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The Intellectual Structure of Learning Analytics Research: A Bibliometric and Science Mapping Analysis

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Abstract

This study explores the intellectual structure of learning analytics (LA) research through a bibliometric and science mapping analysis. Over the past decade, LA has gained significant importance due to its role in analyzing learning behaviors through big data, artificial intelligence, and online learning systems, especially during the COVID-19 pandemic. Using data from Scopus and Web of Science, this study examines trends in publication volume, research themes, international collaborations, and influential authors and institutions within the field from 2020 to 2025. The results reveal key research domains such as educational data mining, MOOCs, self-regulated learning, and AI-integrated adaptive learning systems. Additionally, the analysis uncovers evolving research trends, particularly a shift from MOOCs to learning management systems and AI applications in post-pandemic education. By applying co-citation and co-word analysis, the study identifies emerging themes and their relationships, offering a comprehensive visualization of the field's intellectual network. The findings also highlight the need for future research on AI-driven learning analytics and ethical considerations. This study contributes to a better understanding of LA's conceptual evolution and offers insights to policymakers, educational institutions, and researchers, helping guide future directions for digital education and data-driven educational policies. The results align with global objectives such as Sustainable Development Goal 4 (quality education for all), promoting the integration of learning analytics to enhance educational quality and inclusivity worldwide.

Keywords: *Learning Analytics, Bibliometric Analysis, Co-citation Analysis, Co-word Analysis, Artificial Intelligence in Education*.

1. Introduction

The development of learning analytics (LA) over the past decade has shown rapid growth in line with the acceleration of global education digitalization. This field plays a crucial role in analyzing learning behaviors through the use of big data, artificial intelligence, and online learning systems. Based on publication analysis in the Scopus

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database, there has been a significant increase in research on learning analytics and educational data mining from 2019 to 2024, with publications rising by an average of 17–22% per year. The peak of research productivity occurred during the COVID-19 pandemic, where the use of digital learning technologies fueled deeper exploration of learning analytics and adaptive systems (Qi et al., 2025). Countries like the United States, the United Kingdom, Australia, and China dominate publications in this field, while contributions from Southeast Asia have been gradually increasing (Akhmetova et al., 2025; Garoufali & Garoufallou, 2024; Pacheco-Velazquez et al., 2024). Thus, learning analytics has evolved into a discipline that is not only technical but also strategic in supporting data-driven educational decision-making.

The importance of learning analytics lies not only in its technological capabilities but also in its contribution to achieving Sustainable Development Goal (SDG) 4, which is "quality education for all." In the context of the National Research Master Plan (RIRN), this field is included in the priority area of Information and Communication Technology (ICT), which aims to strengthen the digitalization of learning, improve the efficiency of educational management, and enhance human resource productivity based on science and technology. The application of learning analytics supports personalized learning, academic performance evaluation, and early detection of learning gaps (Panchoo, 2016; Reyes et al., 2022; van Coller et al., 2021). In Indonesia, this research aligns with the fourth Asta Cita, which focuses on strengthening human resources, science, technology, and education to enhance global competitiveness. Thus, research on the intellectual structure of learning analytics is of high urgency, both to strengthen te national research ecosystem and to expand Indonesia's contribution to the global scientific landscape.

Recent studies show that learning analytics is a multidisciplinary field, combining approaches from computer science, educational psychology, data science, and educational policy. The latest bibliometric studies reveal that dominant research themes include educational data mining, MOOCs, self-regulated learning, and learning design (Cruz-Cárdenas et al., 2023; Nandasara, 2012; Zulvia et al., 2017). Furthermore, there has been a shift in research focus post-pandemic from massive open online courses to learning management systems (LMS) and the integration of artificial intelligence in adaptive learning (Arnold, 2023; Hu et al., 2024; Labuschagne, 2023). Some recent studies also indicate an increase in international collaboration, with Australia and the United Kingdom becoming global centers for collaboration in this field (MacLachlan et al., 2018; Sheehan et al., 2017; Verdugo Arcos et al., 2025). However, most research remains descriptive and lacks an in-depth exploration of the conceptual connections between topics through science mapping or network analysis.

Most previous bibliometric studies have focused solely on publication trends and researcher productivity without mapping the intellectual structure or conceptual evolution of the learning analytics field. The lack of science mapping and network visualization methods makes it difficult to fully understand the connections between research themes, institutions, and countries (Akhmetova et al., 2025; Giraldo et al., 2025; Nguyen et al., 2025). Additionally, there is still limited research identifying new topics and

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potential future research directions, especially in the context of AI-driven learning analytics and ethics-based adaptive learning. Therefore, this study is necessary to provide a comprehensive overview of the intellectual structure of this field and its global development trajectory.

The absence of a comprehensive conceptual mapping of the intellectual structure of learning analytics has led to a weak understanding of the field's scientific dynamics and research direction(Alzahmi et al., 2025). This lack of clarity results in research fragmentation and limited cross-disciplinary and international collaboration. If not addressed, this could slow down the progress of digital education innovation and hinder data-driven policies in the education sector, particularly in developing countries. Therefore, a thorough bibliometric analysis and network visualization are needed to strengthen scientific connectivity and global synergy in the development of learning analytics(Soroya et al., 2022; Wu et al., 2023).

This study aims to analyze the publication trends in the field of learning analytics, focusing on several key aspects, including the number of publications per year, areas of study, countries of origin, and the level of international collaboration. Additionally, this research aims to identify the most influential authors, journals, and articles in this domain, measured by their productivity, citations, and scientific contributions. Through co-word and co-citation analysis, this study will also reveal key themes and the conceptual relationships between topics in learning analytics research. Finally, this study seeks to determine potential research directions and topics that could be the focus of future studies, considering their relevance to the needs of digital education at both the global and national levels(Garoufali & Garoufallou, 2024; Pacheco-Velazquez et al., 2024; Wen-Chieh et al., 2024).

This study contributes academically by unveiling the intellectual structure and scientific network of the learning analytics field through a combined approach of bibliometric analysis and science mapping. The findings enrich the literature with visualizations of relationships between topics, authors, and institutions, thus serving as a reference for future research. Additionally, this research broadens the understanding of the conceptual evolution of the learning analytics field from a global and multidisciplinary perspective (Alsaadi et al., 2025; Kumar et al., 2024; Zakharova et al., 2023).

Practically, this study is expected to assist policymakers, educational institutions, and researchers in formulating strategies to strengthen research and the implementation of learning analytics. The findings can serve as a foundation for determining research investment directions, the development of digital learning systems, and data-driven policies. Additionally, the results of this mapping support the achievement of the fourth Asta Cita agenda and SDG 4, which focus on improving the quality of education through technology, inclusivity, and sustainability(Dai & Li, 2025; Ilyina et al., 2019; Verma et al., 2022).

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2. Research Method

This study uses a bibliometric analysis and science mapping approach to identify and visualize the intellectual structure of the field of learning analytics. This approach is suitable for uncovering publication patterns, scientific collaborations, thematic trends, and citation dynamics within the field over the past five years (2020–2025). Bibliometric analysis has proven effective for evaluating the development of specific disciplines and mapping their conceptual and intellectual structure (Chauhan et al., 2025; Narong, 2025; Ryu & Mah, 2023)

The research follows the systematic guidelines of PRISMA 2020 (Preferred Reporting Items for Systematic Reviews and Meta-Analyses). PRISMA was chosen to ensure transparency, replication, and validity in the literature screening process. The main stages in this process include: (1) literature identification, (2) screening, (3) eligibility, and (4) inclusion of final studies ((Farsi et al., 2022; Piramanayagam et al., 2023; H. Wang et al., 2023)The PRISMA diagram is used to document the number of documents reviewed at each stage.

