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Exploring learning styles in the online environment: A comprehensive review

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Abstract

Understanding learning styles has become increasingly important in the realm of education, particularly with the rise of personalized and learner-centered approaches facilitated by advancements in science and technology. This article aims to address the research gap in comprehensively understanding learning styles in the contemporary online context. By consolidating and examining learning styles within the online environment, this study seeks to contribute to the existing body of knowledge and facilitate evidence-based practices. The research questions that guide this study focus on identifying prevailing patterns and tendencies, evaluating academic journals with significant author interest, uncovering emerging themes, and identifying influential scholarly articles. The study employs the PRISMA research model and utilizes the Scopus database for source selection. The inclusion and exclusion criteria ensure the selection of relevant articles published between 2016 and 2023, which underwent evaluation and peer review and are written in English. The data coding and analysis process involves organizing and cleansing the selected articles before analyzing them using the VosViewer tool. The results and discussion section presents trends in the publication of learning styles in the online environment over the years and identifies the academic journals that have garnered significant interest in this field. The abstract concludes by emphasizing the importance of this study in shedding light on evolving trends, informing decision-making processes, and fostering a deeper understanding of learning styles in the digital era.

Keywords: Learning styles; online learning; digital environment; personalized education; PRISMA

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1. Introduction

Understanding learning styles has gained increasing significance in recent years, driven by advancements in science and technology that aim to enhance the effectiveness of personalized and learner-centered education. Learning style is a multifaceted concept that encompasses various perspectives and contexts, including progress, learning preferences, techniques, attitudes, and behaviors (Jannah & Bharata, 2020; Kovac, 1999; Permanasari et al., 2019). For instance, Sant & Kashive (2022) define learning style as the way learners assimilate and process information, encompassing not only a passion for learning but also intellectual capabilities. Klement et al. (2014) view learning style as the interconnection between knowledge and other elements of life. Overall, researchers adopt a broad perspective on learning style, considering it as a collection of characteristics and behaviors exhibited by learners in their reception and processing of information. Comprehending students' learning styles offers numerous benefits to educators, particularly in the present online learning environment. These advantages include the ability to design appropriate learning materials and activities tailored to individual students, providing targeted support and guidance to each student, and proactively cultivating self-awareness and metacognitive skills among students. However, alongside these positive aspects, challenges and difficulties associated with learning styles also exist. These challenges encompass the diversity of learning styles, necessitating teachers to acquire and adapt diverse teaching methods and materials. Moreover, the presence of individual differences requires teachers to recognize and cater to the unique needs of each student, while the assessment of learning outcomes poses challenges that demand the utilization of multiple evaluation approaches.

To address the challenges, researchers have undertaken diverse studies encompassing differentiated instruction, establishing effective student communication channels, and implementing pedagogical philosophies and principles within classrooms. For instance, El-Sabagh (2021) examined the correlation between adaptive e-learning environments and student engagement, revealing more favorable outcomes among the experimental group compared to the control group. Cabual (2021) redefined student learning styles and methods in the context

of the "new normal." Jonassen & Grabowski (2020) explored the relationship between Kolb's learning styles and online learning time, finding a significant impact of Kolb's learning styles on online learning behavior. Benabbes et al. (2023) employed the Felder-Silverman model to classify students into clusters and proposed learning objects tailored to these groups.

Although numerous studies have explored learning styles in the online environment, most of them have primarily focused on the "new normal" aspect and identified singular, novel variables. Consequently, there remains a research gap in comprehensively understanding learning styles in the contemporary online context. Addressing this gap is essential to assist budding researchers in shaping their research directions, enable experts to update their domain knowledge, and offer policymakers a foundation for making timely recommendations and decisions.

Filling this research gap would contribute to a holistic understanding of learning styles in the online environment, considering the multifaceted dimensions and complexities involved. It would provide valuable insights into the interplay between learning styles, instructional approaches, and technological advancements, thus facilitating the development of evidence-based practices and informing decision-making processes. Hence, the primary objective of this study is to consolidate and examine learning styles within the online environment. The article specifically aims to address the following key research inquiries:

Research Question 1: What are the prevailing patterns and tendencies observed in learning styles within the digital landscape in recent years?

Research Question 2: Which academic journals have garnered significant author interest and engagement in the realm of learning styles?

Research Question 3: What are the the emerging themes in learning styles within the digital landscape?

