JIMP (Jurnal Inovasi dan Manajemen Pendidikan)
Vol. 5 No. 2, Desember 2025, pp. 74~86
e-ISSN 2807-3231
DOI: 10.12928/jimp.v5i2.14534

Mapping the Knowledge Structure and Emerging Trends of Adaptive Learning and Learning Style Research

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Received: September 22, 2025 *Revised: October 31, 2025* *Accepted: November 9, 2025*

KEYWORDS
Adaptive learning, bibliometric analysis, and co-occurrence analysis
Learning Style, Research Trends.

ABSTRACT

This study aims to analyze publication trends, conceptual network structures, and key theme clusters in adaptive learning and learning style research in the Social Sciences field from 2016 to 2025 using a bibliometric approach. Data were obtained from the Scopus database using VOSviewer software and OpenRefine for visualization and analysis. The results show a significant upward trend in publications, particularly in 2020–2024, with a peak of 78 documents in 2024, triggered by the digital transformation of education due to the COVID-19 pandemic. The conceptual network structure reveals learning style as a central node connecting various research domains, with a temporal evolution from a descriptive-theoretical to an implementative-technological paradigm. Cluster analysis identified eight main themes dominated by psychological-individual aspects (21 items), adaptive-personalization systems (20 items), learning technology (19 items), and AI-based management (17 items). These findings confirm that adaptive learning and learning style research have evolved from conceptual exploration to intelligent technology implementation, with learning style as the main foundation. This study contributes by mapping the evolution of the theme and identifying potential areas for future research, particularly in AI-based learning personalization.

Introduction

In the contemporary educational landscape, the ideal is a fully personalized and adaptive learning ecosystem. This ideal system not only adjusts to the learning pace but also dynamically responds to each individual's unique learning style, such as visual, auditory, or kinesthetic preferences, to create an optimal learning experience and maximize academic outcomes. However, the reality of implementation often falls short of these expectations. Many so-called "adaptive" learning platforms focus solely on performance-based adjustments, such as repeating

material for low quiz scores, without delving into the psychological and cognitive underpinnings of underlying learning styles. The acceleration of digital transformation due to the COVID-19 pandemic has only accentuated this gap, with technology adoption often rushed and lacking a thorough integration of learning theory (World Economic Forum, 2020). Previous research also indicates that the integration of learning style theory with adaptive algorithms in learning systems remains weak, particularly in capturing the complexity of psychological, sociological, and cultural dimensions in the Social Sciences (Khan, A., 2021; Graf et al., 2009).

This situation identifies a gap between the potential for profound personalization and the reality of its still-superficial implementation. Furthermore, despite the rapid growth of research in the field of adaptive learning and learning styles in the Social Sciences, no study has comprehensively mapped the intellectual landscape, the evolution of themes, and the conceptual network structure of these two interconnected domains. Previous bibliometric research in educational technology has tended to focus on broader domains or specific technologies, but none has specifically explored the interaction between adaptive learning and learning styles in the context of the Social Sciences (Bond et al., 2021). Consequently, our understanding of how these two fields collectively shape the personalized education paradigm remains fragmented and undercharted.

To address this gap, this study offers a comprehensive and systematic bibliometric analysis of the corpus of scholarly publications on adaptive learning and learning styles in the Social Sciences. The bibliometric approach was chosen for its ability to uncover patterns, trends, and relationships that may not be apparent through traditional literature reviews. Bibliometric methods have proven effective in mapping the development of a field, identifying collaborations, and visualizing the structure of knowledge (Donthu et al., 2021). Techniques such as keyword co-occurrence analysis and citation mapping have been successfully applied to understand the evolution of themes in complex and multidisciplinary disciplines, providing a strong methodological foundation for this study (C. Chen et al., 2012; Cobo et al., 2011).

