promote sustainable economic growth and societal well-being.

In the second most important factor (blue) at the bottom of the figure, the term closest to the central trend is students and the term furthest from the central trend is transformation. The third most important factor (purple) in terms of the terms analysed shows that the terms closest to the central trend are satisfaction and implementation, while the opposite term is capabilities. The fourth and fifth most distant factors (orange and green) have energy efficiency and performance as terms of high importance.

5. Conclusion

Digitalisation has fundamentally reshaped the education landscape, offering significant opportunities and challenges. The study highlights its impact in education and how it influences the whole educational process.

Analysing the 238 papers extracted, the study provides a comprehensive overview of the state of the research, including the

period analysed and the number of papers, reflecting the level of interest and importance attributed by the academic community. The limitations of this study are that the analysis is based on data extracted from a single Web of Science database and that the methodology used may have some limitations or involve some errors. Bibliometric analysis can provide an overview of trends and impact of research in a given field but may have limitations in terms of data interpretation and

extrapolation of results. To fully understand the impact of digitalisation in education and to identify best practices and strategies, complementary and diversified studies exploring different aspects of this complex issue are needed. Thus through the critical and objective analysis carried out, we believe that trends in the impact of digitalisation on educational research have been identified, highlighting the predominant areas of research and evolution over time.

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