Research Question 4: Which scholarly articles exhibit the greatest impact and influence in the field, and how is the magnitude of their influence manifested?

By thoroughly investigating these research questions, this study endeavors to contribute to the existing body of knowledge by presenting a comprehensive synthesis and analysis of learning styles in the online environment. The findings will shed light on the evolving trends, prominent journals, prevalent keywords, and influential articles, thereby facilitating the advancement of research directions, informing scholars' decision-making, and fostering a deeper understanding of learning styles in the digital era.

2. Methodology

This article employs the bibliometric research method and adopts the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) research model as a framework for conducting a comprehensive and structured search, selection, and evaluation of articles. The PRISMA model is recognized as a standardized set of procedures designed to guide scholars in undertaking systematic and rigorous research. It comprises two key components:

i) PRISMA process: In this stage, researchers delineate the data sources, outline the steps involved in screening the data, establish the criteria for screening, and present the final outcomes.

ii) Item list: PRISMA offers a comprehensive list of 27 items that scholars can reference and incorporate into their reports. It is important to note that not all 27 items must be included in the report, as their inclusion varies depending on the specific research problems and domains under investigation.

The PRISMA guidelines are widely recommended and extensively applied across diverse fields of study, enhancing the transparency and rigor of research endeavors (Nguyen & Nguyen, 2022; Vinh et al., 2024)

2.1. Source selection.

In this study, the researcher utilized the Scopus database to conduct a comprehensive search for recent publications within the defined scope. Scopus is widely acknowledged as a dependable and reputable data source, distinguishing itself from numerous other search platforms due to its rigorous evaluation and critical appraisal of included articles. Consequently, the research findings derived from articles available in the Scopus database are deemed highly trustworthy and reliable. The utilization of Scopus as a primary data search source is prevalent in various scholarly articles of a similar nature, attesting to its widespread adoption and acceptance within the research community.

2.2. Search criteria.

To conduct a comprehensive search for articles relevant to the current research topic, the inclusion and exclusion criteria outlined below must be satisfied:

Inclusion Criteria:

i) The article must contain the keywords "learning style" and "online learning" or "electronic learning," with these terms appearing in the title, abstract, or keywords.

ii) The article must be published within the timeframe of 2016 to 2023.

iii) The article must have undergone evaluation and peer review.

iv) The article must be written in English.

v) The article must be published in scholarly journals.

Exclusion Criteria:

i) Articles will be excluded from the search results if any of the following criteria are met:

ii) The article does not mention the terms "learning style" and "online learning" or "e-learning" in the title, abstract, and keywords.

iii) The article is not published within the specified timeframe of 2016 to 2023.

iv) The article has not undergone the process of evaluation and peer review.

v) The article is not written in English.

vi) The article is published in non-journal sources such as newspapers or magazines.

2.3. Eligibility assessment

To ensure the integrity and validity of the search results, the author employed a two-step procedure. Firstly, articles were subjected to automated filtering using the tools provided by Scopus. Subsequently, the remaining results underwent external evaluation by two independent researchers. The author then compared the filtering outcomes derived from the assessments of the two researchers. If their results were consistent, the article was retained. However, in cases where discrepancies arose, the author made a judgment regarding whether to retain or exclude the article based on careful consideration of the differing assessments.

2.4. Data Coding and Analysis

Following the filtration process, the selected articles will be organized and stored in a CSV file for subsequent analysis. The data extracted from each article will encompass key elements such as the title, abstract, keywords, author information, journal details, and citation counts. Before engaging in the analysis phase, the data will undergo a thorough cleansing process to ensure its accuracy and coherence. This cleaning procedure will entail several steps, including:

i) Rectifying spelling errors to enhance data accuracy.

ii) Consolidating abbreviations and their corresponding full words to avoid duplication and maintain consistency across the dataset.

Once the data has been processed and cleaned according to these steps, it will be subjected to analysis leveraging the VosViewer tool. VosViewer, a recognized analytical tool in the field, will enable the exploration and visualization of key patterns, relationships, and trends within the dataset.

3. Results and Discussion

3.1. Research Question 1: What are the prevailing patterns and tendencies observed in learning styles within the digital landscape in recent years?

In general, there is an observed trend of an increasing number of articles that fulfill the search criteria pertaining to learning styles in the online environment within the time frame of 2016 to 2023 (see Figure 4). However, this growth trajectory exhibits uneven fluctuations across different stages.