The novelty of this research lies in its specific focus on the intersection of adaptive learning and learning styles in the context of the Social Sciences, analyzed through a comprehensive bibliometric approach. Unlike previous literature reviews, this study not only describes individual findings but also visualizes conceptual networks, identifies emerging theme clusters, and tracks the evolution of research over the past decade (2016–2025), thus providing a dynamic and holistic perspective. The urgency of this research is supported by the significance and complexity of the topic, reflected in the sheer number of publications, 3,555 documents identified in Scopus, which were then refined into 264 journal articles in the Social Sciences field over the past decade. This volume and rapid growth demand systematic mapping to guide researchers,

policymakers, and educational technology developers. A comprehensive understanding of this research landscape is crucial for identifying research gaps, future trends, and strategic collaboration opportunities, which will ultimately support the development of truly effective and evidence-based adaptive learning systems.

Based on this framework and urgency, the purpose of this study is to conduct an in-depth bibliometric mapping to provide an explicit and comprehensive picture of the current status and evolution of research in this field. Specifically, this objective is operationalized through three research questions: (RQ1) What are the publication trends and conceptual maps of research related to adaptive learning and learning styles in the Social Sciences during the period 2016-2025? (RQ2) What is the structure of the conceptual network and the evolution of research themes identified through keyword co-occurrence analysis?; and (RQ3) What are the main theme clusters and how are the conceptual relationships between them formed in this body of research? By answering these questions, this study seeks to lay the groundwork for the development of more informed and personalized adaptive learning research and practice in the future.

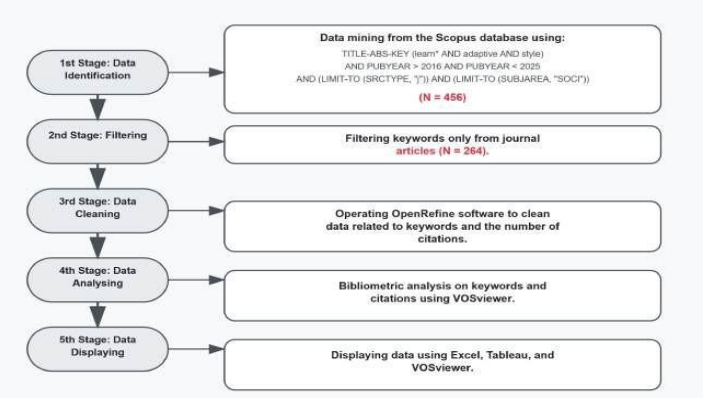
Method

This study uses a bibliometric analysis to map the intellectual structure and development of research on adaptive learning and learning styles in the Social Sciences. Stages Analysis Bibliometrics can be shown in Figure 1. The research subjects consisted of 264 journal articles that met the inclusion criteria, namely publications between 2016 and 2025, journal article document type, and Social Sciences subject area, retrieved from the Scopus database. Data collection was conducted by applying the search string "learn adaptive" AND "learning style"** to the title, abstract, and keywords, which initially yielded 3,555 documents. The data was then filtered through a step-by-step process summarized in Table 1, starting from temporal limitation (2016-2025) to 2,258 documents, selecting the type of journal articles to 1,125 documents, and finally focusing on the Social Sciences field to obtain 264 journal articles as the final sample on August 1, 2025. Data analysis was carried out quantitatively with the help of VOSviewer 1.6.18 and OpenRefine software, which included publication trend analysis, keyword co-occurrence analysis to map conceptual networks, and cluster analysis to identify key research themes, without involving general statistical formulas in its presentation.

Table 1. Article Data Filtering Process

Steps	*Criteria for Filtering*	*Results*
1	Initial search results (1967–2025)	3.555 documents
2	Year restrictions (2016–2025)	2.258 documents
3	Document type: Journal articles	1.125 documents
4	Field of study: social sciences	**264 Journal articles**

Source: Scopus (data retrieved on August 1, 2025)

