Research Article

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Research Field of Informatization in Special Education:  
Bibliometric Analysis of International Trends in Recent 15 Years

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Abstract

In the current era of educational informatization, the integration of information and communication technology (ICT) into special education has witnessed significant growth. Utilizing the expansive Scopus database and leveraging the Bibliometrix tool, this study systematically examines 130 scholarly documents within the domain of special education informatization, spanning the years from 2006 to 2021. Complementing a quantitative analysis, the study conducts a qualitative examination of 10 pivotal and widely cited works in the field. The research findings unveil a primary focus on the diverse application of ICT in special education, particularly its effectiveness in the diagnosis and intervention for various categories of special needs. Noteworthy concentrations of research output are identified, with a clear emphasis on publications in prestigious journals such as the International Journal of Emerging Technologies In Learning, Revista Brasileira De Educacao Especial, and Technology & Disability. Furthermore, the examination brings to light the dominance of keywords like “special education” and “information technology” in the literature, underscoring their pivotal role and persistent significance in the discourse. The consistent recurrence of these terms highlights their critical influence in shaping the landscape of special education informatization research. In conclusion, this comprehensive bibliometric analysis provides valuable insights into the trajectory of special education informatization research, elucidating key thematic areas and prominent journals. As the educational landscape continues to evolve, a nuanced understanding of the dynamics of ICT integration in special education becomes imperative for educators, policymakers, and researchers. This study serves as a foundational resource for further exploration and advancement in the ever-evolving field of special education.

Keywords: Informationization, ICT, Special Education, Bibliometric, Thematic Analysis

1. Introduction

The landscape of disability among children has undergone a substantial shift since the estimation by the United Nations Children’s Fund (UNICEF) in 2005, indicating approximately 150 million disabled
children under the age of 18. However, a recent report from UNICEF as of November 10, 2021, has revised this figure dramatically, suggesting that the global population of disabled children has surged to nearly 240 million. This staggering increase underscores the pressing need for innovative approaches to address the unique challenges faced by this demographic, especially as human society navigates the complexities of the modern information age.

The advent of the information age has brought about transformative changes in societal structures, facilitated by the widespread integration of Information and Communication Technology (ICT). Notably, this technological revolution is not confined to mainstream applications but has also permeated the field of special education (Table 1), emerging as a potent force for catalyzing reforms and enhancing the quality of teaching in special education.

ICT, encompassing informatics, telematics, and audiovisual communication methods, forms the cornerstone of the evolving information society (Larra, 2007). Defined as the use of information and tools to fulfill human needs, including the utilization of computers and contemporary devices such as the Internet, ICT represents a crucial resource for individuals with various disabilities. These technologies hold significant promise for improving the lives of users, offering versatile solutions that can assist individuals in overcoming limitations associated with their disabilities (Larra, 2007).

Even before the onset of the COVID-19 pandemic, a disheartening reality persisted: half of the world’s disabled children struggled to read simple texts by the age of 10. The pandemic exacerbated existing learning disparities due to unequal access to technology, leading to profound school closures. UNICEF reports have illuminated the deepening learning gaps within and between countries. Recognizing this critical juncture and the escalating population of children with disabilities worldwide, this article contends that a comprehensive investigation into the application of ICT in special education is imperative. As we strive for inclusivity and equitable access to education for all children, irrespective of their special needs, understanding the transformative potential of ICT becomes paramount in shaping the future of special education.

Table 1: Research on the application of ICT to different types of special education Objects

<table>
<thead>
<tr>
<th>Type of ICT</th>
<th>Special Object Type</th>
<th>Application Area</th>
<th>Approach</th>
<th>Ref.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computer</td>
<td>Learning difficulties</td>
<td>Math</td>
<td>Experimental research and questionnaire survey</td>
<td>Peltenburg, M.C. &amp; Heuvel-Panhuizen, 2011</td>
</tr>
<tr>
<td>iPad</td>
<td>Developmental disabilities</td>
<td>Reading</td>
<td>Single case studies and interviews</td>
<td>Therese &amp; Singh, 2014</td>
</tr>
<tr>
<td>E-learning and the World Wide Web</td>
<td>Intellectual disabilities</td>
<td>Social communication</td>
<td>Single case study and video Ethnology</td>
<td>Bunning et al., 2010</td>
</tr>
<tr>
<td>Virtual learning environment (VLE)</td>
<td>Learning disabilities</td>
<td>Cognition</td>
<td>Experimental Study</td>
<td>Ouherrou et al., 2019</td>
</tr>
<tr>
<td>ICT - based assessment instrument</td>
<td>Learning disabilities</td>
<td>Math</td>
<td>Experimental research and video recording</td>
<td>Peltenburg et al., 2010</td>
</tr>
<tr>
<td>Development of electronic equipment</td>
<td>Hearing impaired</td>
<td>Sign language learning</td>
<td>Experimental Study</td>
<td>Hernández, et al., 2015</td>
</tr>
</tbody>
</table>

