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Systems Thinking in Science Education: A Bibliometric Study over the Past Decade

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ABSTRACT

This study aims to explore the publication trends in systems thinking within science education from 2014 to 2023, utilizing VOSviewer, Excel, and Biblioshiny for bibliometric analysis, to better understand how systems thinking is integrated into educational practices and its impact on managing complex systems. Analyzing 328 of 880 documents from the Scopus database, results show a gradual increase in publications, with leading journals including Sustainability Switzerland and the Journal of Chemical Education. The United States leads in research output, followed by China and Malaysia. The University of Colorado Boulder and Harvard Medical School are the most productive affiliations. Prominent authors include Yehudit Judy Dori and Jed D. Gonzalo. The most cited document by Grover et al. with 251 citations. Research trends highlight popular topics such as students, education, curriculum, learning, and teaching. However, gaps remain in connecting systems thinking with emerging fields like artificial intelligence, problem-based learning, problem-solving, decision-making, and STEM. These findings guide future research, resource allocation, and strategy formulation to enhance systems thinking in education. Further research using diverse data sources and methodologies is recommended to bridge gaps and improve the application of systems thinking principles.

Keywords: *bibliometric analysis, systems thinking, science education*

INTRODUCTION

Understanding systems thinking is crucial for education, as it influences the content, structure, and processes involved in teaching and learning, helps students understand and manage complex systems, enhancing their ability to think critically and solve problems, and is increasingly recognized as a vital skill for engineers and professionals who manage complex systems (Keating et al., 2021; Mills, 2022). Despite the absence of a universally accepted definition, systems thinking is broadly acknowledged as essential for tackling global challenges and navigating the intricate problems of today's world (Keating et al., 2021; Orgill et al., 2019). Systems thinking involves exploring and describing complex entities by focusing on interconnected wholes and relationships instead of isolated parts, offering a framework for interdisciplinary engineering that unifies various aspects dispersed across scientific and technical literature, complementing traditional reductionist approaches in science and engineering by providing a holistic perspective for understanding interactions within complex systems (Czichos, 2022; Orgill et al., 2019). The growing demand for systems thinking skills spans various industries and organizations, underscoring its importance in the modern workforce.

Integrating systems thinking into educational curricula and professional development is essential for effectively addressing the multifaceted challenges of complex systems and preparing future professionals for an evolving workplace landscape, emphasizing holistic perspectives over isolated parts and leveraging practical, real-world exposure to enhance systems thinking abilities in engineering students.(Shaked & Schechter, 2017; Stirgus et al., 2020). To address this increasing demand, it is crucial to assess and cultivate systems thinking skills not only in the current workforce but also within engineering education programs (Keating et al., 2021). Incorporating systems thinking skills into secondary education is equally important. As students develop a foundational understanding of complex biological systems and learn to solve intricate problems, they become better equipped to handle the complexities they will face in higher education and their professional careers. This preparation is vital in fostering a generation of problem-solvers who can approach challenges with a holistic perspective, ultimately contributing to a more sustainable and efficient management of global systems.

Systems thinking is a vital higher-order skill for secondary students to grasp complex biological systems and tackle intricate problems (Gilissen, 2021; Roslan et al., 2021). Research has investigated various methods to enhance and evaluate this skill in secondary education. Personality traits, particularly agreeableness, influence students' systems thinking abilities, which are demonstrated through tools like causal loops, stocks and flows diagrams, the iceberg metaphor, and rich pictures, with implications for management and education illustrated through case studies. (Roslan et al., 2021; Wycis´lak, S & Radin, 2015). Innovative teaching strategies, such as systemic synthesis questions, have shown potential in developing students' structural and procedural systems thinking skills in organic chemistry courses (Hrin et al., 2016).

Recent studies underscore the rising significance of systems thinking (ST) in science education. There has been a notable increase in ST research, particularly following UNESCO's 2015 declaration of ST as a critical competency (Bozkurt & Bozkurt, 2024). Systems thinking involves comprehending complex systems characterized by their complexity, relationships, and interactions (Seher Budak & Defne Ceyhan, 2024). Researchers have created and validated rubrics for assessing ST skills in science and engineering teachers, fostering a shared language between these disciplines (Lavi & Dori, 2019). To address challenges in ST education, research suggests considering developmental processes, introducing cognitive tools, and encouraging self-internalization. Future research should investigate systems thinking across different science subjects, develop achievement standards, and integrate pedagogical theories to improve systems thinking education (Kyungsuk et al., 2022). One method for identifying future research directions is through bibliometric analysis.

