Scientometric Analysis of the Intersection of STEM Education and Artificial Intelligence: Trends and Perspectives

Análisis Cienciométrico de la Intersección de la Educación STEM e Inteligencia Artificial: Tendencias y Perspectivas

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Abstract
The intersection between Artificial Intelligence (AI) and STEM education has become a growing area of interest. Although several studies have addressed AI in educational contexts, few have offered a comprehensive overview of its relationship with STEM fields. Therefore, the aim of this article is to examine the evolution of academic research in this area through a scientometric approach. A systematic search was conducted in the Scopus and Web of Science databases, focusing on publications that include the terms "STEM," "education," "artificial," and "intelligence." The results highlight two main phases: an initial period of gradual growth and a recent phase of rapid expansion and consolidation. The analysis includes annual publication trends, geographical distribution by country, journal impact, and author productivity. These findings provide educators, researchers, and policymakers with a clearer understanding of the current landscape and the main contributors to the development of AI-STEM education.

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Keywords: STEM, AI, Education, learning, trends, perspectives.

Resumen

La intersección entre la Inteligencia Artificial (IA) y la educación STEM se ha convertido en un campo de interés creciente. Aunque diversos estudios han abordado la presencia de la IA en contextos educativos, pocos han ofrecido una visión integral sobre su relación con las áreas STEM. Por ello, el objetivo de este artículo es examinar la evolución de la investigación académica en esta temática a partir de un enfoque cienciométrico. Se realizó una búsqueda sistemática en las bases de datos Scopus y Web of Science, enfocada en publicaciones que incluyeran los términos "STEM", "educación", "inteligencia" y "artificial". Los resultados evidencian dos fases principales: una etapa inicial de crecimiento gradual y una fase reciente de expansión acelerada y consolidación. El análisis incluye las tendencias anuales de publicación, la distribución geográfica por país, el impacto de las revistas y la productividad de los autores. Estos hallazgos permiten ofrecer a educadores, investigadores y tomadores de decisiones una comprensión más clara del panorama actual y de los principales aportes en el desarrollo de la educación AI-STEM.

Palabras claves: STEM, IA, Educación, aprendizaje, tendencias, perspectivas

1. Introduction

The convergence between Artificial Intelligence (AI) and STEM education has become a key point of educational innovation. Increasingly, educators and researchers agree that it is essential to prepare students for a world progressively automated by emerging technologies, including AI [1]. In this process of digital transformation, AI is beginning to play an increasingly relevant role in teaching and learning within the STEM field [2].

AI-based tools offer significant opportunities to personalize instruction, enhance problem-based learning, and enrich curriculum development. As highlighted by [3], the integration of AI not only redefines how we access and process information, but also fosters educational innovation and demands new skills from students. In other words, its integration highlights the importance of adaptability, critical thinking, and creativity, which has led governments and institutions in various countries to invest in AI literacy and teacher training.

However, despite its growing presence, the academic field that connects AI with STEM education has not yet been fully explored. While there are reviews addressing the role of AI in education or in STEM disciplines, most of them focus on specific topics, such as AI literacy at the primary and secondary levels, without offering a more global perspective. [2]. emphasize that until recently there was no comprehensive review representing the current landscape and research trends in this thematic intersection. Nor have there been scientometric analyses that trace the evolution of this field, identify its foundational works, structural contributions, and the most recent emerging studies.

This article seeks to fill that gap through a scientometric analysis that visualizes the development of research in AI and STEM education. To this end, relevant publications were collected from the Web of Science (WoS) and Scopus databases, and analyzed using the

"Tree of Science" (ToS) methodology [4]. This classification allows the identification of historical milestones, central conceptual approaches, and current research fronts. The ultimate goal is to offer a clear map of the main trends that can guide educators, researchers, and policymakers toward the most influential and promising lines within the AI-STEM field.

2. Methodology

This study was conducted using a scientometric approach to analyze the scientific output related to the convergence between EDUCATION, STEM, and AI. A systematic search was carried out in the Scopus and WoS databases, internationally recognized for their high-quality coverage of scientific literature [5], [6], [7]. The search strategy used the keywords “stem,” “education,” “artificial,” and “intelligence” in the document titles. Various types of publications were included—scientific articles, books, book chapters, and conference proceedings—allowing for a broad and representative view of the state of the art in this thematic intersection. Publications were retrieved from the Scopus and WoS databases, with the search focused on the terms “stem,” “education,” “artificial,” and “intelligence,” which enabled the collection of a significant number of publications linking STEM education with AI. The results are presented in Table I.