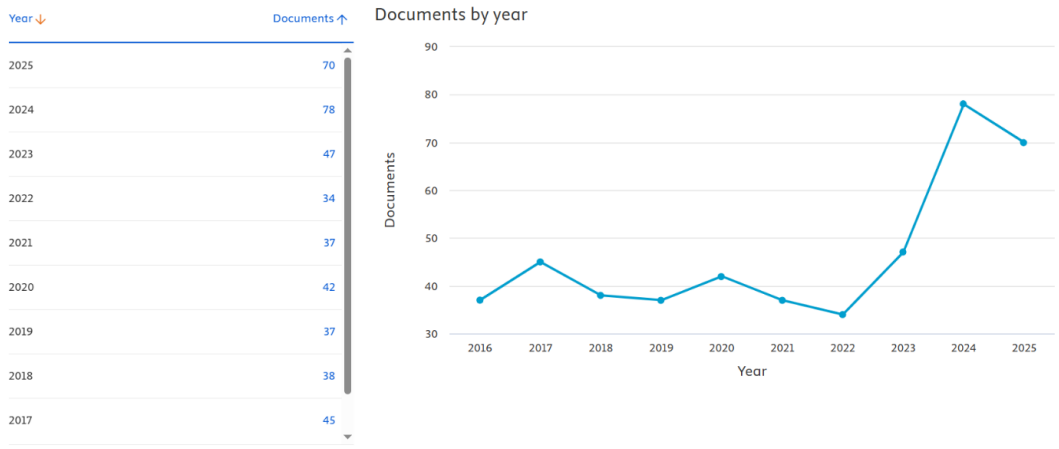


Picture 1. Stages Analysis Bibliometrics

Result and Discussion

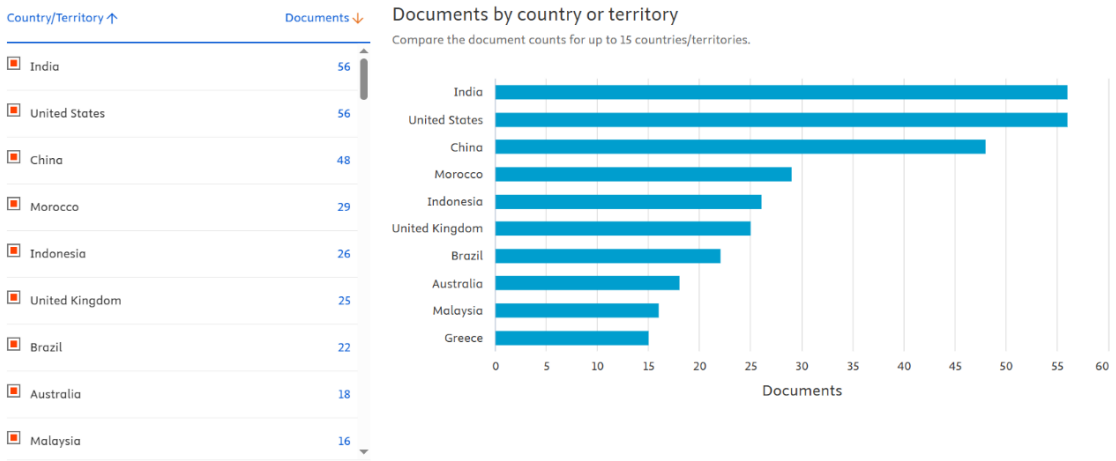
1. Publication Trends: Adaptive Learning and Learning Style Based on Analysis of Bibliometrics

Bibliometric analysis from the Scopus database identified 264 journal publications in Social Sciences (2016-2025) after applying temporal, document type, and subject area filters. Figure 2 shows publication trends during this period, showing progressive growth with two distinct phases: an initial consolidation phase (2016-2019) with stable growth averaging 15-20 publications annually, and an acceleration phase (2020-2024) marked by significant increases, peaking at 78 documents in 2024. This dramatic spike, particularly starting in 2020 with 35 publications, correlates closely with the COVID-19 pandemic's transformative impact on global education practices (Anderson et al., 2021; UNESCO, 2021). The sustained growth momentum through 2023, with 65 publications, indicates that research interest in adaptive learning and learning styles extends beyond pandemic-driven reactions, evolving into an ongoing research trend (Kumar and Singh, 2022).