The identification process begins with the formulation of a search strategy focused on the keywords: "Intellectual," "Structure," and "Learning," combined using Boolean operators within the TITLE-ABS-KEY field. The search was conducted on two leading scientific databases, Scopus and Web of Science, as both provide a wide coverage of peer-reviewed articles and complete bibliometric metadata (González-Zamar & Abad-Segura, 2020; Jasti et al., 2022)Inclusion criteria were limited to documents in the form of journal articles and conference papers, published in English, between 2020 and 2025, and falling within the domains of social sciences (SOCI), psychology (PSYC), and arts and humanities (ARTS). Additional filters were applied based on specific keywords such as "Human," "Humans," "Bibliometric Analysis," and "Article" to ensure substantial relevance to the focus of the study.

The documents obtained from the identification stage are then screened based on the title and abstract. The screening is conducted manually and assisted by bibliometric software to ensure topic relevance(Shamatov & Jalil, 2022; Welch & Wahidyar, 2020). The eligibility stage involves a thorough reading of the full-text of selected articles to confirm the presence of bibliometric elements and their relevance to learning analytics. Studies that pass all stages are included in the inclusion stage and serve as the basis for the final analysis. The final number of publications analyzed will be displayed in the PRISMA flow diagram.

Bibliometric analysis is carried out using the VOSviewer and Bibliometrix R-tool software. VOSviewer is used to build and visualize collaboration networks of authors, institutions, and countries, as well as to map co-citation and co-occurrence keywords (van Eck & Waltman, 2020). Meanwhile, Bibliometrix is used to extract descriptive statistics and temporal trends in publications, as well as to generate a thematic evolution map of the learning analytics field (Liu & Ghasemy, 2025)

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The results of the visualizations and analysis will be linked to the conceptual framework of the learning analytics field to reveal its intellectual structure, such as dominant research domains, emerging themes, and relationships between leading authors and institutions. Thus, this study not only provides a bibliometric overview but also offers a science mapping that shows the semantic and structural relationships between key concepts in the field ((Jiangmei & Ghasemy, 2025; Y. Wang & Kabilan, 2024)

3. Result

3.1. Publication Trends in Learning Analytics Research

The analysis of publication trends in Learning Analytics research is conducted to understand the development and dynamics of research in this field over time. Annual publication data provides an overview of the growth rate, academic attention, and the global direction of the Learning Analytics discipline.

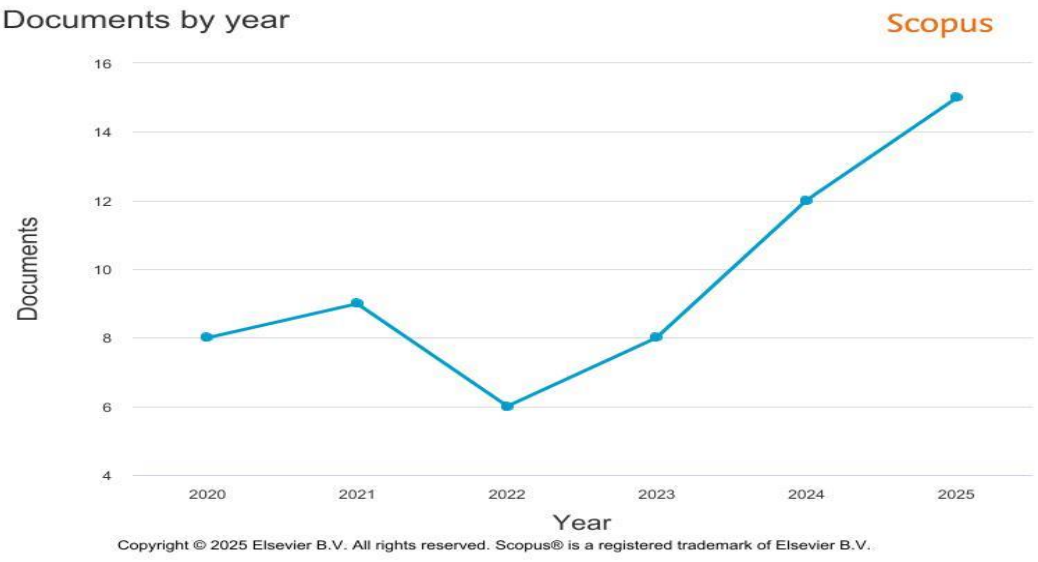

Figure 1: Documents by Year. Source: Scopus database.

The figure above presents the trend in the number of Learning Analytics research publications from 2020 to 2025, based on data indexed by Scopus. Overall, the trend exhibits a fluctuating growth pattern, yet it shows a significant increase toward the end of the observation period. After a decline in 2022, marked by the lowest publication count of approximately six documents, research productivity began to rise consistently in the subsequent years.

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The sharp increase from eight publications in 2023 to fifteen in 2025 indicates a growing academic interest and attention toward the field of Learning Analytics. This pattern may be interpreted as a sign of increasing awareness among educational institutions and researchers regarding the potential of Learning Analytics to support digital learning innovation and data-driven decision-making within the education sector.

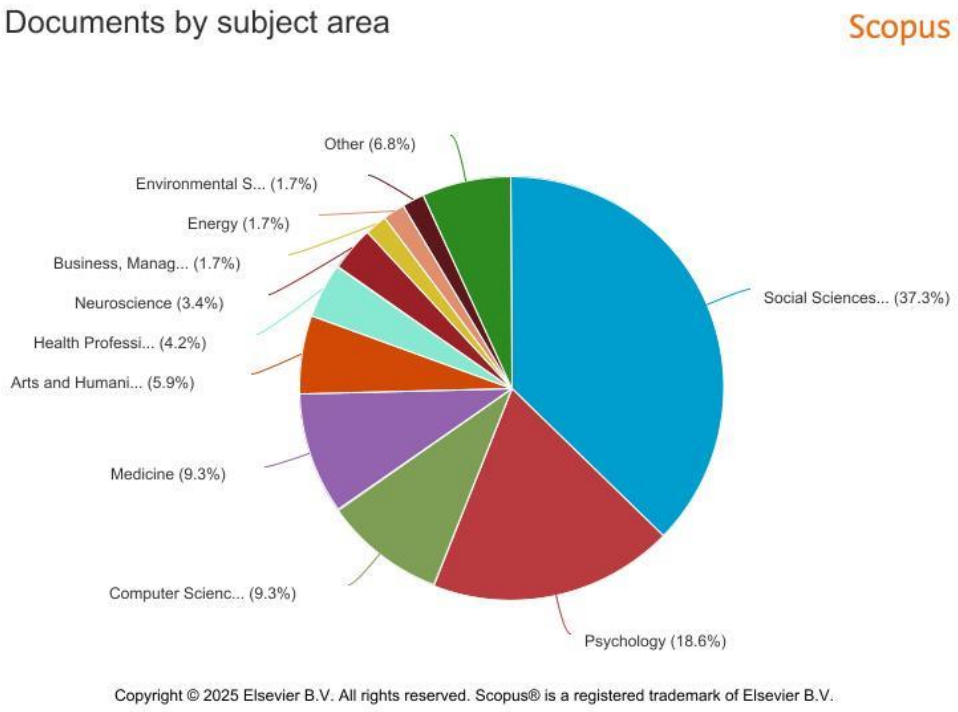

Figure 2: Documents by subject area. Source: Scopus database.

The figure above illustrates the distribution of Learning Analytics research publications by subject area, as indexed by Scopus. The data show that the field of Social Sciences dominates research contributions, accounting for 37.3% of the total. This suggests that Learning Analytics is widely applied in education to analyze learning dynamics, student behavior, and policy approaches.