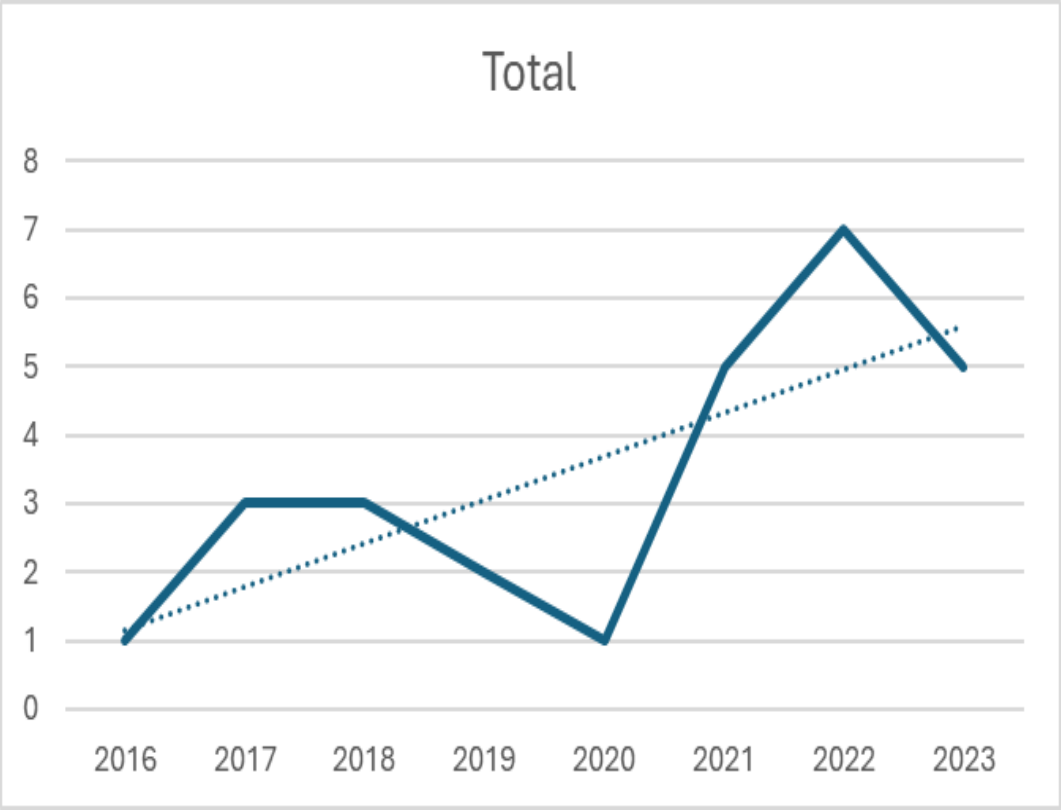

Figure 4. Publication trend of learning styles in e-learning from 2016 to 2023

During the initial period from 2016 to 2018, a modest rise in the quantity of publications is evident, with the number increasing from 1 article to 3 articles. This slight upswing can be attributed to a growing recognition of the significance of learning styles within the online learning context, as well as advancements in technology that support online pedagogy. Subsequently, from 2018 to 2020, a decline in the number of publications is observed, corresponding to the preceding period of growth. This dip can be partially attributed to changes or adjustments in online education policies and regulations, along with shifts in interest and investment within the field. However, a noteworthy surge in the number of articles emerges from 2020 to 2022, with the count escalating from 1 article to 7 articles. This notable increase could potentially be attributed to factors such as heightened research and development endeavors focused on online learning styles, as well as increased support and investment from educational and research organizations. These fluctuations in the publication output over time reflect the evolving landscape of scholarly interest and investment in the exploration of learning styles within the online environment. They also underscore the dynamic nature of the field and the influence of external factors such as technological advancements, policy changes, and research priorities on the quantity and direction of academic output.

3.2. Research Question 2: Which academic journals have garnered significant author interest and engagement in the realm of learning styles?