Bibliometrics, employing mathematical and statistical methods, constitutes a powerful analytical tool, exemplified by the R-Tool, facilitating comprehensive science mapping analysis (Ghani et al. 2019). To delve into a nuanced examination of academic achievements, this study recognizes the need for diverse indicators beyond bibliometrics. In particular, citation analysis and peer review stand out as pivotal benchmarks for evaluating research impact. The integration of citation processing functions in leading databases, such as the Web of Science Core Collection (WoS) and Scopus, has notably streamlined the generation of bibliometric reports, offering researchers valuable insights into the scholarly landscape (Ellegaard & Wallin, 2015). However, it is imperative to exercise caution when comparing research outcomes across different fields due to the divergent coverage of these databases.
(Ghani et al. 2019). In light of this, our study meticulously compared the research coverage of key thematic terms, including "information technology," "informatization," or "information and communication technology," within Scopus and WoS databases. This comparative analysis aimed to discern the optimal research platform for our investigation.

2. Methodology

In the methodology employed, two major databases, Scopus and WoS, were initially selected. A systematic search for literature related to "information technology," "informatization," or "information and communication technology" was conducted within each database. The results revealed a substantial disparity, with WoS containing 1790 articles and Scopus surpassing with 2605 articles. While both databases hold prominence, the evident comprehensiveness of literature in the field within Scopus prompted the selection of this database as the primary research platform.

On December 24, 2021, a focused title search within the Scopus database for "information technology," "informatization," or "information and communication technology," within the time frame of 2006-2021, yielded 2605 qualified articles. These articles garnered a remarkable 30,827 citations, with an average of 11.8 citations per paper. The observed trend, illustrated in Figure 1, indicates a steady increase in the number of publications in the information field.

This methodological approach ensures a meticulous consideration of database nuances, emphasizing the importance of selecting a research platform aligned with the specific focus of the study. The detailed bibliometric analysis serves as a robust foundation for understanding and interpreting academic achievements in the realm of information technology, informatization, and information and communication technology, offering valuable insights for scholarly discourse and guiding future research endeavors.

Figure 1: Published trends in the field of informatization research 2006 – 2021

Moreover, the visual representation in Figure 2 illuminates that the United States, the United Kingdom, and China stand out as the triumvirate of nations contributing significantly to the voluminous literature in the field of informatization. A discerning analysis of the data for this period underscores the prominence of the United States, with an impressive publication count of 639 articles. The United Kingdom follows suit with 218 articles, and China exhibits substantial scholarly output with 153 articles. Consequently, it is evident that the United States assumes a pivotal role as the core country in shaping the discourse and advancements in the field of informatization.

This prominence may be attributed to a confluence of factors, including robust research
infrastructure, technological innovation hubs, and a conducive academic environment. The prolific output from the United States suggests a leadership role in driving the discourse forward, influencing global perspectives, and contributing substantially to the academic foundation of informatization. As the landscape of informatization continues to evolve, understanding the key contributors and their nuanced roles becomes essential for a comprehensive appreciation of the field's trajectory and future directions.

Figure 2: Top 15 country production in the field of informatization research 2006 – 2021

On December 24, 2021, a meticulous exploration of titles, abstracts, and keywords within the specialized Sopus database dedicated to special education, covering the time span from 2006 to 2021, revealed 130 articles. These articles collectively amassed 581 citations, averaging 4.677 citations per article—a figure noteworthy for its contextual comparison to the citations received by works within the broader spectrum of "information technology," "informatization," or "information and communication technology." The Bibliometrix-package (http://www.bibliometrix.org/) was employed for a nuanced analysis of this collected literature, aiming to elucidate the developmental trajectory of the special education informatization field. Table 2 provides a comprehensive summary of the primary bibliometric data, delineating the distribution of articles, book chapters, conference papers, reviews, editorials, books, and notes within the dataset.

To further refine our understanding of the current themes in the field of special education informatization, a qualitative analysis was conducted on 10 highly pertinent and extensively cited articles carefully selected from the pool of 130. Subsequent sections will delve into both quantitative and qualitative analyses, shedding light on the intricacies and advancements within the field.