Bibliometric analysis is an essential tool for the quantitative evaluation and categorization of bibliographic material in scientific fields. This computer-assisted approach examines metadata from electronic databases, extracting indicators such as the h-index, and generates scientific maps using specialized software (Lazarides et al., 2023). Its benefits include the ability to map research trends, identify gaps in the literature, and compare publication patterns across different countries and institutions (Hemmingsen et al., 2023). Bibliometric analyses of systems thinking (ST) literature in science education over the past decade have increasingly gained significance due to their ability to reveal growing publication trends and emphasize science education as a major focal point (Bozkurt & Bozkurt, 2024; Rochman et al., 2024).

Despite this global expansion, collaboration among researchers remains limited, reflecting the diverse perspectives and methodologies within ST research that advocate for a more integrative approach bridging across disciplines (Rochman et al., 2024). Utilizing bibliometric tools, researchers have identified influential authors, journals, organizations, and countries contributing to ST research (Hossain et al., 2020). These analyses offer critical insights into the current landscape and future trajectories of ST in science education, guiding further research and development in this dynamic field. Conducting a bibliometric study on systems thinking in science education over the past decade is essential for comprehensively assessing its growth, identifying key contributors, and outlining future research directions, thereby providing a strong foundational background for this study. This study differentiates itself from existing bibliometric analyses of systems thinking by focusing on publication trends over the past decade. It employs a comprehensive visualization approach that integrates Biblioshiny, VOSviewer, and Excel, in contrast to the predominant use of VOSviewer in similar studies. Additionally, this study provides a detailed examination of research areas that have yet to be explicitly connected to systems thinking.

This study addresses several specific research questions aimed at systematically exploring systems thinking in science education. It begins by examining the publication trends and research patterns over recent decades (RQ1), highlighting the evolving nature of this field. Additionally, it aims to identify leading academic journals dedicated to systems thinking in science education (RQ2), offering insights into where influential research is published. The study also delves into the structure of collaboration networks within the field (RQ3), providing a nuanced understanding of how researchers interact globally. Furthermore, it seeks to identify the most frequently cited authors in this area of research (RQ4) and pinpoint publications that have significantly shaped the discourse on systems thinking in science education (RQ5). Lastly, the study explores primary research areas within this domain (RQ6), aiming to categorize and synthesize the breadth of research interests and methodologies employed. Together, these research questions aim to provide a comprehensive analysis of the current state and future directions of systems thinking research within science education, offering valuable insights for researchers, educators, and policymakers alike.

METHODOLOGY

Utilizing bibliometric analysis as the primary method, this study explores scientific knowledge and trends in various disciplines, including systems thinking in science education. Recent studies have shown a significant increase in systems thinking research, particularly after UNESCO's 2015 declaration of systems thinking as a key competency for sustainable development education (Bozkurt & Bozkurt, 2024). When conducting bibliometric analyses, researchers can utilize different databases such as PubMed, Scopus, and Web of Science, each with its strengths and coverage (AlRyalat et al., 2019; Donthu et al., 2021). Scopus, in particular, has been noted for its comprehensive coverage across various academic disciplines (García-Ávila et al., 2023; Mongeon & Paul-Hus, 2016; Rochman et al., 2024). These analyses have revealed trends in publication numbers, research focus areas, and collaboration patterns, providing valuable insights into the development and future directions of systems thinking in science education (Bozkurt & Bozkurt, 2024; Rochman et al., 2024).

This study was structured by formulating specific research inquiries and selecting appropriate keywords and databases. The research questions explored various aspects, including annual publication trends, document sources, subject areas, and countries of origin; affiliations; leading authors; contributions from Indonesian experts; highly cited papers; and future research opportunities related to systems thinking in science education. The study utilized the search keywords "Systems Thinking" AND "Science Education" and employed the Scopus database for bibliometric analysis within the publication year range of 2014-2023. This timeframe selection was deliberate to encompass recent developments in the field, tracking the evolution of systems thinking, research trends, and their impact on science education. The search yielded 328 of 880 documents from journals published globally, ensuring the data captured recent advancements in scholarly literature. Data analysis commenced with importing CSV, and RIS data from Scopus into Microsoft Excel, VOSviewer, and RStudio/Biblioshiny. This initial step facilitated the comprehensive processing of publication output, document sources, affiliations by country and institution, subject categories, and top authors and citations. The analysis aimed to enhance understanding of the research landscape from 2014 to 2023 in systems thinking within science education. Following data processing, the data was visualized using VOSviewer, RStudio/Biblioshiny, and Microsoft Excel. VOSviewer generated network, overlay, and density visualizations to depict relationships and trends within the data. Microsoft Excel was utilized for creating tables and diagrams to present research trends in a clear and comprehensible manner. After visualizing the data, a detailed interpretation phase followed, involving analysis of network clusters, comparison of earlier and recent studies, and scrutiny of density patterns. These visual interpretations provided insights into research saturation, identified emerging topics and suggested future research directions. The interpretations derived from these visual analyses contributed to a deeper understanding of the evolving dynamics and trends in systems thinking in science education, guiding future research endeavors and strategic decision-making processes.