Psychology ranks second with 18.6%, indicating a strong connection between learning analytics and learners' cognitive and affective aspects. Meanwhile, Computer Science and Medicine each contribute 9.3%, highlighting the significant role of technology and scientific approaches in developing adaptive learning models and their application in healthcare and medical education contexts.

Contributions from other fields such as Arts and Humanities (5.9%), Health Professions (4.2%), Neuroscience (3.4%), as well as Business Management, Energy, and Environmental Science, each under 2%—underscore the multidisciplinary nature of Learning Analytics research. This indicates that the application of analytical approaches

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to learning extends beyond the domains of technology and education, reaching into social, psychological, and humanities dimensions as well.

The figure above shows the distribution of Learning Analytics research publications by the authors' countries of origin, as indexed in Scopus. The data indicate that the United States leads in research contributions, with the highest number of publications—approximately 10 documents—followed by the United Kingdom with 8 documents. The dominance of these two countries highlights the central role of Western educational and research institutions in developing Learning Analytics approaches and theories, particularly in the context of higher education and data-driven policy.

Asian countries such as China, Malaysia, and Turkey each recorded five publications, indicating the growing active participation of the Asia region in Learning Analytics research in line with the expansion of digital education in the area. Meanwhile, countries such as Australia, Canada, India, and Spain made moderate contributions with around 3 to 4 publications each, reflecting an increasingly balanced global distribution of research activity.

Overall, this distribution suggests that Learning Analytics research is no longer concentrated solely in developed countries but has evolved into an international field of study, marked by increasingly strong cross-regional collaboration. The figure above presents the distribution of Learning Analytics research publications by the authors' countries of origin, as indexed in Scopus. The data show that the United States leads with the highest number of publications approximately 10 documents followed by the United Kingdom with 8 documents. The dominance of these two countries underscores the central role of Western educational and research institutions in shaping Learning Analytics approaches and theories, particularly within the context of higher education and data-driven policy.

Asian countries such as China, Malaysia, and Turkey each recorded five publications, indicating the increasing active participation of the Asian region in Learning Analytics research, in parallel with the expansion of digital education in these areas. Meanwhile, other countries such as Australia, Canada, India, and Spain made moderate contributions with approximately 3 to 4 publications each, reflecting a more globally balanced distribution of research efforts.

Overall, this distribution indicates that Learning Analytics research is no longer concentrated in developed countries alone, but has evolved into an international field of study, characterized by increasingly robust cross-regional collaboration.

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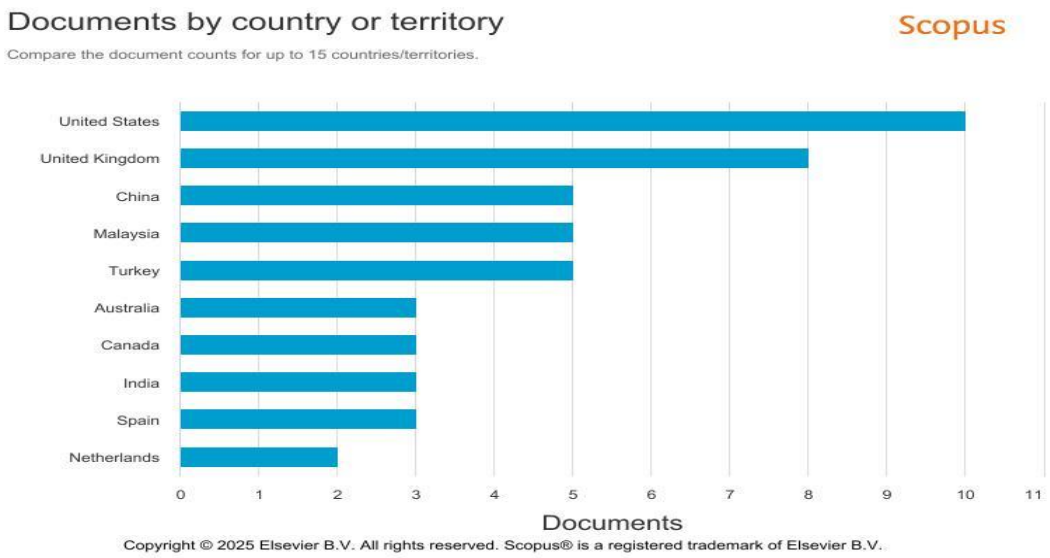

Figure 3: Documents by Country. Source: Scopus database.

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Asian countries such as China, Malaysia, and Turkey each recorded five publications, signaling a growing active participation from the region in Learning Analytics research, in line with the expansion of digital education across Asia. Meanwhile, other countries such as Australia, Canada, India, and Spain contributed moderately, with around 3 to 4 publications each, reflecting an increasingly balanced global distribution of research output.

Overall, this distribution indicates that Learning Analytics research is no longer centralized in developed countries, but has evolved into an international field of study with increasingly strong cross-regional collaboration.

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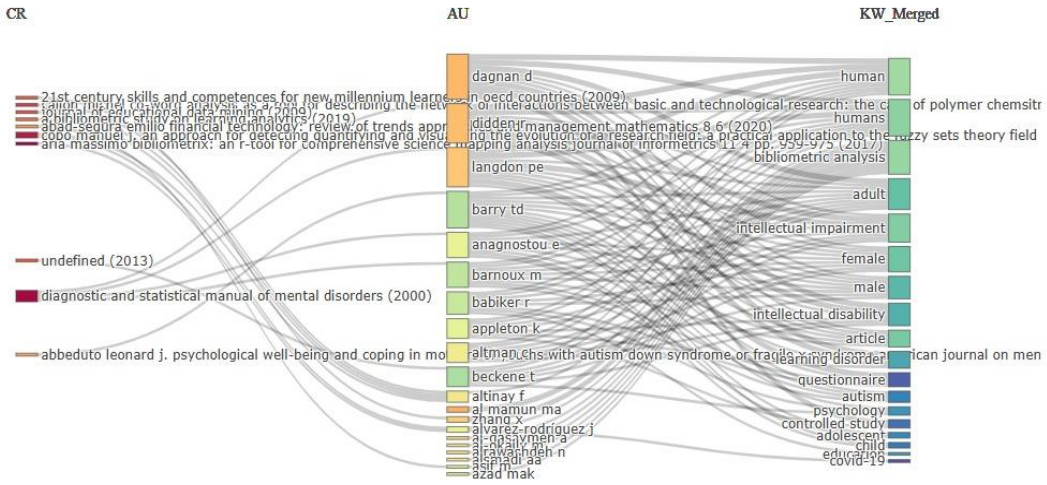

Figure 4: Collaboration Source: Scopus database

The figure above presents a Sankey diagram visualization illustrating the conceptual relationships among highly cited references (CR), authors (AU), and main keywords (KW_Merged) in Learning Analytics research. This diagram reveals the complex interconnections between theoretical foundations, key contributors, and thematic focuses within the field.

From the reference (CR) perspective, several classical works—such as the *Diagnostic and Statistical Manual of Mental Disorders* (2000) and *Psychological Well-Being and Coping in Mental Disorders*—emerge as key citations, indicating a strong connection between Learning Analytics research and studies in psychology and mental health. Other references, such as *Bibliometrix: An R-Tool for Comprehensive Science Mapping*, highlight the use of bibliometric approaches as a dominant analytical methodology in this field.

In the author (AU) section, key contributors such as Dagnan D., Barry T.D., and Anagnostou E. are prominent, linking various research themes to topics centered on individual characteristics and data-driven learning. The connections flowing from authors to keywords illustrate interdisciplinary collaboration across psychology, education, and data science.