Table I. Search parameters used in both databases.

Parameter	Web of Science	Scopus
Range	2004-2024	
Date	April 3, 2025	
Document Type	Paper, book, chapter, conference proceedings	
Words	(TITLE-ABS-KEY (Stem) AND TITLE-ABS-KEY (education) AND TITLE-ABS-KEY (artificial) AND TITLE-ABS-KEY (intelligence)	
Results	958	794
Total (Wos+Scopus)		1618

With the selected documents, relevant data were collected, such as title, abstract, keywords, authors, institutional affiliations, and DOI. This information was organized into a structured database that facilitated subsequent analysis [4], [8], [9], [10]. The main objective was to examine how the relationship between STEM education and Artificial Intelligence has developed in the academic literature. For the analysis of connections between countries, the software Gephi was used. This tool enables the visualization of links within the publication set through network graphs. These visualizations made it possible to identify research communities, key authors in the field, and regions with the highest scientific output, providing a clearer view of the current landscape and research dynamics on the topic.

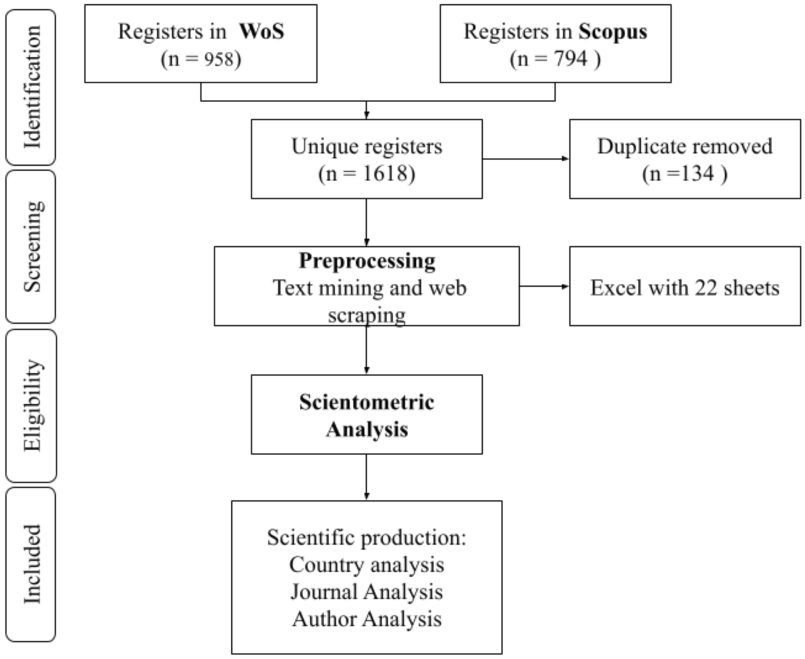

Figure 1. Database search criteria and results.

3. Results

Scientific Annual Production

Figure 2 shows the evolution of scientific production and its impact in terms of citations between 2004 and 2024. The graph reveals a progressive increase in both the total number of publications (red line) and the number of accumulated citations (purple line), with particularly notable growth starting in 2017. The highest number of citations was recorded in 2020, reaching a total of 5,920, while the peak in publications occurred in 2023, with 504 documents registered. The vertical bars reflect the distribution of scientific production in the Scopus (green) and WoS (orange) databases, showing a sustained increase across both platforms. It is worth noting that the number of publications rose from just 1 in 2004 to 298 in 2024, representing a 29,70% increase over two decades. These results suggest the strengthening and consolidation of the analyzed thematic area, as evidenced by both the growing research interest and its impact on the scientific literature.