RESULT AND DISCUSSION

Publication Trends

The figure below illustrates the publication trends in Systems Thinking in Science Education from 2014 to 2023, based on the analysis of 328 documents. The data reveals a gradual increase in publications over the decade, starting with 16 documents in 2014 and reaching 53 documents in both 2022 and 2023. The trend exhibits intermittent fluctuations: a slight decrease to 17 publications in 2016, followed by a notable rise to 22 documents in 2017, indicating a surge in research interest during that period. This upward trajectory continued with peaks in 2019 (40 documents) and stability from 2020 onwards, suggesting sustained scholarly attention to systems thinking within science education. Overall, the data reflects a growing and sustained interest in the field, with periodic increases and stable periods contributing to the cumulative growth of research output over the years.

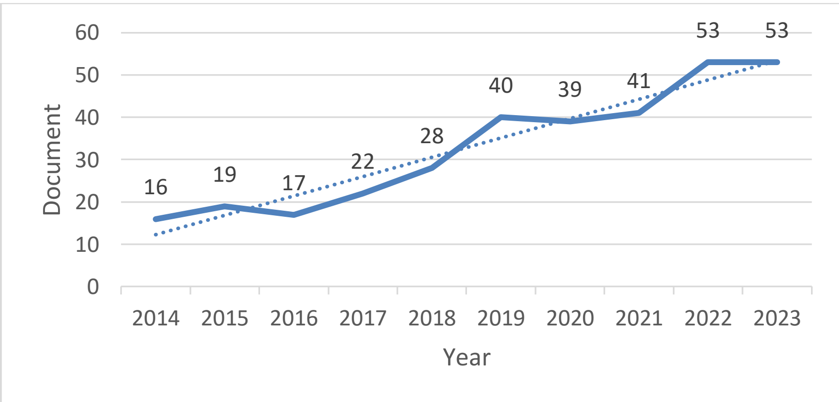

Figure 1. Annual publication trends for the period 2014-2023

Main Source Document

The analyzed articles were sourced from a wide range of journals that encompassed various topics concerning systems thinking in science education across diverse academic disciplines. According to the data, five prominent journals emerged as leading publishers in this field: Sustainability Switzerland, Journal of Chemical Education, Journal of Geoscience Education, Frontiers in Education, and International Journal of Engineering Education. These journals are indexed in Scopus, with one journal classified in Q1, publishing 10 articles, and four journals classified in Q2, collectively contributing 30 articles, as depicted in the accompanying figure 2.

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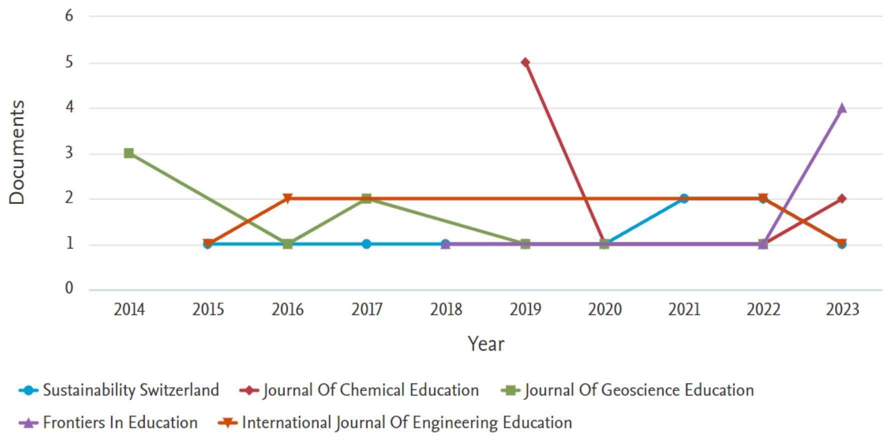

Figure 2. Distribution of indexed journals

Additionally, Table 1 provides a detailed explanation of the top five journals that are highly prolific in publishing articles related to systems thinking.

Table 1. Distribution of documents from the top five related sources from 2014 to 2023

Source	SJR Index (Scimagojr 2023)	Document
Sustainability Switzerland	0.66 (Q1)	10
Journal Of Chemical Education	0.54 (Q2)	9
Journal Of Geoscience Education	0.44 (Q2)	9
Frontiers In Education	0.63 (Q2)	6
International Journal of Engineering Education	0.35 (Q2)	6

The table presents journals focused on systems thinking in science education, categorized by their SJR Index and number of publications in 2023. Sustainability Switzerland leads with a high SJR Index (0.66) and 10 publications, emphasizing sustainability and interdisciplinary perspectives. Journal of Chemical Education and Journal of Geoscience Education follow with moderate SJR Indexes (0.54 and 0.44 respectively) and 9 publications each, focusing on integrating systems thinking into chemical and geoscience education. Frontiers in Education (SJR 0.63) explores systems thinking across STEM disciplines, publishing 6 documents, while International Journal of Engineering Education (SJR 0.35) contributes to systems thinking in engineering education with 6 publications. These journals collectively contribute to advancing systems thinking in educational contexts through diverse research and innovative approaches.