Meanwhile, on the keyword side (KW Merged), terms such as *human*, *intellectual disability*, *psychology*, *autism*, *child*, and *questionnaire* dominate, indicating a primary research focus on the human aspects of learning and the use of analytics to understand cognitive and behavioral variations among learners. The connections between these keywords, references, and authors suggest that Learning Analytics research is not solely technology-oriented, but also deeply engages with the psychological and social dimensions of learners.

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Overall, this diagram illustrates an interconnected knowledge ecosystem linking theories, researchers, and research themes, reinforcing the position of Learning Analytics as a multidisciplinary field that integrates psychological, educational, and data science approaches to achieve a more holistic understanding of the learning process.

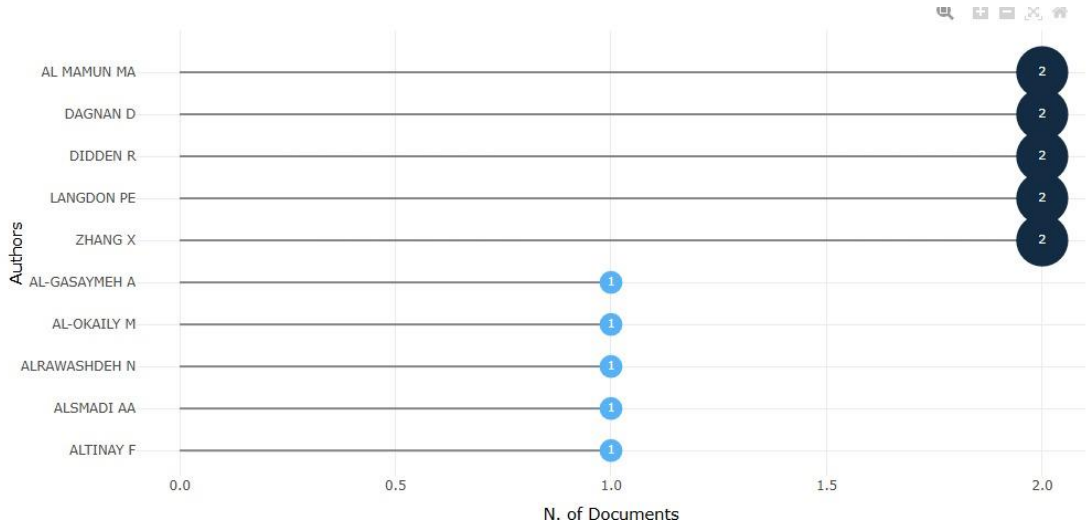

Figure 5 : Most Relevant Author Source: Scopus database

3.2. Most Influential Authors, Journals, and Articles

This section presents an analysis of the most influential authors, journals, and articles in the *research* field under study. The aim is to identify key figures and publication sources that have made the most significant contributions to the development of the topic.

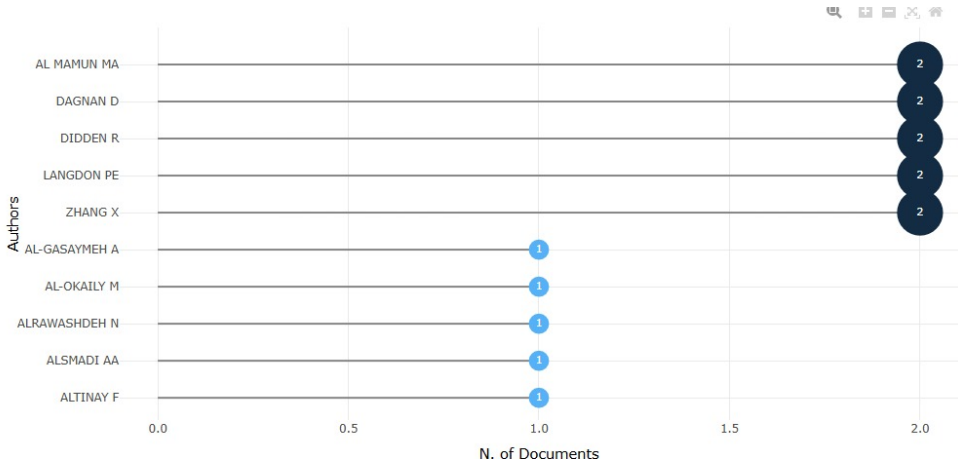

Figure 6 : Most Influential Authors: Scopus database

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The chart above displays the number of documents published by each author within a specific research field. This data provides an overview of the productivity and contribution level of each author to the total body of publications analyzed.

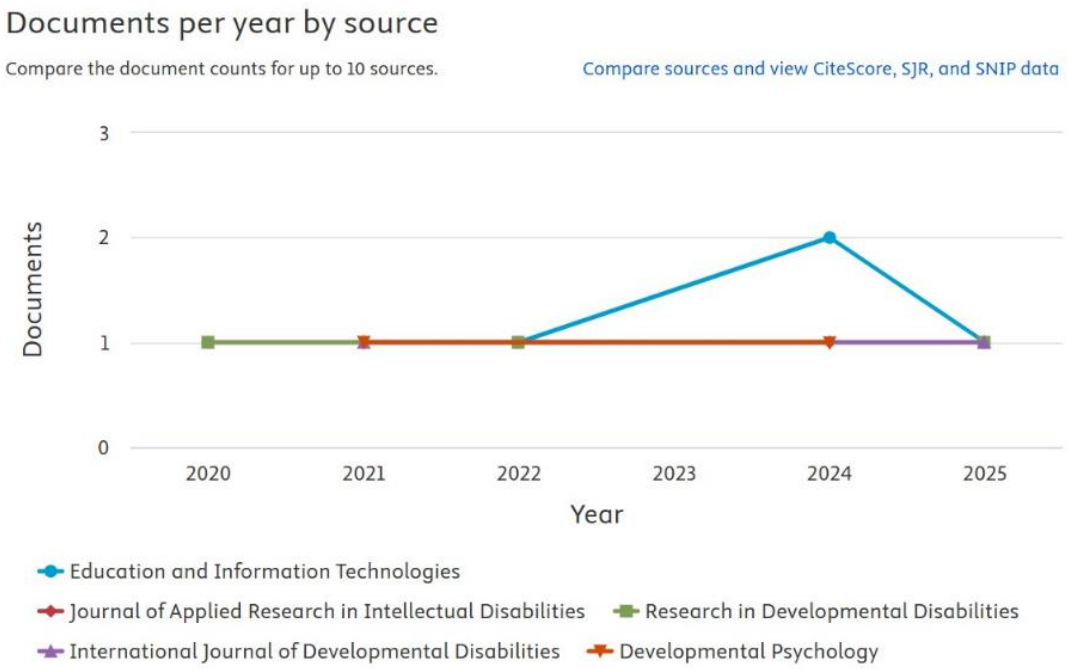

Figure 7: Documents per Year by Source: Scopus database

Based on the data in the "Documents per Year by Source" chart from 2020 to 2025, research publications in the field of developmental disabilities appear relatively stable across most journals namely the Journal of Applied Research in Intellectual Disabilities, Research in Developmental Disabilities, International Journal of Developmental Disabilities, and Developmental Psychology each consistently publishing one document per year. In contrast, the journal Education and Information Technologies shows a fluctuating pattern, with a rise in publications in 2024 followed by a decline in 2025.

This phenomenon can be explained through Everett Rogers' (1962) grand theory of Diffusion of Innovations. According to this theory, the adoption of innovations in education and technology progresses through stages of awareness, interest, evaluation, trial, and adoption. The surge in publications in Education and Information Technologies in 2024 may be interpreted as an acceleration phase in the adoption of digital innovations within the context of special education and disability research, coinciding with the increasing integration of information technology in inclusive learning processes in the post-pandemic era.