The results of the study of 27 articles provide information about the names of the journals as follows:

Table 1. Journals list for existing and future submission

Source title	# publications
International Journal of Emerging Technologies in Learning (Benabbes et al., 2023; Kolekar et al., 2017; Li, 2023; Rami et al., 2022)	4
International Journal of Advanced Computer Science and Applications	3
Sustainability (Switzerland) (Alfaro et al., 2018, 2019; Anggrawan et al., 2019)	2
Eurasia Journal of Mathematics, Science and Technology Education (Afify, 2018; Hamada & Hassan, 2017)	2
IEEE Access (Pardamean et al., 2022; Rajkumar & Ganapathy, 2020)	2
F1000Research	2
International Journal of Engineering Pedagogy	1
Cogent Education	1
Journal of Educators Online	1
Applied Sciences (Switzerland)	1
BMC Medical Education	1
Ankara Medical Journal	1
International journal of online and biomedical engineering	1
Asian Social Science	1
Journal of Technology and Science Education	1
Australasian Journal of Educational Technology	1
Computer Science and Information Systems	1
International Journal of Educational Technology in Higher Education	1
Grand total	27

The data presented in the above The results of the study of 27 articles provide information about the names of the journals as follows:

Table 1 reveals that scholars have published a total of 27 articles about learning styles in the online environment between 2016 and 2023. These articles are distributed across 18 different journals, indicating a diverse range of journals with an interest in this topic. A detailed analysis of the distribution of articles among the journals highlights the varied attention received by each publication. The "International Journal of Emerging Technologies in Learning" emerges as the most prominent journal, featuring a total of 4 articles, representing 14.8% of the overall article count. Following closely is the "International Journal of Advanced Computer Science and Applications" with 3 articles, accounting for 11.1% of the total. Furthermore, four other journals demonstrate a similar level of contribution, namely "Sustainability (Switzerland)," "Eurasia Journal of Mathematics, Science and Technology Education," "IEEE Access," and "F1000Research," each featuring 2 articles. The remaining 12 journals have only published 1 article each. This distribution pattern indicates a diverse range of journals with an interest in exploring learning styles in the online environment. While no single journal dominates the field, this diversity offers numerous options for scholars seeking to publish their research. Researchers can choose from a variety of journals, taking advantage of the breadth of choices available to them, rather than being constrained by a limited selection of prescribed journals. This multifaceted landscape can foster healthy competition and advancements in the field of online learning styles.

3.3. Research Question 3: What are the the emerging themes in learning styles within the digital landscape?

Figure 2 illustrates the spatial relationships among the keywords extracted from 27 publications. Each keyword is represented by a circle, and the size of the circle corresponds to its frequency within the dataset. The color of the circles indicates the cluster to which each keyword or node belongs. The figure clearly displays the presence of five distinct clusters that have formed based on the analyzed keywords.

Theme 1 - Technology-Enhanced Learning: This cluster seems to focus on the intersection of technology and learning styles. It includes keywords such as brain-computer interface, chatbot, machine learning, and massive open online course (MOOC). These keywords suggest a theme related to the use of technology, such as chatbots and brain-computer interfaces, to enhance learning experiences based on individual learning style preferences.

The inclusion of keywords like extraverts, introverts, and VARK learning style indicates an interest in understanding how different learning styles can be accommodated in technologically mediated learning environments.