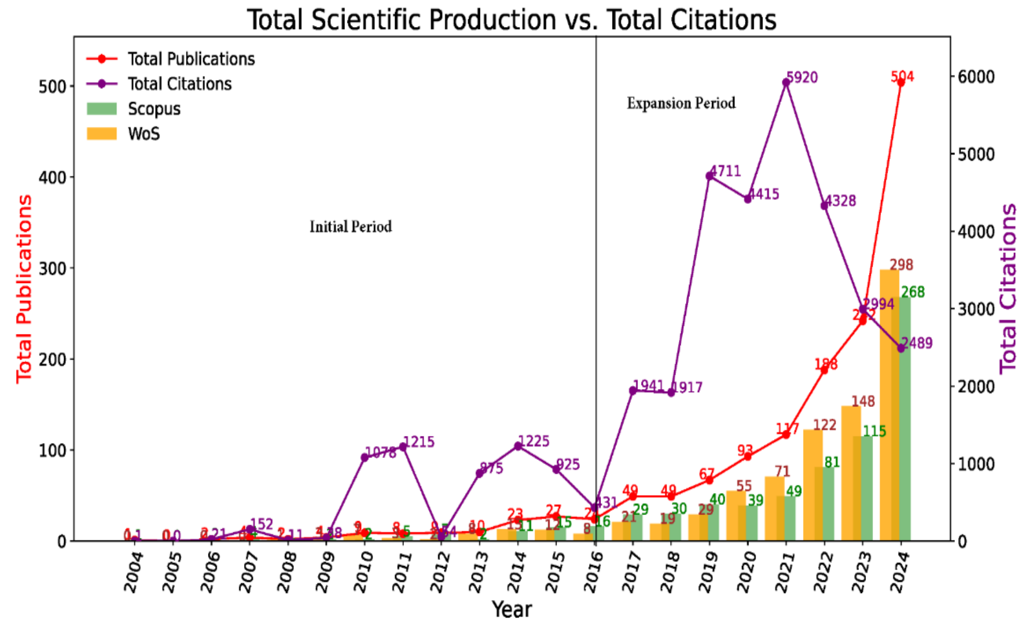

Figure 2. Total Scientific Production vs. Total Citations

Initial Period (2004-2016)

The total number of publications during this period was 123, with an average of 9.46 publications per year. The number of publications increased from 1 in 2004 to 24 in 2016, resulting in an average annual growth rate of 28.24%. The total number of citations was 6,326, with an average of 486.62 citations per year—significantly lower than in the expansion period. The most cited paper of this period presents a platform called ASSISTments to improve the student learning experience in classrooms [11].

Expansion Period (2017-2024)

During this period, a total of 1,309 publications were recorded, with an average of 163.63 publications per year. The number of publications rose from 49 in 2017 to 504 in 2024, resulting in an average annual growth rate of 39.75%. The total number of citations was 28,715, with an average of 3,589.38 citations per year, indicating higher academic output and impact. A further detail within this period is that from 2017 to 2019, Scopus (green bar) led in scientific production, while from 2020 to 2024, WoS (yellow bar) became the leading database in terms of scientific output.

Country Analysis

Table II presents the scientific output of the 10 countries with the highest contribution and influence in the field of STEM Education and Artificial Intelligence, enabling an analysis of variables such as productivity (based on the number of published articles), impact (based on citation count), and quality (measured by Scimago quartile rankings). The United States leads in production with 577 publications, representing 23.08% of the total, establishing it as the main content generator in this field. This leadership is also reflected in its impact, with 18,307 citations (5.8%), indicating strong influence and visibility per published article, followed by China with 10,625 citations (3.37%).

Table II. Countries with the greatest contribution to STEM education and artificial intelligence research, scientific production, citations and quartile distribution

Country	Production		Citation		Quality			
	Count	%	Count	%	Q1	Q2	Q3	Q4
Usa	577	23.08	18307	5.8	243	48	18	8
China	355	14.2	10625	3.37	212	34	12	12
Japan	90	3.6	7899	2.5	62	9	5	0
Germany	88	3.52	9427	2.99	50	6	2	3
India	82	3.28	5314	1.68	28	8	5	6
United Kingdom	77	3.08	8825	2.8	51	4	3	3
Italy	67	2.68	7255	2.3	33	5	1	3
Spain	60	2.4	7477	2.37	32	1	3	3
Australia	57	2.28	6120	1.94	34	4	1	0
Malaysia	52	2.08	3286	1.04	23	9	4	2

Source: Self-prepared.