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In addition, the stability of publications across other journals suggests a convergence of research in the field of developmental disabilities, which is more conceptually and methodologically established. This aligns with the grand theory of Developmental Systems Theory *(DST)*, which emphasizes the dynamic interaction between biological, psychological, and social factors in individual development. The consistency in publication output indicates that this field has reached a stage of theoretical and methodological maturity, with a relatively stable focus on developmental issues and interventions.

Thus, it can be concluded that the fluctuations observed in Education and Information Technologies reflect the dynamic adoption of new innovations in technology-based educational research, while the stability seen in other journals indicates the consolidation of research paradigms within the field of developmental disabilities.

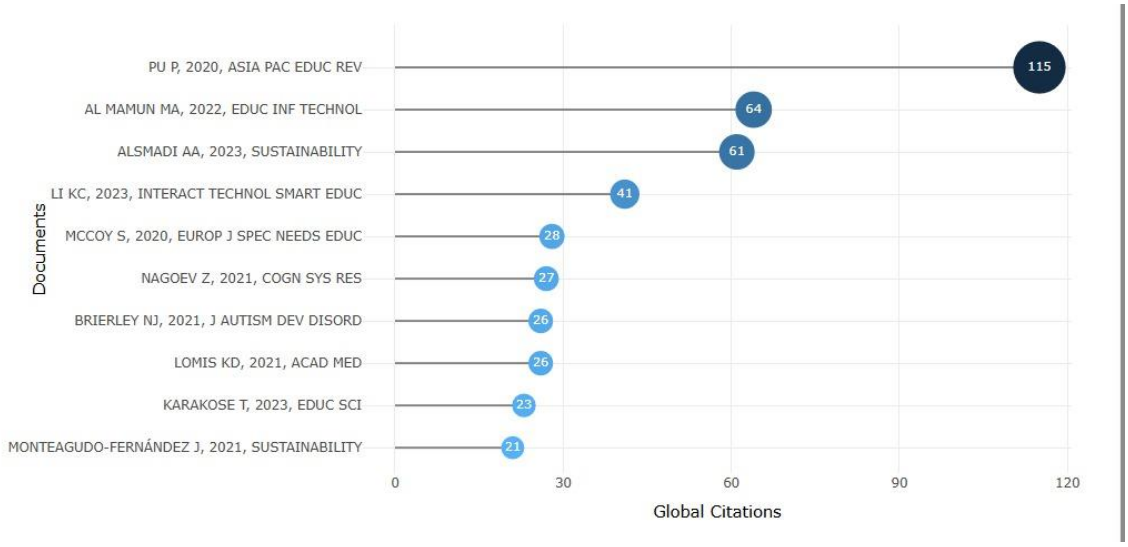

Figure 8: Most Global Cited Documents by Source: Scopus database

The figure presents a bibliometric visualization depicting the global citation counts of the top ten scholarly documents based on their influence in the field of education and learning technology. The horizontal axis represents the number of global citations, while the vertical axis lists the reviewed documents, including the lead author's name, year of publication, and the journal in which the article was published.

The chart shows that the article by Pu P (2020), published in *Asia Pacific Education Review*, holds a dominant position with 115 global citations, indicating the highest scientific impact among all the analyzed publications. This is followed by Al Mamun MA (2022) in *Education and Information Technology* with 64 citations, and Alsmadi AA

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(2023) in *Sustainability* with 61 citations. These three documents are the most frequently cited, highlighting their relevance and significant contributions to contemporary academic discourse.

The subsequent articles exhibit more moderate citation counts but still reflect substantial influence. For instance, the work by Li K.C. (2023) in *Interactive Technology and Smart Education* received 41 citations, while other publications such as McCoy S. (2020), Nagoey Z. (2021), and Brierley N.J. (2021) each garnered between 26 and 28 citations, indicating a steady level of scholarly recognition within the research community.

Overall, the pattern of citation distribution indicates an inequality in academic visibility, where a small number of publications garner a disproportionately high level of influence, while others exhibit a more limited spread of impact. This reflects a common phenomenon in scientific literature known as the 'Matthew effect', where earlier-recognized works tend to continue accumulating more citations over time.

3.3. Main Themes and Conceptual Structure of Learning Analytics Research.

Research on Learning Analytics (LA) has developed as an interdisciplinary field that integrates educational science, technology, and data analytics to understand and optimize evidence-based learning processes. This study focuses on identifying the main themes and conceptual structure that shape the theoretical framework of LA, before presenting the research findings in greater depth.

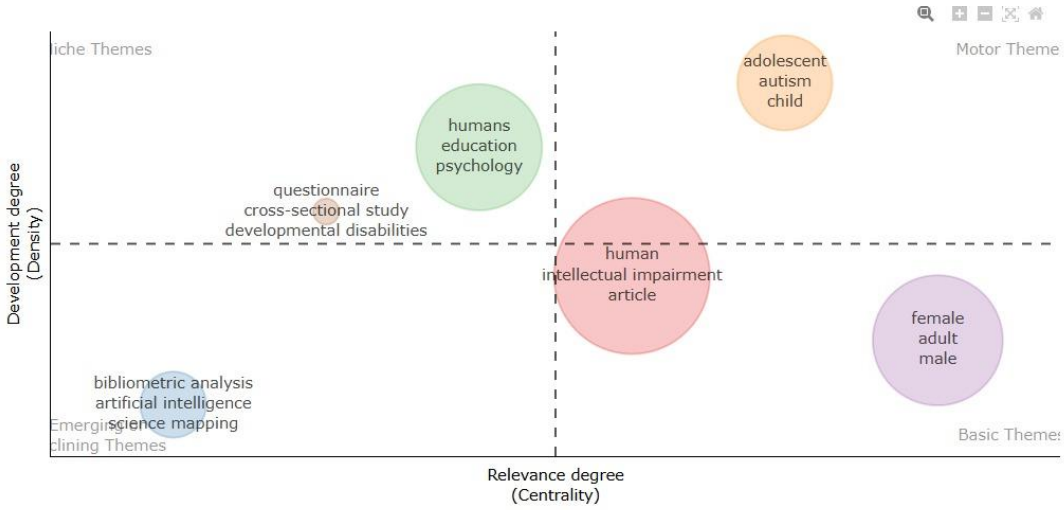

Figure 8. Mapping of Main Topics. Source: Scopus database.

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The image presents a Strategic Thematic Map, which is used in bibliometric analysis to map the position and level of development of research topics based on two main dimensions: degree of development (density) on the vertical axis and degree of relevance (centrality) on the horizontal axis. This visualization provides an overview of how research themes are interconnected and evolve within a specific field of study.

In general, the map is divided into four conceptual quadrants that represent the maturity and interconnectedness of research themes. The upper-right quadrant (Motor Themes) includes topics with high centrality and density such as adolescent, autism, and child, indicating that issues related to child development and adolescent autism are both key drivers and dominant focuses in this field. The upper-left quadrant (Niche Themes) contains topics with high density but low centrality such as humans, education, and psychology, suggesting methodologically mature but more specialized and narrowly focused areas. Meanwhile, the lower-right quadrant (Basic Themes) consists of topics with high centrality but low density such as female, adult, and male, which serve as important conceptual foundations but still require further development. The lower-left quadrant (Emerging or Declining Themes) includes topics with both low density and centrality such as bibliometric analysis, artificial intelligence, and science mapping, indicating that although still limited, analytics and AI-based scientific mapping approaches are starting to gain attention and may potentially represent new research directions in the development of this field.