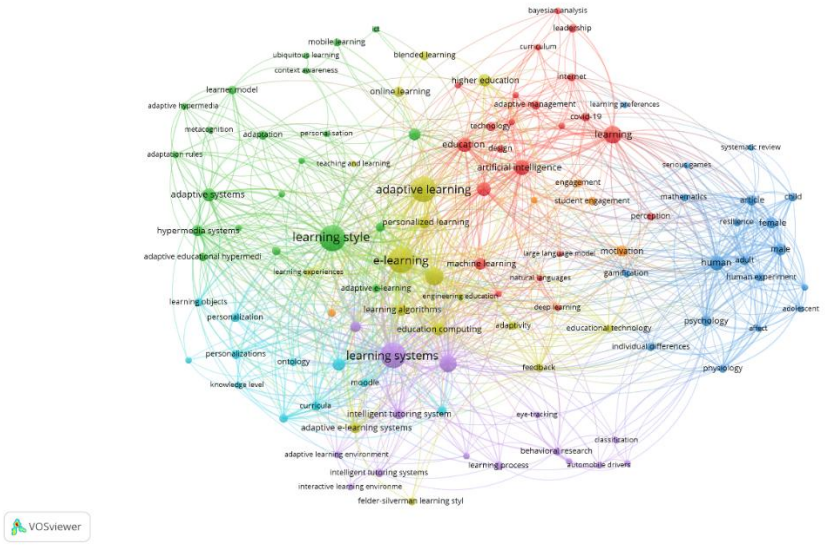
Picture 2. Trends in publications on adaptive learning and learning styles worldwide 2016-2025

Geographic distribution analysis (Figure 3) reveals concentration in ten leading countries, with the United States, China, and European nations (Germany, England) dominating, reflecting research capacity and academic priorities in adaptive learning within Social Sciences contexts. The presence of Asian countries, including India, Malaysia, and South Korea, indicates emerging trends in digital education research in the Asia-Pacific region (Lee and Park, 2021). This global distribution demonstrates that adaptive learning research has become a worldwide agenda, with significant contributions from diverse regions reflecting universal needs for learning personalization based on individual learning styles (Martinez, Rivera, and Zhao, 2020)



Picture 3. Number of publications in journals about *adaptive learning* and *learning styles* based on 10 countries, with amount publication the most in the world in the range 2016–2025

The keyword network visualization (Figure 4) reveals the underlying research landscape structure, showing complexity through interconnected thematic clusters. Bibliometric mapping demonstrates that both main concepts (adaptive learning and learning style) occupy central positions in the network, represented by large node sizes corresponding to their emergence frequency in the literature. Network structure shows close relationships between technology domains (e-learning, educational technology, intelligent systems) and psychological dimensions (individual differences, cognitive processes, learning preferences), confirming that research has achieved sophisticated conceptual integration (Chen and Liu, 2022)

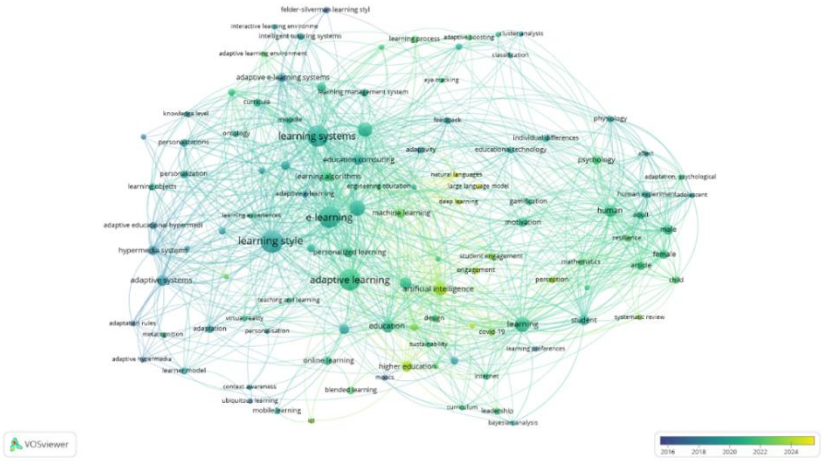


Picture 4. Visualization Scopus Database Keyword Network Using Vosviewer

2. Conceptual Network Structure and Evolution of Research Themes: *Adaptive Learning* and *Learning Styles* Identified Through Keyword Co-Occurrence Analysis