Documents based on Subject Area

A total of 328 publications focusing on systems thinking in science education between 2014 and 2023 were gathered, with a strong emphasis on subject areas falling under the social sciences. The data indicates that five primary subject areas dominated the publications: social science (222 documents), computer science (59 documents), engineering (48 documents), medicine (32 documents), and environmental science (29 documents). Figure 3 visually illustrates the distribution of documents across these subject areas, highlighting their significant roles in advancing systems thinking within the realm of science education. This comprehensive review underscores the interdisciplinary nature of research in this field, exploring various academic disciplines to enhance understanding and application of systems thinking principles in educational contexts.

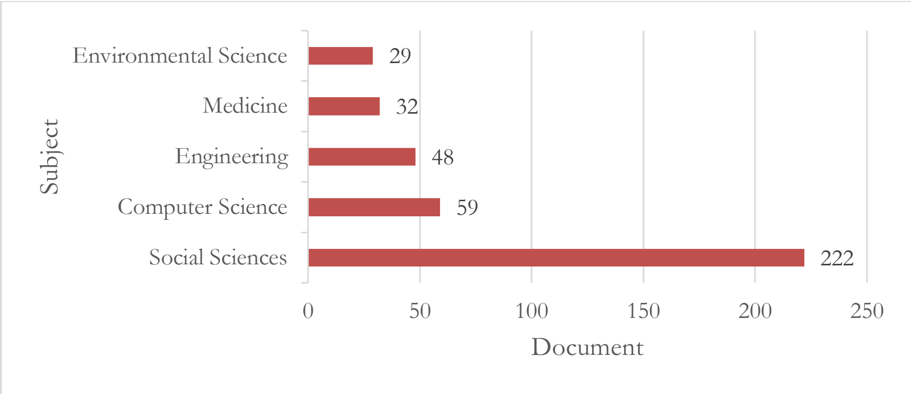

Figure 3. Document by subject area

Top Publications by Country

The data reveals the productivity of several countries in publishing articles on systems thinking in science education, as reflected by the number of articles authored by researchers from each country. The United States leads significantly with 532 articles, indicating a strong research output and leadership in this field. China follows with 75 articles, demonstrating a substantial contribution to the literature on systems thinking within science education. Malaysia has also shown notable activity with 77 articles, underscoring its growing role in advancing research in this area. Australia and Spain contribute comparatively fewer articles, with 39 and 33 respectively. Despite the lower numbers, these countries still play important roles in contributing to the global discourse on systems thinking in science education.

The distribution of publications on systems thinking in science education highlights global interest and engagement, showcasing diverse contributions from different regions. It also indicates varying levels of institutional support, research infrastructure, and academic collaboration among nations. The United States leads in research output, followed by significant contributions from China and Malaysia, underscoring ongoing international collaboration and the potential for advancements in applying systems thinking principles globally. In the context of Indonesia, where research output may be comparatively lower, Malaysia's productivity in this field serves as a notable example. Indonesian researchers could draw inspiration from Malaysia's proactive engagement and substantial contributions to the literature. This comparative perspective encourages Indonesian scholars to prioritize and advance systems thinking within their educational frameworks. By enhancing research efforts and fostering collaborations, Indonesian researchers can leverage regional insights and methodologies to enrich discussions and practices related to systems thinking in science education. Figure 4 visually illustrates the top five countries contributing to publications on systems thinking in science education, providing a clear overview of their relative research outputs and contributions to the field.