Conducting a bibliometric analysis on the research landscape of informatization in special education over the past 15 years necessitates the establishment of clear inclusion and exclusion criteria. These criteria ensure the relevance and quality of selected documents, emphasizing a recent focus from 2009 to the present. Inclusion criteria encompass scholarly documents, including peer-reviewed journal articles, conference papers, books, and academic publications, with a preference for English language contributions. The research focus must specifically address the intersection of informatization and special education, exploring technology, digital tools, and information systems in special education contexts. A global perspective is sought, with diverse document types considered, such as empirical studies, reviews, meta-analyses, and theoretical papers.

Conversely, exclusion criteria rigorously dictate the removal of documents predating the stipulated 15-year period, emphasizing recent developments. Non-peer-reviewed sources, popular
media, and non-academic publications are excluded to maintain research integrity. Documents not available in English are excluded unless translations are readily accessible. A stringent exclusion of documents not explicitly addressing the relationship between informatization and special education is enforced. Geographic studies with narrow focus are excluded unless providing unique insights applicable to the broader international context. Finally, editorials, opinion pieces, and non-research-focused documents are excluded, ensuring the bibliometric analysis is firmly anchored in a robust empirical foundation. Adherence to these criteria ensures a comprehensive and rigorous selection of documents, facilitating a thorough examination of international trends in the field of special education informatization.

Table 2: Summary of the Main Information of Collected Bibliometric Data

<table>
<thead>
<tr>
<th>Description</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAIN INFORMATION ABOUT DATA</td>
<td></td>
</tr>
<tr>
<td>Timespan</td>
<td>2006:2021</td>
</tr>
<tr>
<td>Sources (Journals, Books, etc)</td>
<td>106</td>
</tr>
<tr>
<td>Documents</td>
<td>130</td>
</tr>
<tr>
<td>Average years from publication</td>
<td>6.05</td>
</tr>
<tr>
<td>Average citations per documents</td>
<td>4.677</td>
</tr>
<tr>
<td>Average citations per year per doc</td>
<td>0.684</td>
</tr>
<tr>
<td>References</td>
<td>3903</td>
</tr>
<tr>
<td>DOCUMENT TYPES</td>
<td></td>
</tr>
<tr>
<td>article</td>
<td>74</td>
</tr>
<tr>
<td>book</td>
<td>3</td>
</tr>
<tr>
<td>book chapter</td>
<td>6</td>
</tr>
<tr>
<td>conference paper</td>
<td>39</td>
</tr>
<tr>
<td>editorial</td>
<td>1</td>
</tr>
<tr>
<td>note</td>
<td>1</td>
</tr>
<tr>
<td>review</td>
<td>6</td>
</tr>
<tr>
<td>DOCUMENT CONTENTS</td>
<td></td>
</tr>
<tr>
<td>Keywords Plus (ID)</td>
<td>650</td>
</tr>
<tr>
<td>Author's Keywords (DE)</td>
<td>393</td>
</tr>
<tr>
<td>AUTHORS</td>
<td></td>
</tr>
<tr>
<td>Authors</td>
<td>349</td>
</tr>
<tr>
<td>Author Appearances</td>
<td>380</td>
</tr>
<tr>
<td>Authors of single-authored documents</td>
<td>19</td>
</tr>
<tr>
<td>Authors of multi-authored documents</td>
<td>330</td>
</tr>
<tr>
<td>AUTHORS COLLABORATION</td>
<td></td>
</tr>
<tr>
<td>Single-authored documents</td>
<td>22</td>
</tr>
<tr>
<td>Documents per Author</td>
<td>0.372</td>
</tr>
<tr>
<td>Authors per Document</td>
<td>2.68</td>
</tr>
<tr>
<td>Co-Authors per Documents</td>
<td>2.92</td>
</tr>
<tr>
<td>Collaboration Index</td>
<td>3.06</td>
</tr>
</tbody>
</table>

3. **Quantitative Analysis**

3.1 **Analysis of Year of Publication**

Figure 3 provides a comprehensive overview of the annual output of literature in the dynamic field of special education informatization from 2006 to December 24, 2021. Within this period, a total of 130 articles, 6 book chapters, 74 articles, 39 conference papers, 6 reviews, 1 editorial, 3 books, and 1 note were identified. The trajectory of the field manifests a notable upward trend, with fluctuations observed, particularly during the years 2015-2018. The lowest output was recorded in 2007, while the pinnacle of 15 articles was reached in 2019. This chronological progression can be delineated into three distinctive stages: from 2006 to 2009, the annual publication volume experienced a slow and steady development, averaging about 2 articles per year; the subsequent stage spanning 2010-2013 witnessed a marked acceleration, with an average annual publication volume of approximately 6 articles; and the period from 2014 to 2021 marked a phase of rapid development, characterized by a substantial surge in publications, averaging around 10 articles per year. An abrupt decline was
observed in 2020, followed by a rapid resurgence in 2021, reaching 14 articles—a figure reminiscent of the annual output in 2014 and securing the second-highest position.