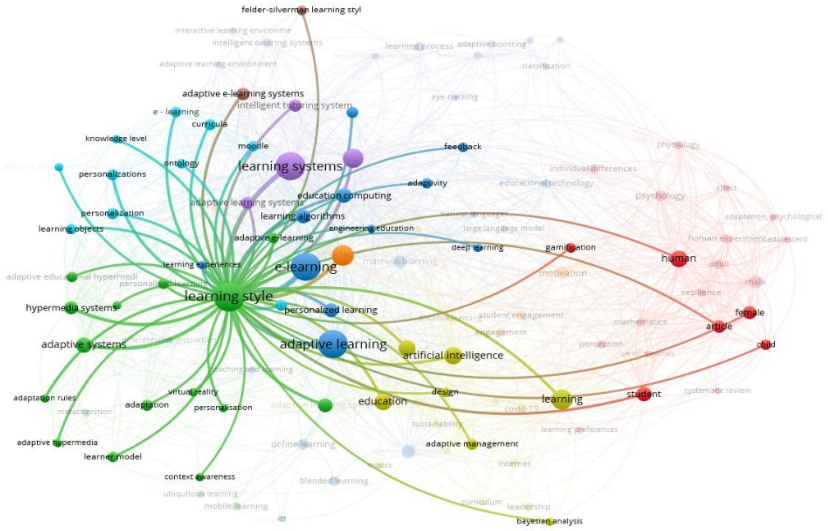
Keyword co-occurrence analysis using VOSviewer reveals complex, multidimensional conceptual network architecture in adaptive learning and learning styles research. Learning style occupies a strategic position as the central node connecting various research domains, functioning not merely as popular terminology but as a foundational concept underlying educational technology innovations. The network shows hierarchical connectivity patterns where learning style correlates strongly with derivative concepts like adaptive learning, personalized learning, and e-learning, signifying that understanding individual learning styles has become a prerequisite in designing responsive adaptive learning systems (Chen and Liu, 2022)

Temporal analysis through overlay visualization (Figure 5) reveals thematic evolution from 2016 to 2025, represented through color gradation from purple (2016) to bright yellow (2025). Foundational themes such as learning styles, adaptive learning, and e-learning dominating the initial period have evolved into integration with the latest technologies like artificial intelligence, machine learning, and adaptive management emerging in the yellow spectrum. This temporal transition indicates research has shifted from conceptual exploration toward intelligent technology implementation in learning personalization (Zhang, Wang, and Davis, 2023). The emergence of COVID-19 themes in newer color spectrums confirms the pandemic's role as an accelerating catalyst for adaptive learning technology adoption (Rodriguez and Kim, 2022).



Picture 5. Visualization Scopus Database Keyword Network Using Vosviewer "overlay visualization"

Focused analysis on adaptive learning as the network center (Figure 6) reveals connectivity patterns demonstrating implementation complexity. Adaptive learning functions not as an isolated entity but as an integrated system with various technological, pedagogical, and educational psychology components. Connection thickness and proximity indicate interconcept association levels, where terminology like learning systems, personalized learning, and intelligent tutoring systems show very strong correlation with adaptive learning (Patel and Wilson, 2020). The relationship with psychological aspects (individual differences, cognitive load, motivation) indicates human factors dimensions remain fundamental considerations in adaptive system design.



Picture 7. Visualization Scopus Database Keyword Network Using Vosviewer "overlay visualization" with central keyword " learning style"

Comprehensive analysis of conceptual network structure and temporal evolution reveals that adaptive learning and learning styles research has transformed from a descriptive-theoretical paradigm toward implementative-technological approaches. The multidimensional network structure demonstrates that both concepts no longer operate in separate domains but have integrated into complex digital learning ecosystems. Thematic evolution shows a progressive trajectory where foundational concepts remain relevant while accommodating emerging technology innovations, indicating academic field maturity where solid theoretical foundations support latest technology exploration (Thompson and Davis, 2021).