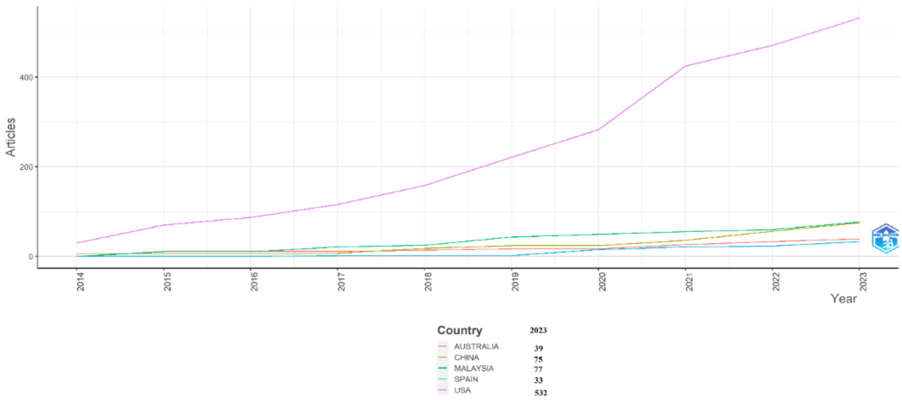

Figure 4. Country production over time

University Affiliation

The data presented in Figure 5 outlines the top affiliations contributing to publications focused on systems thinking in science education, detailing the number of articles produced by each institution. Leading the list is the University of Colorado Boulder with 22 articles, closely followed by Harvard Medical School with 21, and Penn State College of Medicine with 19 articles. All India Institute of Medical Sciences and Amsterdam University of Applied Sciences each contributed 13 and 12 articles, respectively. Monash University, Universiti Teknologi Malaysia, University of Helsinki, Michigan State University, and Universiti Kebangsaan Malaysia each produced between 10 to 11 articles. These affiliations span across different continents, emphasizing their significant contributions to advancing research in systems thinking within science education globally. The diversity of these institutions underscores the widespread interest and collaboration in this field, which plays a crucial role in the continuous evolution and application of systems thinking principles in educational settings and research endeavors worldwide.

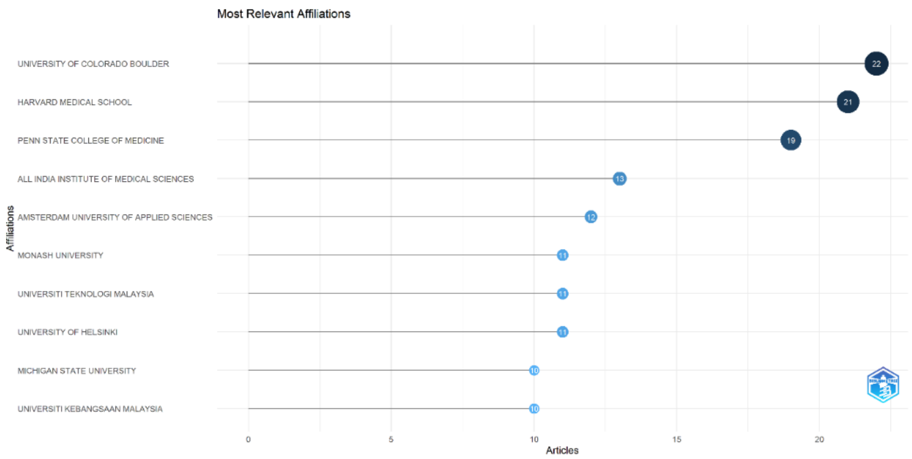

Figure 5. Most relevant Affiliation

Top 10 Authors

Figure 6 presents the authors who have made significant contributions to the literature on systems thinking in science education, detailing the number of documents each author has authored. Yehudit Judy Dori from Israel and Jed D. Gonzalo from Pennsylvania, USA, lead with 5 documents each. Close behind are D. R. Wolpaw with 4 documents, and D. Dori, Rea Lavi, and M.K. Orgill with 3 documents each. Additionally, authors such as S. York, J. Adler, E. Akiri, and C. Andersen have contributed 2 documents each to this field of study. These authors collectively represent diverse expertise and significant research contributions within systems thinking in science education, underscoring their pivotal roles in advancing knowledge and scholarship in this domain.

Their cumulative efforts are instrumental in fostering the development and practical application of systems thinking principles in both educational settings and ongoing research endeavors.