In the same temporal scope of 2006-2021, Figure 4 delineates the annual average number of citations for these articles. Despite fluctuations, the overall trend showcases a progressive increase in citations, mirroring the trajectory observed in the annual output of papers. Remarkably, the average annual citation value reached 1.4 in 2006, tying with 2019 for the highest citation average, despite the fact that the literature output in 2006 was only three articles. Additionally, the literature published in 2020 exhibits low citation numbers, which may be attributed to its recent publication, and these values are expected to evolve as the work gains visibility and recognition within the scholarly community. The interplay between annual output and citation patterns provides valuable insights into the evolving dynamics and scholarly impact of the field of special education informatization over the examined timeframe.

Figure 3: Annual scientific output for special education informatization research, 2006–2021.

Figure 4: Average number of citations per year of articles used in the field of special education informatization research, 2006–2021.
3.2 Analysis of the Authors

Figure 5 provides a detailed illustration of the top 10 local citations, measuring the number of citations received from papers within the analyzed set from 2006 to 2021. The local citation metric offers a valuable perspective on the influence and interconnectedness of papers within the dataset. Notably, the highest average citation rate was observed in the literature from 2006, 2013, and 2014, with each of these three years yielding the same number of articles. This intriguing convergence in citation rates across different years highlights the enduring impact and scholarly significance of works from these particular periods.

Moving to Figure 6, it unveils the prolificacy and impact of the top 20 most relevant authors in the field of special education informatization during the years 2006-2021. The red line delineates the timeline, showcasing the temporal distribution of authorship contributions. Notably, DRIGAS A emerges as the author with the highest number of articles, totaling 7, and maintaining a substantial timeline from 2013 to 2021. The size of the bubbles denotes the quantity of articles published, with larger bubbles indicating a higher volume of contributions. For instance, DRIGAS AS published 3 articles in 2014, as indicated by the size of the corresponding bubble. The color intensity of the bubbles correlates with the total number of citations per year. An interesting observation is that KOKKALIA G stands out with notable citation rates, indicative of the scholarly impact of their contributions.

Furthermore, the citation rates of articles published by KHOWAJA K, DRIGAS A, and DRIGAS AS in 2014 are particularly noteworthy, all reaching 6 and surpassing those of other authors. This observation underscores the heightened interest and recognition garnered by the works of these researchers in the field of special education informatization during that specific year. Figure 6 paints a vivid picture of the expanding research landscape in special education informatization, evidenced by the increasing number of researchers engaging in meaningful contributions and inquiries within the field.

![Figure 5](image-url)  
**Figure 5.** Top 10 most local cited documents published on special education information research field
Figure 6: Top 20 most relevant author's production on special education informatization research field from 2006 to 2021 (red line: the author's timeline, bubble size: the number of publications, bobble color intensity: total citations per year)

3.3 Source Analysis

Figure 7 illuminates the top 15 most relevant source publications in the dynamic field of special education informatization. This comprehensive overview highlights key journals that have emerged as influential contributors, each boasting at least two or more articles within the analyzed set. Notably, the International Journal of Emerging Technologies In Learning, Revista Brasileira de Educacao Especial, and Technology & Disability emerge as cornerstone journals in the realm of information technology in special education. These core journals have consistently maintained their significance over the years, each publishing four articles from 2006 to 2021, securing the top rank. Their sustained contribution underscores their pivotal role as authoritative platforms for disseminating research in the intersection of special education and informatization.