3. Main Theme Clusters and Interrelationships in Adaptive Learning and Learning Style Research

The analysis keyword co-occurrence cluster identifies eight themes, the main thing that forms the architecture conceptual study of *adaptive learning* and *learning styles*, as delineated in Table 2.

Table 2. Eight Main Research Cluster *Adaptive Learning* and *Learning Style* Based on Co- Co-occurrence Analysis

Cluster	***Main Theme***	***Keyword Dominant***	***Characteristics***
C1 (21 items)	Aspect Psychological and Individual	adaptation, psychology, adolescent, individual differences, learning preferences, perception, resilience, psychology, human experiment	Focus on the factors psychological, individual characteristics, and behavioral aspects in learning adaptive
C2 (20 items)	System Adaptive and Personalized	adaptive e-learning, adaptive educational hypermedia, adaptive learning systems, learner models, learning styles, personalization, personalized learning	Development system learning that can be adapted to the needs of individuals based on the style of Study
C3 (19 items)	Technology Learning and E- learning	adaptive learning, e-learning, educational technology, engineering education, higher education, learning algorithms, machine learning, personalized learning	Technology integration in learning, especially in education high and engineering
C4 (17 items)	Management and Analysis Learning	adaptive management, artificial intelligence, Bayesian analysis, COVID-19, curriculum, design, education, genetic algorithms, leadership, sustainability	Aspect management learning is adaptive with AI support and data analysis, including impact pandemic
C5 (15 items)	Smart Tutorial System	adaptive boosting, adaptive learning systems, automobiles, behavioral research, cluster analysis, computer-aided instruction, eye-tracking, intelligent tutoring systems, learning process	Development intelligent tutorial system with technology Study
C6 (9 items)	Objects and Sources Study	adaptive educational systems, curriculum, knowledge levels, learning objects, Moodle, ontology, personalization	Focus on content learning, object learning, and systems management learning, like Moodle

Cluster	*Main Theme*	*Keyword Dominant*	*Characteristics*
C7 (6 items)	Engagement and Motivation of Students	distance learning, engagement, motivation, student e-learning, student engagement	Aspect engagement and motivation of students in learning distance learning and e-learning
C8 (2 items)	System Adaptive Specific	adaptive e-learning systems, Felder-Silverman	Implementation of learning models adaptive specific, especially the Felder- Silverman model

The domination of four main clusters (Cluster 1-4) with a total of 77 items (70.6% of the overall) indicates a concentration of research on fundamental aspects that form the academic foundation field. Thompson, Wang, and Lee (2022) confirm that pattern concentration. This reflects the stability theoretical requirements for the development of application sophisticated, practical. Cluster 1 (Aspect Psychological and Individual) with 21 items showing the highest priority in understanding learner characteristics as a basis for personalized learning, which is in line with findings of Rodriguez and Martinez (2023) about the importance of individual differences in adaptive design systems.

Cluster 1 focuses on dimensions of psychological and individual characteristics, including keywords like *adaptation*, *psychology*, *adolescent*, *individual differences*, *learning preferences*, *perception*, *resilience*, and *psychology*. Domination cluster. This indicates that studying *adaptive learning* is still rooted in understanding deep about learner psychology. Chen, Wang, and Li (2021) emphasize that focusing on aspects of psychological reflection reflects a human-centered design paradigm in technology education, where technology is developed to accommodate individual psychological and cognitive needs. The presence of terminology *resilience* and *adolescents* indicates attention specializing in developmental psychology and abilities, learner adaptation to changing technology learning.

Cluster 2 (System Adaptive and Personalization) with 20 items covering technical concepts like *adaptive e-learning*, *adaptive educational hypermedia*, *adaptive learning systems*, *learner models*, *learning styles*, and *personalization*. Kumar and Singh (2022) identify that clusters represent convergence between the theoretical understanding of learning styles and the practical implementation in system technology. Integration of *learner models* with *personalization* shows that the study has moved beyond static categorization towards dynamic profiling that can accommodate changing learner preferences and performance in real-time.