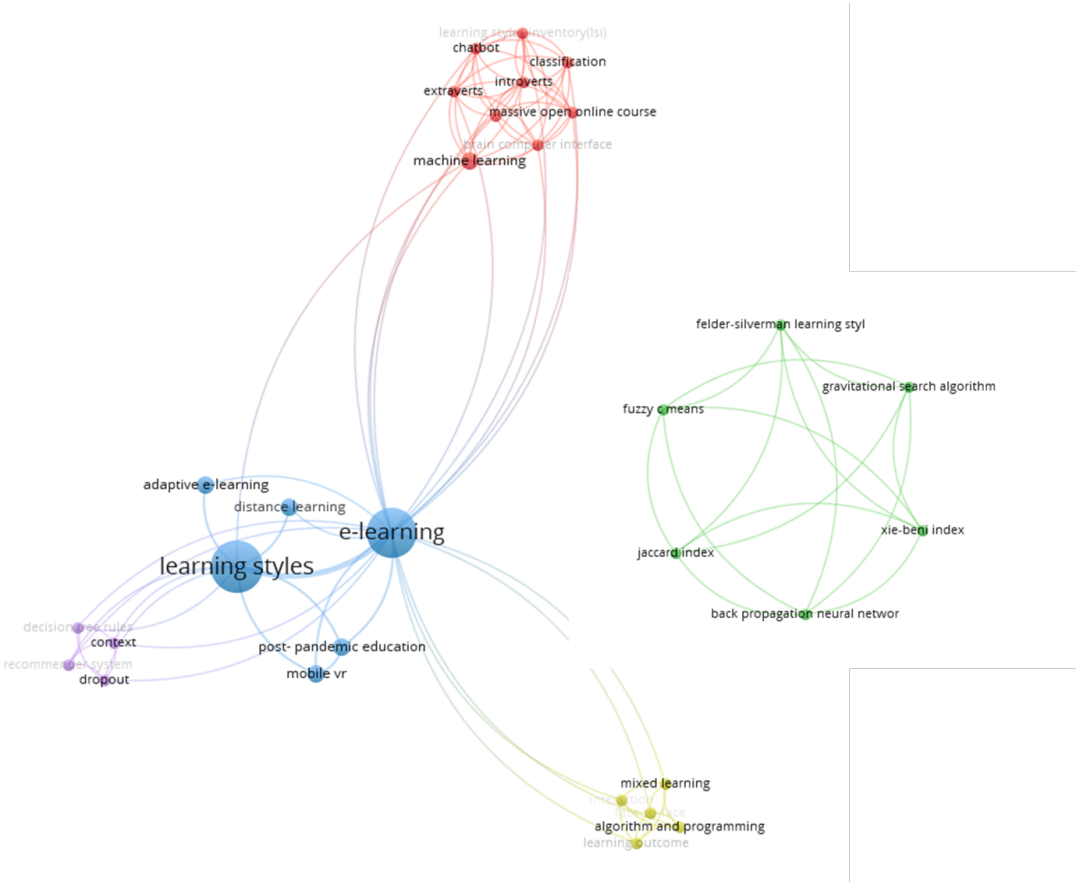

Figure 5. Emerging themes from 27 publications

Theme 2 - Algorithmic Approaches: This cluster appears to revolve around machine learning algorithms and their application in learning style analysis. Keywords such as backpropagation neural network, fuzzy c-means, and gravitational search algorithms indicate a focus on algorithmic approaches for classifying and understanding learning styles. The inclusion of evaluation metrics like the Jaccard index and Xie-Beni index suggests a theme of assessing the effectiveness and performance of learning style classification algorithms.

Theme 3 - Online and Virtual Learning: This cluster centers on the broader topic of e-learning and learning styles, particularly in the context of distance learning and post-pandemic education. Keywords like adaptive e-learning, distance learning, and mobile VR (virtual reality) point to a theme of exploring how learning styles can be accommodated and leveraged in online and virtual learning environments. The mention of post-pandemic education suggests an interest in understanding the role of learning styles in the evolving educational landscape influenced by the COVID-19 pandemic.

Theme 4 - Instructional Modalities and Learning Outcomes: This cluster focuses on the interaction and learning outcomes in various learning environments. Keywords such as face-to-face, interaction, and mixed learning indicate a theme of exploring the impact of different instructional modalities on learning outcomes. The inclusion of keywords like algorithm and programming suggests a potential interest in understanding how programming and algorithmic thinking can be integrated into learning experiences to enhance outcomes.

Theme 5 - Contextual Personalization and Decision-Making: This cluster appears to center on the concept of context and decision-making in the context of learning styles. Keywords like context, decision tree rules, and recommender system suggest a theme related to utilizing contextual information and decision-making models to personalize learning experiences based on individual learning styles. The mention of dropout may indicate a focus on identifying factors that contribute to learner disengagement or attrition in relation to learning styles.

3.4. Research Question 4: Which scholarly articles exhibit the greatest impact and influence in the field, and how is the magnitude of their influence manifested?