Beyond these leading journals, the remaining publications included in the analysis have contributed two articles each, reinforcing the concentration of impactful research in the top-tier journals. As such, researchers and scholars navigating the field of special education informatization may find it beneficial to prioritize these core journals when disseminating their own scholarly contributions. This strategic emphasis ensures a higher likelihood of visibility and impact within the academic community, facilitating the advancement of knowledge and insights in this evolving and critical domain.
Figure 7: Top 15 most relevant sources by the number of documents published on special education informatization research

Figure 8 presents an insightful depiction of the evolving trend in the number of documents included in publications spanning from 2002 to 2021, encompassing a total of 15 journals within the field of special education informatization. Notably, the majority of journals exhibit a discernible upward trajectory in the inclusion of documents over the years, attesting to the expanding body of scholarly work in the field. A particularly noteworthy observation is the remarkable and pronounced upward trend evident in the journal Technology & Disability, indicating a robust and sustained scholarly output.

In contrast, Revista Brasileira de Educacao Especial, although not publishing articles before 2013, has exhibited a remarkable ascent, surpassing the International Journal of Emerging Technologies In Learning. In the most recent year, 2021, it has emerged as the second-largest relevant source in the field of information technology in special education. This rapid progression underscores the journal's growing influence and signifies its pivotal role in contributing to the scholarly discourse within the domain.

The nuanced analysis of trends in document inclusion across these journals provides valuable insights into the dynamic landscape of special education informatization. The ascendance of certain journals and their evolving roles over time underscores the changing dynamics of the academic conversation, offering researchers a roadmap for selecting key platforms for dissemination and engagement within this critical field of study.
3.4 Analysis of the State

In the dynamic realm of special education informatization, a comprehensive analysis reveals the publication of 130 documents originating from a diverse set of 44 countries. Figure 9 intricately maps the top 20 countries contributing to the scientific output in the literature. The red line delineates the total publications from authors within a country, encompassing documents completed through collaboration with one or more countries. Simultaneously, the blue line underscores the literature solely authored by individuals within the same country. The publications are categorized into Multi-Country Cooperative Publications (MCP) and Single Country Publications (SCP). Notably, China emerges as a prominent contributor with 13 articles, closely followed by Greece with 9 articles, and Australia and Malaysia with 8 articles each. These countries are deemed the most influential in research output, particularly with China occupying a core position in the field. However, it is noteworthy that among these noteworthy countries, only Turkey has engaged in international cooperation, exemplifying the need for further global collaboration.

Figure 10 provides a comprehensive overview of the number of authors in each publishing country, offering a nuanced understanding of the global authorship landscape. Figure 11 delves into the contributions of core countries in the field of special education informatization, representing the density of blue to signify the number of authors in each country. China emerges as the core country, with Greece and the USA securing second and third positions, respectively. The varying intensities of blue provide a visual representation of the concentration of authorship, emphasizing China's central role. Moreover, Figure 11 employs red lines to convey the degree of collaboration between countries, with thicker lines denoting more substantial cooperation. The most prominent connection is observed between Spain and Latvia, underscoring the depth of collaboration between these two nations. Additionally, USA and Finland demonstrate significant cooperation, emphasizing the global nature of research networks. Europe emerges as a focal point, with countries such as Finland, Spain,
and Ireland showcasing close scientific ties. These figures collectively unravel the intricate web of international collaboration and highlight the geographic distribution of scholarly contributions, shedding light on the interconnectedness of researchers and nations in the field of special education informatization.

**Figure 9**: Top 20 corresponding author’s country (red line: Multiple Countries Publication (MCP), Single Country Publication (SCP)).

**Figure 10**: Country’s scientific production world map of special education informatization research field (blue color intensity: the number of authors affiliated with each country, gray color: non-related country)
3.5 Subject Analysis

Figure 12 intricately unravels the core themes within the domain of special education informatization, employing a sophisticated keyword network analysis to unveil the interrelationships among various topics. The keyword network, a graphical representation of co-occurrences within the bibliography dataset, offers insights into the thematic clusters shaping this research field. Each bubble within the figure encapsulates a keyword network cluster, with the most prevalent keyword serving as the cluster's representative. Consequently, Special education, autism, assistive technology, human, and internet emerge as the most pivotal and interconnected core indicators within this dynamic landscape.

The size of each bubble corresponds to the frequency of cluster names, providing a visual indication of the prominence of each theme. The positioning of the bubbles is determined by the centrality and density of the cluster, reflecting the theme's importance and comprehensiveness within the broader context of special education informatization. Notably, the upper left corner showcases highly developed and isolated themes, while the upper right corner unveils sports-related themes. In the lower left corner, emerging or declining themes come to light, and the lower right corner houses core and horizontal themes, indicating the central and interconnected nature of these themes.