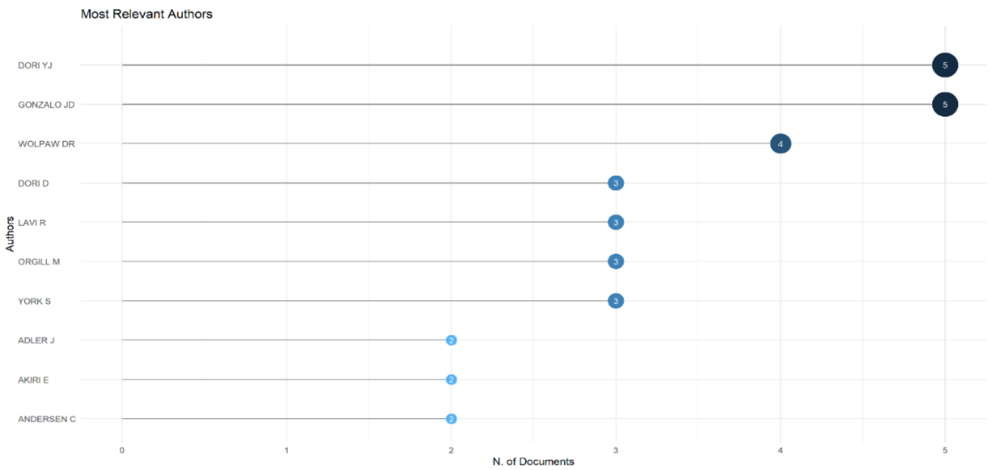

Figure 6. Top 10 Authors

Document Citation

The data on the most globally cited documents provides valuable insights into the influential contributions of systems thinking in science education. Grover et al.'s 2015 study stands out prominently with 251 citations. Following closely, Buitrago Flórez et al. (2017) and Papanastasiou et al. (2019) each contribute significantly with 227 and 203 citations respectively, likely exploring diverse aspects of curriculum development and educational technology integration. Orgill et al. (2019) and Repenning et al. (2015) also feature prominently with 136 and 133 citations, respectively. The collective citations across these studies reflect a global interest in fostering systems thinking skills among students, underscoring the importance of innovative educational practices in preparing future generations for challenges in science and technology. These findings highlight the diverse methodologies and approaches being explored to promote effective learning environments that support systems thinking principles in science education.

Table 1. A breakdown of the top 10 documents on Scopus by number of citations

Author/ Year	Title	DOI	TC	TC per Year
Grover S et al., 2015	Designing for deeper learning in a blended computer science course for middle school students	10.1080/08993408.2015.1033142	251	25.1
Buitrago Flórez F et al., 2017	Changing a Generation's Way of Thinking: Teaching Computational Thinking Through Programming	10.3102/0034654317710096	227	28.38
Papanastasiou G et al., 2019	Virtual and augmented reality effects on K-12, higher and tertiary education students' twenty-first century skills	10.1007/s10055-018-0363-2	203	33.83
Orgill M et al., 2019	Introduction to Systems Thinking for the Chemistry Education Community	10.1021/acs.jchemed.9b00169	136	22.67
Repenning A et al., 2015	Scalable Game Design: A Strategy to Bring Systemic Computer Science Education to Schools through Game Design and Simulation Creation	10.1145/2700517	133	13.3
Basu S et al., 2017	Learner modeling for adaptive scaffolding in a Computational Thinking-based science learning environment	10.1007/s11257-017-9187-0	129	16.13
Kuo H-C et al., 2019	Promoting college student's learning motivation and creativity through a STEM interdisciplinary PBL human-computer interaction system design and development course	10.1016/j.tsc.2018.09.001	111	18.5
York et al., S,	Applications of Systems Thinking in	10.1021/acs.jchemed.9b00261	101	16.83

Author/ Year	Title	DOI	TC	TC per Year
2019	STEM Education			
Marshall J et al., 2014	Transdisciplinarity and Art Integration: Toward a New Understanding of Art-Based Learning across the Curriculum	10.1080/00393541.2014.11518922	92	8.36
Keinänen M et al., 2018	How to measure students' innovation competences in higher education: Evaluation of an assessment tool in authentic learning environments	10.1016/j.stueduc.2018.05.007	83	11.86

The most globally cited document in the analyzed database is "Designing for Deeper Learning in a Blended Computer Science Course for Middle School Students" by Grover et al., 2015, with 251 citations. This paper explores various research studies and methodologies aimed at enhancing computational thinking skills among middle school students. It delves into topics such as project-based learning, assessment strategies, programming environments, and student attitudes toward computer science. The primary objective is to improve students' comprehension of computer science concepts and enhance learning outcomes through deliberate instructional strategies and curriculum design.

The study also addresses systems thinking concerning efforts to engage underrepresented students in the field of computing at the secondary school level and involves them in programming concepts. SRI International is developing a systematic framework for assessing Computational Thinking (CT), focusing on computer science concepts, inquiry skills, communication skills, and collaboration skills as key elements of CT practices. Additionally, the research encompasses the development of a computational curriculum aimed at computational thinking and computational practices in secondary schools. This paper has significantly influenced the discourse on teaching computational thinking and has been pivotal in shaping educational practices globally. It has sparked investigations into the effectiveness of different teaching approaches in computer science education, highlighted the importance of integrating computational thinking skills early in education, and underscored the need for inclusive strategies to broaden participation in computer science among diverse student populations.