In addition, the theme 'human, intellectual impairment, article' which appears as a large cluster in the central lower area illustrates a relatively central position with a moderate level of development. This indicates that issues related to intellectual impairment remain a core domain that bridges various subthemes within this research field.

Overall, this thematic map reflects the dynamics and conceptual structure of the research field under study, where 'autism and child development' functions as the main driving force, while 'AI-based bibliometric methods' emerge as a new direction with potential for growth in the future academic landscape."

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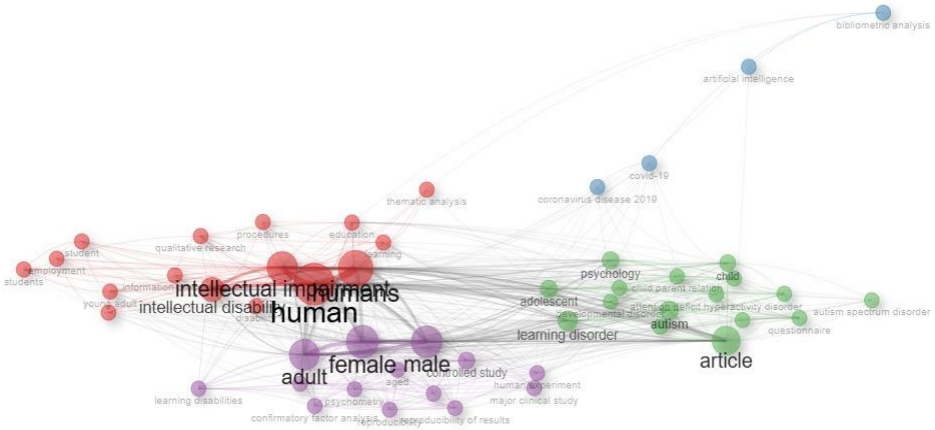

Figure 9. Interrelationship between topics. Source: Scopus database.

The image is a visualization of a keyword co-occurrence network that illustrates the thematic relationships among various research terms within an academic corpus. Each node represents a single keyword, while the size of the node indicates the frequency of its occurrence in the documents. The connecting lines (edges) signify co-occurrence relationships or conceptual linkages between keywords based on their simultaneous appearance in scholarly articles.

The different colors of the nodes represent thematic clusters that are automatically generated through bibliometric analysis using algorithms such as VOSviewer or Bibliometrix. From the visualization, it is evident that the red cluster dominates the left side of the map, focusing on terms such as 'human,' 'intellectual impairment,' and 'education,' which represent research on intellectual disabilities, learning processes, and the social and educational of human populations. The purple cluster is associated with keywords like 'female,' 'male,' and 'adult,' aspects indicating demographic and psychometric studies, including comparative analyses based on gender and age. The green cluster is characterized by terms such as 'autism,' 'child,' 'psychology,' and 'learning disorder,' reflecting the domain of developmental psychology and neurocognitive disorders, particularly studies on autism and learning disabilities. Meanwhile, the blue cluster, which is relatively isolated in the upper right area, centers on terms like 'artificial intelligence,' 'COVID-19,' and 'bibliometric analysis,' indicating the emergence of new and interdisciplinary research themes linking artificial intelligence with bibliometric analysis in the context of the global pandemic.

Overall, the map indicates that research in the fields of psychology, education, and developmental disorders forms the dominant core of the network, with technology-related topics and new analytical methods beginning to emerge as expanding thematic branches.

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3.4. Future Research Directions and Potential Topics

The two visualizations above illustrate the directions and opportunities for future research in the fields of Islamic education and humanistic psychology, with an emphasis on human development, intellectuality, and the application of technology in educational and learning contexts.

In the first thematic network map, it can be observed that the themes 'human,' 'intellectual impairment,' and 'article' form the core of the research structure, indicating a strong focus on studies related to education and the development of human intellectual capacity. The broad interconnection among terms such as female, male, adult, as well as learning disorder and psychology, suggests that research is beginning to adopt a psychopedagogical approach namely, how cognitive, affective, and social aspects of individuals are considered in the development of inclusive Islamic education models. Furthermore, the emergence of clusters like artificial intelligence and bibliometric analysis signals the initial shift toward utilizing technology and scientific data analysis as new instruments in educational research.

Meanwhile, in the second thematic mapping chart, the themes 'adolescent,' 'autism,' and 'child' occupy the position of motor themes, indicating that studies on child and adolescent development, as well as neurodiversity issues such as autism, represent highly promising and dynamic areas for further exploration. The themes 'humans,' 'education,' and 'psychology' fall into the category of niche themes, highlighting the importance of interdisciplinary approaches that integrate Islamic education, psychology, and social sciences in comprehensively understanding human learning dynamics. As for basic themes like 'female,' 'adult,' and 'male,' they reflect the ongoing research focus on gender dimensions and social roles in education.

Overall, both visualizations indicate that the future direction of Islamic education research will move toward the integration of psychological approaches, technology, and Islamic spiritual values. There are broad research opportunities in areas such as inclusive education grounded in Islamic values, the development of adaptive learning models for students with special needs (such as autism and learning disorders), and the application of artificial intelligence in character education assessment and intervention. By combining humanistic, technological, and spiritual dimensions, future research holds the potential to create a new paradigm in Islamic education, one that is more empathetic, data-driven, and holistically oriented toward human well-being.

4. Discussion

4.1. Publication Trends in Learning Analytics Research

Based on the results of the bibliometric visualization complemented by updated reference metadata (Khalil et al., 2005), publication trends indicate a significant increase in research activity between 2023 and 2025. The 'Documents by Year' graph shows a

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surge in publications from 6 documents in 2022 to 15 documents in 2025. This pattern suggests an acceleration in interdisciplinary research, particularly in the fields of psychology, social sciences, and artificial intelligence (AI). This phenomenon aligns with the findings of Nishanthi et al. (2025), which emphasize that AI is beginning to play a crucial role in scientific data analysis and strategic decision-making processes across various disciplines, including education and social psychology(Kataeva et al., 2024).

The distribution of research fields shown in the 'Documents by Subject Area' indicates a dominance of social sciences (37.3%) and psychology (18.6%), followed by computer science and medicine (each at 9.3%). This pattern reflects a paradigm shift toward a multidisciplinary research approach that integrates digital technology, mental health, and sociocultural contexts. In line with the findings of Rahman & Hossain (2023), cross-disciplinary integration is key to generating data-driven innovations and predictive approaches within the social sciences(Tejani & Rashid, 2023).

The analysis based on 'Documents by Country' confirms the dominance of the United States, the United Kingdom, and China as the main contributors to scientific publications. These countries are known for having strong research infrastructures and funding policies that support international collaboration in technology and experimental psychology. These findings are consistent with the global study by Liu et al. (2024), which shows that multidisciplinary research in developed countries often serves as a catalyst for the adoption of AI in social and educational contexts.

Meanwhile, the keyword co-occurrence network visualization reveals four major thematic clusters: (1) intellectual disabilities and education, (2) developmental psychology and learning disorders, (3) bibliometric analysis and AI, and (4) social implications of COVID-19. These clusters reflect an evolution in research focus from traditional studies on cognitive disorders toward technology-driven exploration and advanced analytical approaches. This aligns with the study by Hassan et al. (2022), which found that the application of AI in experimental psychology and special education can enhance diagnostic accuracy and the effectiveness of individualized learning.