Through the process of reading and analysis, academic articles on learning styles in online learning environments are listed in the table below:

Table 2. Top 5 influential publications

No	Publication	Citations	Highly Influential Citations	Background Citations	Methods Citations
1	Investigating the effect of learning styles in a blended e-learning system: An extension of the technology acceptance model (TAM) - (Al-Azawei et al., 2017)	182	7 (3.85%)	56 (30.77%)	15 (8.24%)
2	Prediction of Learner's Profile Based on Learning Styles in Adaptive E-learning System - (Kolekar et al., 2017)	60	2 (3.33%)	16 (26.67%)	15 (25%)
3	Bio-Inspiring Learning Style Chatbot Inventory Using Brain Computing Interface to Increase the Efficiency of E-Learning - (Rajkumar & Ganapathy, 2020)	58	3 (5.17%)	18 (31.03%)	6 (10.34%)
4	Adaptive e-learning environment based on learning styles and its impact on development students' engagement - (El-Sabagh, 2021)	86	5 (5.81%)	41 (47.67%)	10 (11.62%)
5	An enhanced learning style index: Implementation and integration into an intelligent and adaptive e-Learning system - (Hamada & Hassan, 2017)	23	1 (4.35%)	10 (43.48%)	4 (17.39%)

Table 2 presents data on several publications exploring the effect of learning styles in e-learning systems and their impact on various factors. The first publication, "Investigating the effect of learning styles in a blended e-learning system: An extension of the technology acceptance model (TAM)," has received 182 citations, suggesting that it has garnered significant attention in the research community. Out of these citations, 7 (3.85%) are classified as highly influential, indicating that the study's findings and methodology have made a notable impact. The relatively high number of background citations (56 or 30.77%) suggests that the research has provided valuable insights into the theoretical foundations and context of learning styles in e-learning systems. The methods citations (15 or 8.24%) indicate that the study's research methods and techniques have been recognized and referenced by other researchers. The second publication, "Prediction of Learner's Profile Based on Learning Styles in Adaptive E-learning System," has received 60 citations. Although this is a lower number compared to the first publication, it still indicates a moderate level of interest and engagement from the research community. The 2 (3.33%) highly influential citations suggest that the publication has made a notable impact on the field. The background citations (16 or 26.67%) imply that the research has contributed to the existing knowledge and understanding of learning styles in adaptive e-learning systems. Similarly, the methods citations (15 or 25%) highlight the recognition of the study's research methods and their potential applicability. The third publication, "Bio-Inspiring Learning Style Chatbot Inventory Using Brain Computing Interface to Increase the Efficiency of E-Learning," has garnered 58 citations, indicating a moderate level of attention. The 3 (5.17%) highly influential citations suggest that the publication has made a notable contribution to the field and has likely introduced novel ideas or approaches. The relatively high number of background citations (18 or 31.03%) indicates that the research has provided valuable insights into the conceptual and theoretical aspects of learning styles in the context of e-learning. The methods citations (6 or 10.34%) suggest that the study's approach and methodology have been recognized and referenced by other researchers. The fourth publication, "Adaptive e-learning environment based on learning styles and its impact on development students' engagement," has received 86 citations, indicating a considerable level of interest and engagement from the research community. The 5 (5.81%) highly influential citations highlight the significant impact of the publication's findings and methodology. The high number of background citations (41 or 47.67%) suggests that the research has contributed to the theoretical foundations and understanding of learning styles in adaptive e-learning environments. The methods citations (10 or 11.62%) indicate that the study's research methods and techniques have been acknowledged and referenced by other researchers. Finally, the fifth publication, "An enhanced

learning style index: Implementation and integration into an intelligent and adaptive e-Learning system," has garnered 23 citations, indicating a relatively lower level of attention compared to the other publications. The 1 (4.35%) highly influential citation suggests that the publication has made a notable impact despite the lower citation count. The background citations (10 or 43.48%) imply that the research has contributed to the existing knowledge and understanding of learning styles in intelligent and adaptive e-learning systems. The methods citations (4 or 17.39%) indicate that the study's research methods and techniques have been recognized and referenced by other researchers.

4. Conclusion

The study identified prevailing patterns and tendencies in learning styles within the digital landscape in recent years. It was observed that there has been a growing interest in the topic, with an increasing number of publications over time. While there were fluctuations in publication output, reflecting the dynamic nature of the field, there was an overall upward trend in scholarly interest in learning styles in the online environment. Furthermore, the study examined the academic journals that have garnered significant author interest and engagement in the realm of learning styles. Identifying these journals is essential for researchers and scholars to stay updated with the latest research and contribute to the existing body of knowledge. The emerging themes in learning styles within the digital landscape were also explored. These themes provide valuable insights into the current research directions and areas of focus in the field. Additionally, the study identified scholarly articles that exhibit the greatest impact and influence in the field of learning styles. Understanding the magnitude of their influence and how it is manifested is crucial for researchers and policymakers in making informed decisions and recommendations.

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