In terms of quality, the United States also ranks first with 243 publications in top-tier journals, followed by China with 212. These results position the United States as the leader in production, a benchmark in impact, and a major contributor to high-quality scientific output, followed closely by China. Japan and Germany make moderate contributions, while countries such as India show significant production with lower impact, and the United Kingdom stands out for a high proportion of Q1 publications relative to its overall output (66.23%). Overall, the data reveal a concentration of scientific leadership in the United States and China, alongside a growing presence from Asian and European countries.

Recent research from the United States demonstrates how ChatGPT can enhance the grading process while providing outstanding results in student feedback [12]. Additionally, a study conducted by researchers in China compares the effectiveness of ChatGPT and human collaborators in supporting student learning [13]. The findings indicate that both human and AI-assisted collaboration contribute to a greater understanding of academic topics.

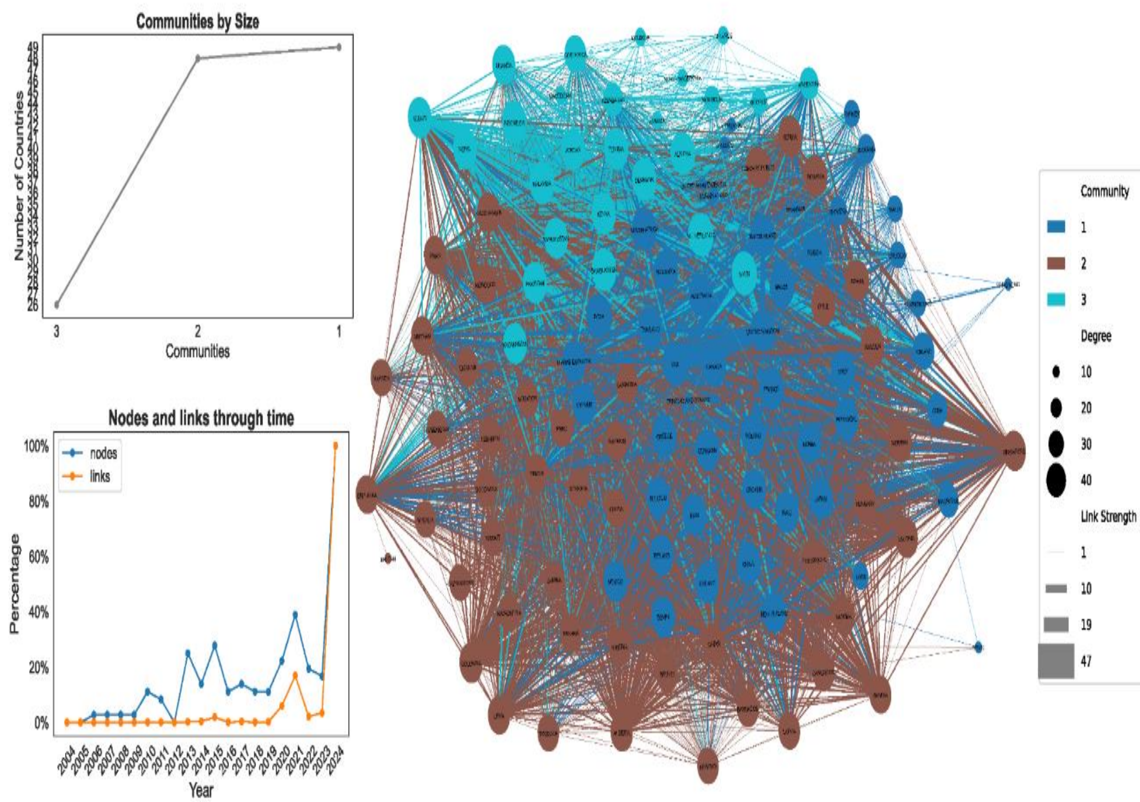

Figure 3. Collaboration network by countries for STEM Education and AI research

Journal Analysis

Table III presents the scientific production of the 10 most relevant journals in terms of contribution and output on the topics of STEM Education and Artificial Intelligence. It includes the number of articles found in WoS and Scopus, as well as the combined total (excluding duplicates), the SJR (Scimago Journal Rank), the h-index, and the corresponding quartile according to the Scimago classification. The ranking of the journals shows a range from 14 to 72 total publications, with a noteworthy observation that in 6 out of the 10 journals there is a higher concentration of publications indexed in Scopus. This indicates a slightly broader coverage of the literature on STEM Education and Artificial Intelligence within this database.