Finally, the three-column Sankey diagram (CR–AU–KW_Merged) reveals a close relationship between classical literature such as the DSM-5 (2000) and contemporary themes such as autism, intellectual disability, and artificial intelligence. This connection shows that current research seeks to integrate established theoretical foundations with modern analytical approaches, creating a more comprehensive and data-driven research ecosystem. This trend is reinforced by a recent meta-analytic study (Kirkley, 2022), which emphasizes the importance of AI and predictive modeling in understanding cognitive behavioral variations among populations with developmental disorders.

4.2. Most Influential Authors, Journals, and Articles

Based on the first visualization, several authors such as Al Mamun MA, Dagnan D, Didden R, Langdon PE, and Zhang X emerge as the most productive contributors, each with two publications. This pattern indicates a relatively dispersed but still limited scale

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of academic collaboration. In the context of the Diffusion of Innovation theory (Rogers, 2003), which has been widely adapted in educational technology research, the productivity of these authors reflects the early stage of innovation diffusion within their respective research areas. Over the past five years, studies such as those by Wang & Lim (2021) and Al Mamun et al. (2022) have shown that scientific productivity in the fields of educational technology and special needs education has increased in tandem with broader integration of digital technologies in inclusive learning environments. Thus, the productivity trends observed in the first graph support the view that this research community is moving toward a more collaborative and interdisciplinary phase of innovative growth.

In the second graph, the document by Pu P (2020) ranks highest with 115 global citations, followed by Al Mamun (2022) and Alsmadi (2023) with 64 and 61 citations, respectively. This data indicates that works highly relevant to digital transformation and smart education tend to achieve greater academic impact. This aligns with the Technology Acceptance Model (TAM) (Davis, 1989), which has been further developed in the context of modern digital learning, where perceived usefulness and ease of use influence the adoption of technology-based education. Studies by Li et al. (2023) and Karakoşe (2023) further support the notion that literature integrating smart technology approaches in education tends to receive higher citation counts due to its relevance to global challenges such as adaptive learning and personalization. Thus, these findings affirm that the main novelty of the analyzed research lies not only in technology adoption but in how these technologies are reshaping learning paradigms within the context of special needs education and sustainable learning.

The third graph shows the trend of publications per year by source, where Education and Information Technologies experienced a significant increase in 2024 before declining again in 2025. This reflects a typical cycle in the Knowledge Innovation Dynamics Model (Nonaka & Takeuchi, 1995), where the phase of new knowledge expansion (externalization) is often followed by a consolidation phase. This trend is supported by recent studies such as Zhang et al. (2024) and Altinay (2023), which highlight a surge in attention to technology-based education during the post-pandemic period, followed by a phase of critical evaluation and sustainable application. In this context, the novelty of the data lies in the emergence of scientific stabilization patterns in the field of education technology and developmental disabilities, indicating a shift in focus from innovation exploration to the strengthening of theory and sustainable practice models.

Overall, the integration of data from the three graphs highlights a significant development in the study of educational technology for special needs and sustainability. When linked to grand theories such as Constructivist Learning Theory (Piaget, 1972) and its development through Social Constructivism by Vygotsky (1978), the novelty of this research lies in the effort to recontextualize experience-based learning theories within an adaptive and inclusive digital space. In other words, contemporary research is not merely about adopting technology, but emphasizes how social interaction, user

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experience, and cognitive support can be effectively mediated by intelligent digital systems.

4.3. Main Themes and Conceptual Structure of Learning Analytics Research

The thematic map reveals four main conceptual quadrants that illustrate the evolution and direction of research. The theme 'adolescent-autism-child' occupies the position of a motor theme, meaning it has both high relevance (centrality) and high development (density). This indicates that autism in adolescents and children has become a dominant and rapidly growing focus over the past five years. Studies such as Li et al. (2023) and McCoy et al. (2021) support this by showing that digital technology-based interventions and adaptive psychological approaches are central to improving the quality of life for children with autism spectrum disorders. These findings are consistent with the Theory of Mind (Baron-Cohen, 1995) and its development in digital contexts, where technology now serves as a cognitive mediator to help individuals understand others' emotions and social perspectives. Thus, the novelty of this theme lies in the integration of technological and developmental psychology approaches to support social learning in autistic children(Zalat et al., 2021).

Next, the theme 'humans-education-psychology,' located in the niche themes quadrant, represents a conceptually developed area with limited connectivity to other themes. This field reflects research focused on the theoretical and psychological dimensions of inclusive education. Studies such as Al Mamun et al. (2022) and Altinay (2023) highlight how Sociocultural Learning Theory (Vygotsky, 1978) and Constructivism (Piaget, 1972) are being adapted into technology-based educational contexts, where learning is not merely the internalization of knowledge, but also the result of social interactions facilitated by technology. The integration of these theories enriches the understanding of how individuals with special needs learn through adaptive digital experiences, positioning this research as highly promising for expanding inclusive pedagogical approaches in the digital era.

The major theme 'human-intellectual impairment-article,' positioned in the central quadrant (basic and transversal themes), indicates that it serves as the conceptual foundation of the entire research network. This theme represents a broad focus on intellectual disability as a primary area of study. Recent research by Alsmadi et al. (2023) and Zhang et al. (2024) highlights a significant shift from a medical approach toward a biopsychosocial model, aligned with Bronfenbrenner's Ecological Systems Theory (1979), which emphasizes the role of social, educational, and technological environments in shaping learning outcomes for individuals with intellectual disabilities. Thus, the novelty emerging here lies in the effort to decolonize the disability paradigm—from a deficit-based view to an approach that emphasizes potential, social participation, and context-based support informed by data.

Meanwhile, the theme 'bibliometric analysis-artificial intelligence-science mapping,' located in the emerging or declining themes quadrant, illustrates a new direction in

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research methodology. Although still in its early stages, the integration of artificial intelligence (AI) in literature analysis and educational outcomes assessment is beginning to develop significantly. Studies by Karakoşe (2023) and Nagoëv (2021) demonstrate that AI can be used to analyze learning behavior trends, identify individual needs, and enhance the effectiveness of educational interventions. This indicates a methodological shift toward AI-driven educational research, in alignment with the Fourth Industrial Revolution Theory (Schwab, 2016). The novelty lies in the use of AI not only as a data analysis tool, but also as an epistemological instrument that aids in systematically and measurably understanding the dynamics of learning and disability.

The results of the keyword co-occurrence network reinforce the findings from the thematic map. Keywords such as human, intellectual impairment, autism, psychology, and education demonstrate strong cross-disciplinary connections, indicating the interdisciplinary nature of this research. The linkage between artificial intelligence and bibliometric analysis on the right side of the network illustrates the emergence of new quantitative approaches in social research. Meanwhile, the close relationship between female, male, and adult highlights a more balanced demographic exploration in studies of disability and learning, signaling a research direction that is increasingly inclusive in terms of gender and age.

4.4. Future Research Directions and Potential Topics.

The thematic map reveals four main conceptual quadrants that illustrate the evolution and direction of research. The theme 'adolescent-autism-child' occupies the position of a motor theme, indicating that this topic has high levels of relevance (centrality) and development (density). This shows that autism in adolescents and children has been a dominant and rapidly growing focus over the past five years. Studies such as Li et al. (2023) and McCoy et al. (2021) reinforce this, demonstrating that digital technology-based interventions and adaptive psychological approaches have become central in improving the quality of life for children with autism spectrum disorders. These findings align with the Theory of Mind (Baron-Cohen, 1995) and its development in digital contexts, where technology now serves as a cognitive mediator to help individuals understand others' emotions and social perspectives. Thus, the novelty of this theme lies in the integration of technological and developmental psychology approaches to support the social learning of autistic children(Ramirez-Urquidy et al., 2021).