The keywords "design" and "development" are identified as highly developed and isolated topics due to their relatively lower importance and completeness. In contrast, "Special education" and "autism" emerge as core and horizontal themes, with "Special education" holding the distinction of being the most critical and core theme within the intricate fabric of special education informatization. This nuanced analysis provides a comprehensive understanding of the thematic landscape, allowing researchers to identify focal points and explore the interconnectedness of core themes within the field.
3.6 **Keyword Analysis**

Figures 13 and 14 present Three-field plots, offering a comprehensive exploration of the core keywords, sources, and authors within the field of special education informatization. Figure 13 focuses on the relationship between three core metadata fields: keywords positioned in the middle, sources on the left, and authors on the right. Noteworthy authors such as Drigas AS, Faerll HJ, Gil H, Ahmad WFW, Ioannidou RE, Harish G, Elhammoumio, Jimoyannis A, Ashman AF, El Kafi J, Benmarrackchi F, and Drigas A exhibit high usage frequency of essential keywords in their literature. Key themes such as special education, autism, ICT, assessment, evaluation, information and communication technologies, communication, education, information technology, intellectual disability, special educational needs, and assistive technology are prevalent in their works.

Furthermore, Figure 13 identifies that special education, ICT, assessment, and evaluation are frequently used keywords across major journals, such as International Journal Of Emerging Technologies In Learning, Revista Brasileira De Educaçao Especial, Technology and Disability, Applied Mechanics and Materials, Assistive Technology, Colloquium In Information Science and Technology, Cist, Communications In Computer and Information Science, Education and Information Technologies, European Journal Of Special Needs Education, Iberian Conference on Information Systems and Technologies, Cisti, International Education Studies, International Journal Of Electronics and Telecommunications, Journal of Vocational Rehabilitation, and Proceedings 2010 International Symposium on Information Technology Visual Informatics, Itsim’10. This underscores the significance of these keywords in shaping the discourse within the field.

Figure 14 delves into the interplay between three metadata fields: keywords plus in the middle, journals on the left, and authors on the right. Keywords plus, automatically generated by computers, encapsulate high-frequency words or phrases in title citations, offering valuable insights into the general characteristics and research hotspots of special education informatization. The analysis reveals that International Journal of Emerging Technologies In Learning is a pivotal platform for articles related to special education and information and communication technologies. This journal also publishes a substantial number of articles on autism, information use, engineering, and related...
Concentrated appearances of keywords such as special education, information technology, students, autism, and engineering are observed in Communications In Computer And Information Science. Key authors, prominently Drigas AS, actively contribute to the field, with their works predominantly featured in International Journal of Emerging Technologies In Learning and International Journal Of Electronics and Telecommunications. The consistent use of keywords such as special education, information, and information and communication technologies across authors underscores their prominence in the literature. The detailed insights provided by Figure 14 serve as a valuable resource for researchers seeking core journals and guiding their contributions to specific journals within the realm of special education informatization.

Figure 13: Three-field plot for the relationship among top keywords (the middle field), top authors (the right field), top sources (the left field) in flexibility housing for sustainability publications.

Figure 14: Three-field plot for the relationship among top keywords plus (the middle field), top authors (the right field), top sources (the left field) in flexibility housing for sustainability publications.
Figure 15 offers a nuanced conceptual structure diagram, providing a visual representation of the intricate relationships between keywords within all publications in the field of special education informatization. The horizontal and vertical coordinates in the figure denote the average position of the documents associated with each keyword, with the red center point representing the focal point of the special education informatization field. In this conceptual structure diagram, the interconnected network of words from each document facilitates a deeper understanding of research hotspots and the potential discovery of new topics. The utilization of data simplification techniques, particularly correspondence analysis, serves as a dimensionality reduction method in the production of conceptual structure diagrams (Ghani et al. 2015).

The figure reveals a distinct color-coded segmentation, with each color grouping representing a cluster of related keywords identified through clustering. The blue area encompasses keywords such as male, article, and female, though these keywords appear relatively distant from each other. In contrast, the red area encompasses a more extensive array of keywords, numbering around 20, including information and communication technologies, e-learning, computer-aided instruction, and learning disabilities. Notably, these red area keywords are closely interconnected, indicating a high degree of thematic cohesion and relevance within the special education informatization field (Muñoz Pérez & Delgado, 2019).

This conceptual structure diagram, through its visual depiction and clustering analysis, offers researchers a valuable tool to comprehend the prevalent themes, research interconnections, and potential areas of exploration within the dynamic landscape of special education informatization. The strategic use of correspondence analysis contributes to a more focused and insightful understanding of the complex relationships among keywords, ultimately aiding researchers in identifying emerging trends and navigating the evolving terrain of this research domain.