Table III. Top ten journals

Journal	SN	Wos	Scopus	Total	SJR	H-Index	Quartile
Asee Annual Conference And Exposition, Conference Proceedings	21535965	0	72	72	0.200	43	—
International Journal Of Artificial Intelligence In Education	15604292, 15604306	53	9	54	1960	68	Q1
Lecture Notes In Computer Science (Including Subseries Lecture Notes In Artificial Intelligence And Lecture Notes In Bioinformatics)	03029743, 16113349	0	33	33	0.352	499	Q2
Proceedings - Frontiers In Education Conference, Fie	15394565	0	30	30	0.211	49	–
Communications In Computer And Information Science	18650929, 18650937	0	25	25	0.182	75	Q4
Ieee Access	21693536	20	4	21	0.849	290	Q1
Education And Information Technologies	13602357	17	9	17	1.654	97	Q1
Frontiers In Education	2504284X	16	10	16	0.650	55	Q2
Acm International Conference Proceeding Series	-	0	16	16	0.191	164	–
Lecture Notes In Networks And Systems	23673370, 23673389	0	14	14	0.166	48	Q4

Source: Self-prepared.

The journal with the highest number of publications in the fields of STEM Education and Artificial Intelligence is the ASEE Annual Conference and Exposition, Conference Proceedings. However, it does not have a particularly significant h-index, which suggests that the journal does not hold a high level of prestige regarding publications related to these fields. In contrast, the journal Lecture Notes in Computer Science (including the subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics) has the highest h-index among the top journals, with a value of 499, and is classified within quartile Q2. This contrast highlights an important distinction between publication volume and scholarly impact: while the ASEE Proceedings may serve as a frequent outlet for disseminating research, particularly through conference presentations, its influence in terms of long-term citations and academic recognition appears limited. Meanwhile, Lecture Notes in Computer Science, despite publishing fewer articles in this specific domain, demonstrates far greater academic visibility and impact. This suggests that quality and influence, as measured by bibliometric indicators like the h-index, do not necessarily correlate with quantity of publications, and reinforces the need to evaluate journals not just by output, but also by their role in shaping the scholarly conversation.

The average h-index of the leading journals is 138.8, a figure largely influenced by high-impact publications such as Lecture Notes in Computer Science (h-index = 499), IEEE Access (h-index = 290), and ACM International Conference Proceeding Series (h-index = 164), all of which exceed 150 points and reflect a strong bibliometric impact of these topics in the field.

Regarding quartile rankings, a varied distribution is observed. While some journals, such as Lecture Notes in Computer Science, are placed in quartile Q2 and present high SJR values, others, such as Communications in Computer and Information Science, are classified in quartile Q4. This diversity suggests a dual trend in the dissemination of knowledge and the impact of both fields within the scientific community.

A representative example in the literature is the work by Williams et al., which explores three AI literacy curricula designed for middle school students. These programs—centered on active learning, ethical integration, and technological accessibility—were implemented in virtual workshops with positive results, both in technical understanding and critical reflection on the social impact of AI. Through activities like basic programming and discussions on algorithmic bias, students developed key skills that go beyond mere technical proficiency [14].

Other highly cited studies also provide valuable insights. One of them presents the use of interactive learning agents as tools that allow educators without programming experience to build intelligent tutors, thus democratizing the development of personalized educational systems [15]. Another proposes a structured curriculum for secondary education in Europe, designed to be implemented without prior knowledge, and positively evaluated over a three-year period across various school contexts [16].

Additionally, there are studies that delve into cognitive and collaborative aspects of AI-supported learning. One investigates how real-time attention monitoring can enhance the effectiveness of intelligent educational systems, particularly by intervening when distractions or negative emotional states are detected [17]. Another highlights a platform that involves active participation from students and teachers in co-creating educational content, relying on adaptive algorithms and continuous feedback as engines for improvement [18].