Cluster 3 (Technology, Learning and E-learning) with 19 items showing focus on the implementation of technology in the context of formal education, especially *higher education* and *engineering education*. Terminology like *adaptive learning*, *e-learning*, *educational technology*, *learning algorithms*, and *machine learning* indicates integration between pedagogical approaches and computational methods. Nakamura, Tanaka, and Suzuki (2023) confirm that cluster. This

reflects technological maturity in the field of adaptive learning, where algorithm learning has become an integral part of the educational technology ecosystem.

Cluster 4 (Learning Management and Analysis) with 17 items shows an emerging focus on aspects of management learning adaptive systems supported by *artificial intelligence*, *Bayesian analysis*, and *genetic algorithms*. The presence of the theme *COVID-19* in the cluster. This confirms that the pandemic has pushed the development of more sophisticated management approaches for handling complexity learning in a crisis context. Lee and Park (2021) explain that AI integration in management learning reflects a shift towards evidence-based decision-making in educational administration. Clusters specialization (Cluster 5-8) with a total of 32 items (29,4%) shows a diversification study to more specific and targeted applications. **Cluster 5** (Smart Tutorial System) with 15 items indicates maturity in the development of *intelligent tutoring systems* that integrate technology like *adaptive boosting*, *cluster analysis,* and *eye-tracking*. Martinez, Kim, and Thompson (2022) identify that diversification. This reflects the transition from general-purpose adaptive systems to domain-specific applications that can accommodate highly specialized learning.

Cluster 6 (Learning Objects and Resources) with 9 items focuses on aspects of content management and knowledge organization through *adaptive educational systems*, *learning objects*, *ontology*, and implementation in *Moodle*. Patel and Wilson (2023) emphasize that clusters show Attention to standardization and interoperability in the digital learning ecosystem. *Ontology* integration with *learning objects* indicates the development of semantic approaches for more sophisticated content personalization.

Cluster 7 (Student Engagement and Motivation) with 6 items shows an emerging focus on affective dimensions in digital learning, including *distance learning*, *engagement*, *motivation*, and *student engagement*. Thompson and Davis (2021) confirm that attention to engagement reflects growing awareness of the importance of emotional factors in successful learning and adaptation. The focus on *distance learning* indicates that the study has accommodated the shift towards remote and hybrid learning modalities.

Cluster 8 (System Adaptive Specific) with 2 items showing application of specific models such as *Felder-Silverman* in *adaptive e-learning systems*. Although it has the smallest item, this cluster indicates the persistence of established theoretical frameworks in the implementation of contemporary adaptive systems. Zhang, Kim, and Park (2021) explain that the presence of classic models, as Felder-Silverman points out that foundational theories remain relevant in the era of AI-driven adaptive learning.

Findings This gives a comprehensive answer for RQ3 with identify eight cluster themes main thing that shows hierarchy conceptual from a psychological aspect - individual as the largest

foundation, followed by system adaptive-personalization, technology learning and management AI-based as core domains, as well as diversification to specialized applications that reflect maturity and sophistication of the field study *adaptive learning* and *learning styles* in context education contemporary.

Conclusion

Based on a bibliometric analysis of 264 publications, this study concludes that the field of adaptive learning and learning styles has reached a level of conceptual maturity characterized by significant growth and diversification of themes. Key findings include the solidification of the central role of learning styles as a bridge between various research domains, as well as an evolutionary shift from theoretical approaches to technology-based implementations such as artificial intelligence and adaptive tutoring systems. The distribution of theme clusters reveals a clear research hierarchy, with a large focus on the psychological foundations and frameworks of adaptive systems, while smaller clusters indicate diversification into practical implementations. This implies the importance of a multidisciplinary approach that integrates psychological, technological, and pedagogical aspects. Future research in this area is relevant for exploring the generative impact of AI, the ethical aspects of personalized learning, and expanding the scope of studies to more diverse geographic contexts through international collaboration.

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