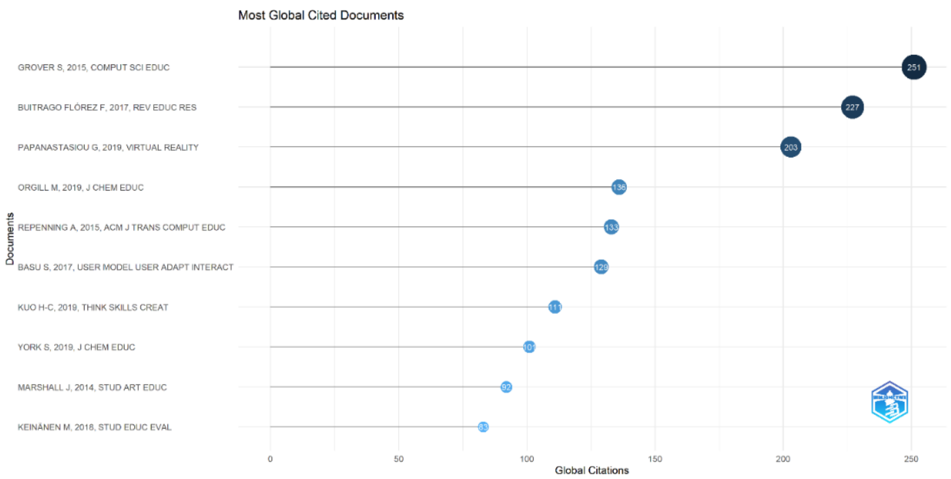

Figure 7. The top 10 documents on Scopus by number of citations

Mapping Systems Thinking in Science Education with VOSviewer Network Visualization

The classification of study subjects in systems thinking within science education is significant, revealing a total of 2065 keywords, of which 130 meet the inclusion criteria. After merging identical terms, the final count stands at 130 terms. Network visualization uncovers six clusters, comprising 2160 links with a total link strength of 4141. These clusters focus on students, education, curriculum, teaching, critical thinking, learning, and systems thinking, with occurrences of 68, 63, 55, 48, 44, 43, and 41 respectively. In the visualization, larger circles represent higher keyword frequencies in the documents (Donthu et al., 2021).Figure 8 showcases the network visualization generated by VOSviewer, emphasizing the most frequently occurring keywords and their interconnected networks.

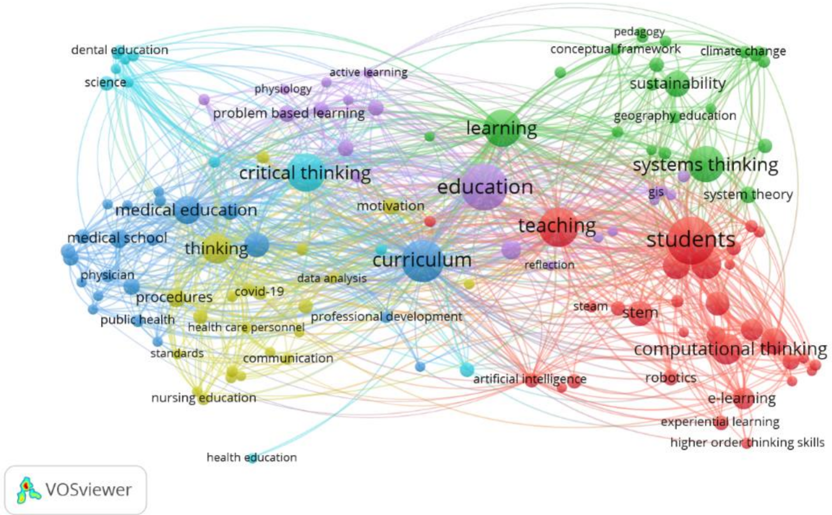

Figure 1. Network visualization of co-occurrences with index keywords

In Figure 8 below, it is evident that the term "systems thinking" is connected to 60 links, with a total link strength of 114, appearing 41 times. The terms it connects with include students, education, curriculum, learning, teaching, STEM, engineering education, learning systems, sustainability, thinking, medical education, environmental education, science education, leadership, system theory, geography education, nursing education, skill, design, assessment, behavioral research, modeling, undergraduate, and climate change. However, it is also apparent that "systems thinking" has not yet connected with several other important terms. This indicates potential areas for further exploration by researchers to link these terms with systems thinking, such as problem-based learning, problem-solving, decision-making, artificial intelligence, active learning, robotics, higher-order thinking skills (HOTS), e-learning, data science, technology, entrepreneurship, interpersonal communication, creativity, motivation, perception, pedagogy, computational thinking, innovation, and secondary education.

The network visualization using VOSviewer reveals six clusters with a total of 2160 links and a combined link strength of 4141, indicating a well-connected research landscape with multiple focal points. The clusters prioritize key terms such as students, education, curriculum, learning, teaching, critical thinking, and systems thinking, each with varying occurrences and link strengths. The larger circles in the visualization denote higher frequencies of these keywords in the documents, highlighting their prominence in the field. From this data, we can conclude that while systems thinking is already well-integrated with several key educational and disciplinary terms, there remain significant opportunities for further research to connect it with other critical concepts. This gap suggests that the field of systems thinking in science education is still evolving, with ample scope for interdisciplinary research that could bridge existing gaps and enhance our understanding and application of systems thinking principles across diverse educational contexts. By addressing these unexplored connections, researchers can contribute to a more holistic and comprehensive framework for systems thinking, ultimately enriching educational practices and outcomes.