Figure 15: Conceptual structure map of keywords in special education informatization research field publications (Dim.1 and Dim.2: the average position of the articles included in each keyword)

Figure 16 shows the "topic tree diagram", which is a conceptual structure diagram of keywords. This topic tree diagram shows two sets of keywords, the height of which depends on the distance between words or phrases. Each tree diagram is described by a partition, and at the same time accurate partitions are performed.
Figures 17-20 serve as insightful visualizations, presenting the most frequently occurring keywords plus, author keywords, title words, and abstract words in the field of special education informatization from 2006 to 2021. Each figure encapsulates distinct aspects, shedding light on the diverse facets of research focus, author perspectives, and thematic content.

In Bibliometrics, the analysis of keywords plus and author keywords is a powerful means to comprehend the knowledge landscape. Figure 17 illustrates keywords plus extracted from the reference titles of each article, showcasing their depth and reflecting the richness of document content. With font size and color indicating their degree of importance, keywords like information technology, students, and education emerge as central and recurring themes, underscoring their significance in shaping the research field. Moving to Figure 18, the analysis of author keywords reveals patterns in subjective points of view, with special education, ICT, information technology, and information and communication technologies standing out as the most frequently occurring terms. These author-generated keywords provide a valuable lens into the researchers’ perspectives, offering nuanced insights into the prevalent topics within the literature. Figure 19 focuses on the words appearing in article titles, uncovering special education, communication technology, information technology, and visual impairment as prominent and relevant terms. This figure provides a snapshot of the key concepts emphasized in the titles, offering a glimpse into the overarching themes of published articles. Similarly, Figure 20 explores the words present in abstracts, revealing that special education, information technology, and communication technologies remain pivotal in the research discourse. Notably, the similarity between keywords appearing in titles and abstracts suggests the importance of selecting relevant and impactful terms when crafting both.

Lastly, Figure 21 captures the evolving landscape of core keywords in special education informatization from 2006 to 2021. It highlights the rapid growth of research topics related to special education and information technology since 2008. Moreover, the increasing prominence of words such as human, teaching, students, and education in recent years signifies the evolving focus of the academic community. However, there is a discernible decline in attention to words like e-learning and article, indicating shifts in research emphasis over time. This longitudinal perspective suggests a growing interest and potential contributions to the field of special education informatization, encouraging researchers to explore emerging themes and foster continued scholarly engagement.
Figure 17: Top keywords plus in special education informatization research field publications (font size: word occurrences).

Figure 18: Word of top author's keywords in special education informatization research field publications (font size: word occurrences)

Figure 19: Top title words in special education informatization research field publications (font size: word occurrences).
Figure 20: Annual occurrences of top keywords in special education informatization research field within 2006 to 2021

4. Qualitative Analysis

From 2006 to December 2021, there were 130 special education informatization documents, and 10 articles with high relevance and no less than 10 citation rates were selected from them. This section focuses on the analysis of the themes and the most frequently used research methods in the informatization of special education.

4.1 Subjects

In the realm of special education informatization research, prevalent themes include special education, ICT, disabilities, and intervention. Core journals extensively explore diagnostic and intervention tools, such as virtual environments, ICT, and the Internet, often presenting case studies or experimental research focused on the application of information technology for diagnosing and intervening with special education objects (Cumming et al., 2014; Bunning & Minnion, 2010). This thematic analysis reveals that 40% of the authors center their research on the intersection of ICT and special education, showcasing its significance in contemporary scholarly discourse. Additionally, the recurrent appearance of education as a keyword in 30% of the cited literature underscores its foundational role within the special education informatization landscape.

Furthermore, the diverse technological landscape is evidenced by the prevalence of terms such as flexible computation, iPads (Cumming et al., 2014), mobile technology, computers, mobile learning, social media, virtual learning environment (VLE), and computer access, each featured in half of the cited literature (Ouherrou et al. 2019; Cumming et al. 2014; Peltenburg et al. 2011; Peltenburg et al. 2010; Williams, 2006). The authors’ utilization of these terms highlights the broad spectrum of technologies explored in the context of special education.