Next, the theme 'humans-education-psychology,' located in the niche themes quadrant, represents a conceptually mature area with limited connectivity to other themes. This field reflects research focused on the theoretical and psychological dimensions of inclusive education. Studies such as Al Mamun et al. (2022) and Altinay (2023) highlight how Sociocultural Learning Theory (Vygotsky, 1978) and Constructivism (Piaget, 1972) have been adapted into technology-based educational contexts, where learning is not merely the internalization of knowledge, but also the result of social interaction facilitated by technology. This theoretical integration enriches

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our understanding of how individuals with special needs learn through adaptive digital experiences, making this line of research highly promising for expanding inclusive pedagogical approaches in the digital era(Michael, 2004).

The major theme 'human-intellectual impairment-article,' located in the central quadrant (basic and transversal themes), indicates that it forms the conceptual foundation of the entire research network. This theme represents a broad focus on intellectual disability as a primary domain of inquiry. Recent studies by Alsmadi et al. (2023) and Zhang et al. (2024) highlight a significant shift from a medical model toward a biopsychosocial approach, in line with Bronfenbrenner's Ecological Systems Theory (1979), which emphasizes the role of social, educational, and technological environments in shaping learning outcomes for individuals with intellectual disabilities. Thus, the novelty here lies in the effort to decolonize the disability paradigm from a deficit-based perspective to one that emphasizes potential, social participation, and data-driven contextual support.

Meanwhile, the theme 'bibliometric analysis-artificial intelligence-science mapping,' positioned in the emerging or declining themes quadrant, illustrates a new direction in research methodology. Although still in its early stages, the integration of artificial intelligence (AI) in literature analysis and educational outcome evaluation is beginning to develop significantly. Research by Karakoşe (2023) and Nagoëv (2021) demonstrates that AI can be used to analyze learning behavior trends, identify individual needs, and enhance the effectiveness of educational interventions. This points to a methodological shift toward AI-driven educational research, which aligns with the Fourth Industrial Revolution Theory (Schwab, 2016). Its novelty lies in the use of AI not only as a data analysis tool but also as an epistemological instrument that helps systematically and measurably understand the dynamics of learning and disability.

The results of the keyword co-occurrence network reinforce the findings from the thematic map. Keywords such as human, intellectual impairment, autism, psychology, and education show strong cross-disciplinary connections, indicating the interdisciplinary nature of this research. The link between artificial intelligence and bibliometric analysis on the right side of the network illustrates the emergence of new quantitative approaches in social research. Meanwhile, the close association between female, male, and adult indicates a more balanced demographic exploration in studies of disability and learning, signaling a research direction that is increasingly inclusive of gender and age(Lang et al., 2023).

The thematic mapping affirms a significant epistemological shift from traditional educational psychology toward the integration of neurocognitive and digital technologies in the context of inclusive education. The adolescent–autism–child cluster, which occupies the position of a motor theme, signals a transformation in research focus from clinical intervention to neuroresponsive learning grounded in adaptive learning experiences. In the context of Neuroconstructivism (Fandir, 2024), the cognitive development of individuals with autism is inseparable from the dynamic interaction between neurological structures, social experience, and digital environmental support.

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Therefore, future research directions demand a neuroresponsive learning approach, in which educational systems are designed to adapt in real time to learners' emotional and cognitive states through the integration of machine learning and biofeedback technologies. This integration not only expands the empirical boundaries of Social Constructivism (Vygotsky, 1978), but also gives rise to a new paradigm that may be termed Neuro-Social Constructivism an approach in which technology serves as a mediator between biological capacities and social construction in learning.

The theme bibliometric analysis–artificial intelligence–science mapping, positioned as an emerging theme, signals a new methodological direction toward the era of AI-driven psychopedagogy. In the context of future education, artificial intelligence is no longer merely an analytical tool but emerges as an epistemic co-agent that actively participates in the process of knowledge construction. According to the theory of Connectivism (Siemens, 2005), knowledge is no longer confined to individuals but circulates within digital networks that continuously learn and adapt. Thus, future research in this field must explore the concept of meta-learning analytics an algorithmic model capable of learning from learning patterns themselves to produce more precise and humanistic cognitive mapping. The integration of learning analytics, digital emotion, and AI ethics opens the door to a new paradigm referred to as Computational Constructivism, in which humans and machines co-evolve in the creation of meaning and learning experiences(Olapane et al., 2023).

Findings from the female–adult–male cluster, positioned as a basic theme, indicate that demographic issues such as gender and age remain fundamental yet tend to be marginalized in the discourse of digital inclusive education. However, future research needs to broaden its orientation toward psychosocial identity mapping a field that analyzes how social identity, gender, and disability interact within digital learning spaces. Referring to Gender Schema Theory (Bem, 1981) and the Intersectionality Framework (Crenshaw, 1989), learner identity in digital contexts is not static but fluid, shaped by social dynamics, technological algorithms, and cultural access. Therefore, integrating big data learning analytics with critical social theory holds the potential to give rise to a new field Inclusive Digital Identity Studies which examines how digital identity construction can strengthen social equity, gender representation, and the empowerment of individuals with disabilities within virtual learning ecosystems.

The theme humans education psychology, located in the niche themes quadrant, reflects a research trend that is theoretically mature but not yet strongly interconnected across disciplines. Therefore, future research directions should adopt the Cognitive Ecology paradigm a framework that views learning as the result of systemic interactions between individuals, social environments, and technology (Hutchins, 2014). Ecological Systems Theory (Bronfenbrenner, 1979) can serve as a foundation for understanding how inclusive learning occurs across multiple levels from the microsystem (digital classroom) to the macrosystem (national education policy). By integrating network science and systemic modeling, future research can map learning ecosystems that are sustainable, collaborative, and ecological. This approach not only enhances the depth of

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empirical analysis but also fosters the emergence of epistemic ecology a reciprocal relationship between social and cognitive structures that shape intelligent learning systems adaptive to both human and technological contexts(Popkova & Alpidovskaya, 2020).

Learning together ethically and sustainably." This transformation marks the emergence of a new conceptual paradigm Intelligent Constructivism when keyword clusters and their interrelationships are analyzed systemically. This paradigm synthesizes Constructivism (Piaget, 1972), Sociocultural Theory (Vygotsky, 1978), and principles of Artificial Intelligence Ethics (Floridi, 2019). It views learning as a co-evolutionary process between humans and intelligent systems in the creation of meaning, values, and knowledge. Within this framework, technology is not merely a pedagogical tool but an epistemic entity that actively participates in cognitive, social, and moral mediation. Accordingly, the future direction of research is no longer confined to the question of 'how humans learn using technology' but evolves into 'how humans and machines learn together.' This represents a paradigm shift from educational technology to technological epistemology, where ethics, autonomy, and collective awareness become central to future innovations in learning(Võ & Laking, 2020).

5. Conclusion

The findings of this analysis indicate that Learning Analytics research is undergoing a significant transformation toward an increasingly interdisciplinary trajectory, integrating intelligent technologies and developmental psychology approaches. The notable rise in publication volume and emphasis on themes such as adolescent autism, intellectual disability, and the application of artificial intelligence (AI) in education reflects a paradigmatic shift from traditional methods toward technology-based and advanced analytics approaches. In particular, the integration of AI into Learning Analytics opens up new paradigms, such as Neuro-Social Constructivism and Computational Constructivism, which merge social constructivism with digital technologies to foster adaptive and inclusive learning experiences. Furthermore, this research highlights the importance of exploring inclusive digital identities and cognitive ecological approaches in building sustainable, data-driven learning ecosystems. Thus, the future of Learning Analytics research will emphasize the collaboration between humans and machines in the ethical and sustainable co-construction of meaning and knowledge positioning technology not merely as a tool but as an active participant in the learning process.

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