Figure 4 illustrates the journal citation network, the community distribution diagram, and the node-link graph over time. The citation network highlights three main clusters of journals: The first group concentrates on studies investigating the implementation of artificial intelligence in STEM education to enhance personalized instruction, intelligent tutoring, and student engagement [19]. The second group reflects interdisciplinary efforts that link AI with broader educational transformations, such as reprogramming traditional learning models and promoting innovation in teaching practices [20]. The third cluster includes publications focused on theoretical frameworks and teacher perspectives regarding the integration of AI tools in higher education institutions [21].

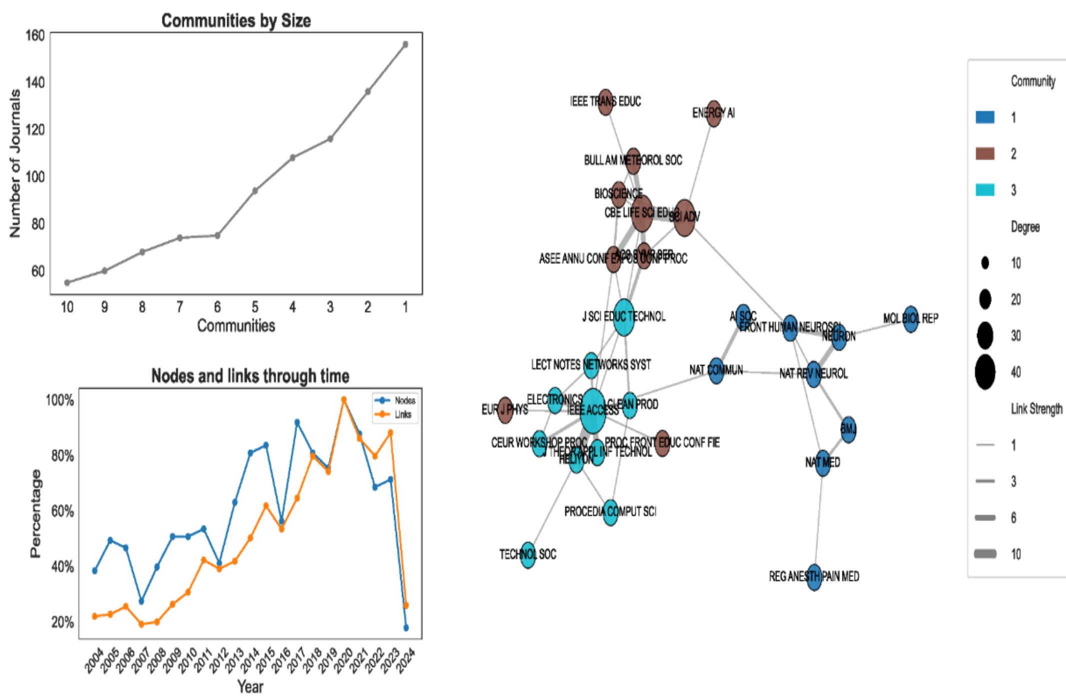

Figure 4. Network of major collaboration between journals, divided into focus communities

Conclusions

The results of the scientometric analysis reveal sustained and structural growth in academic output concerning the intersection of STEM Education and Artificial Intelligence, particularly after 2017. This consolidation reflects a global interest in adapting educational systems to an increasingly automated environment, where AI stands out as a cross-cutting technology with emerging applications in both teaching and learning assessment [22], [23] (;). Influential studies further demonstrate that AI not only optimizes educational processes but also opens new pedagogical opportunities through adaptive learning and computational thinking [24].

Recent research has increasingly incorporated ethical and collaborative frameworks, marking an evolution in curriculum design. Some works emphasize the need to align AI literacy with international competency standards, such as those promoted by UNESCO, ensuring that AI education is not only technical but also humanistic and critical [25], [26], [27]. Moreover, there is a growing interest in the role of AI within interdisciplinary contexts—particularly in health, sustainability, and bioinformatics—where the convergence of science, technology, and education demands integrated approaches [28], [29].

Despite the thematic richness found, some limitations remain. First, while progress has been made in the design of AI-based educational tools, challenges persist related to equitable access, teacher training, and algorithmic transparency. Second, although AI is increasingly used in automated assessment and formative feedback processes [30], [31], further empirical studies are needed to validate these implementations at scale. Future research could focus on evaluating the real impact of these developments in diverse school settings, emphasizing mixed methods that combine quantitative analysis with case studies.

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