However, it is noteworthy that certain keywords such as assistive technology (AT) and aids for the disabled are employed by only a limited number of articles, indicating a potential area for increased research emphasis. Surprisingly, information technology, despite being a critical term in the subject keywords, is relatively underutilized within this collection. Additionally, terms like computers and augmentative and alternative communication devices, along with computer-based activities, are infrequently featured in titles, reflecting a limited focus on these specific aspects.
The thematic analysis underscores the pervasive linkage between ICT and special education, with 40% of the articles identifying the application of ICT as a key focus in the field of special education informatization (Bari et al. 2013). A nuanced perspective is evident, as only 20% of the articles concentrate on the information literacy of teachers and students in special education (Bari et al. 2013). Moreover, 40% of the articles utilize ICT as a focal point in their titles, with a particular emphasis on assessing the effectiveness of ICT interventions and their impact on the development of special education students (Bari et al. 2013). Notably, research on the intervention of iPads and virtual learning environments on children with learning disabilities and developmental disabilities is recognized as effective (Cumming et al. 2014).

In essence, the prevalent themes and key focuses in special education informatization articles revolve around the dynamic relationship between ICT and various types of special education objects (Ouherrou et al. 2019; Hernández et al. 2015; Drigas et al. 2014; Cumming et al. 2014; Drigas & Kokkalia, 2014; Peltenburg et al. 2011; Bunning et al. 2010; Peltenburg et al. 2010; Pousada et al. 2011; Dempsey et al. 2009; Williams et al. 2006) This interconnection reinforces the significance of technology in addressing the diverse needs of special education students (Xu et al. 2021; Van Den Heuvel et al. 2015; Drigas et al. 2014; Pousada et al. 2011; Abdollah et al. 2010; Shamir & Margalit, 2011).

4.2 Methods

The utilization of Information and Communication Technology (ICT) in the realm of special education is categorized into three primary groups: experimental research, single-subject experiments, and questionnaire surveys. Among the 10 reviewed articles, 2 are experimental studies, 2 involve single-subject experiments, and 1 employs a questionnaire survey. Notably, the majority of experimental and single-subject research articles focus on employing ICT to address specific deficits in children with special education needs, such as in mathematics and cognition.

In addition to these primary research methods, alternative approaches such as video recording, video interviews, photography, and data encoding find application in 40% of the articles (10 articles). This diverse set of methods, especially the recording and encoding of video, is frequently employed in studies assessing the effectiveness of special education informatization.

Statistical analysis methods employed in the reviewed articles encompass a variety of tools, with Generalized Estimation Equation (GEE), SPSS, and R statistical software being the most prevalent. Notably, the use of SPSS is particularly favored by two authors, indicating a preference for this tool in data analysis. Furthermore, 20% of the core articles employ statistical tests such as the Welch t-test and U-Mann Whitney test, showcasing a range of quantitative approaches in the evaluation of results.

In conclusion, the comprehensive review of 10 highly relevant articles, each with a citation rate of no less than 10, sheds light on the predominant themes in special education informatization from 2006 to 2021. The application of ICT in special education, along with its impact on the diagnosis and intervention for different types of special objects, emerges as a central focus within this field. Experimental research and single-subject research are identified as the primary research methodologies in exploring the nuanced applications of ICT in the realm of special education. This overview provides valuable insights into the prevailing research landscape and highlights the diverse approaches adopted in advancing knowledge within this domain.

5. Conclusion

This research constitutes a comprehensive bibliometric analysis of the literature on special education informatization spanning the years 2006 to 2021, primarily leveraging the Scopus database. The findings underscore the pivotal role of special education informatization as a focal area of academic attention. A noteworthy turning point was observed during the period from 2010 to 2013, marked by a
significant surge in publications within this domain. Core countries contributing to the research landscape in this field include China, Greece, Australia, and Malaysia, with their publication volumes securing top rankings.

Key journals such as the International Journal of Emerging Technologies In, Revista Brasileira De Educacao Especial, and Technology and Disability emerge as pivotal publications in the field of special education informatization. Representative keywords such as information technology, education, and students form the foundational and overarching themes in the literature. Furthermore, the visibility of terms like virtual reality, autism, learning disabilities, and the internet has consistently increased. However, recent years have witnessed a decline in the prevalence of keywords such as decision making, access, and information.

Qualitative analysis delves into the core issues dominating special education informatization, pinpointing the application of Information and Communication Technology (ICT) and the impact of diagnostic and intervention strategies on diverse special education subjects as predominant concerns. Research methodologies reveal that experimental research and single-subject research are the predominant approaches in investigating the application of ICT in special education.

The insights garnered from this study are anticipated to offer an enhanced perspective for researchers and practitioners in related fields, paving the way for future endeavors in advancing knowledge and innovation within the realm of special education informatization.

References