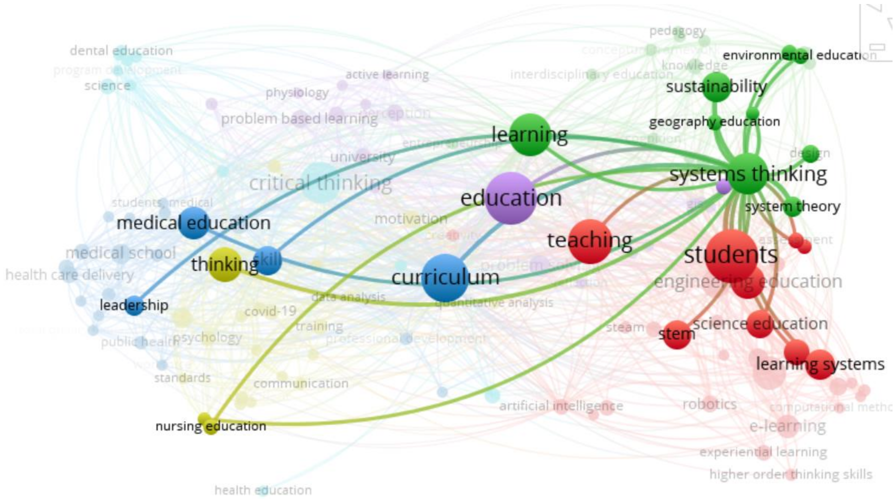

Figure 9. Network visualization of systems thinking term

Overlay Visualization

The overlay visualization is symbolized by colors indicating yearly experimental trends, with purple representing earlier years of study and yellow signifying more recent analyses. The brighter or more yellow a term's color, the more recently it has been studied by experts. Conversely, the darker the color, the longer it has been since experts investigated that term or topic. In this context, the term "systems thinking" appears in a greenish-yellow hue, indicating that it is still considered important, new, and a topic of current interest. This suggests that systems thinking remains a significant area of exploration and implementation in education, as it is a crucial skill for students to master. Additionally, several terms are relatively unexplored and appear in brighter colors, indicating their novelty. These new terms include artificial intelligence, STEM, problem-based learning, learning environment, behavioral research, data science, pedagogy, creativity, and health education. These emerging topics highlight areas where further research and exploration are needed to integrate systems thinking effectively within educational contexts.

The overlay visualization of co-occurrence, depicted in Figure 10, underscores these trends by illustrating the temporal evolution of research interests in systems thinking and its associated terms. This visual representation provides valuable insights into how research focus has shifted over time and identifies key areas for future investigation. By understanding these trends, researchers can better prioritize their efforts to address gaps in the literature and advance the application of systems thinking in education.

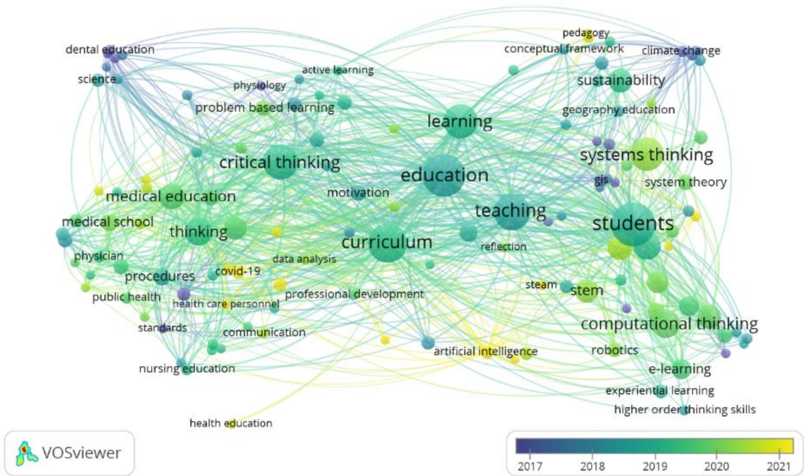

Figure 10. Overlay of visualization of co-occurrences with index keywords

Density Visualization

Density visualization illustrates the saturation level of a topic, with colours such as red, blue, yellow, and green representing yet-to-be-analyzed, rarely-studied, and highly evaluated areas, respectively. Brighter colours indicate a higher frequency of the analyzed term in relevant experiments. The distribution of keyword density also reveals the frequency of research topics (van Eck & Waltman, 2010). For instance, the terms students and education are often analytically implemented, while rarely analyzed and relevant terms focus on problem-based learning, problem-solving, decision-making, artificial intelligence, active learning, robotics, higher-order thinking skills (HOTS), e-learning, steam, data science, technology, entrepreneurship, interpersonal communication, creativity, motivation, perception, pedagogy, innovation, and secondary education. Figure 11 presents the density visualization of systems thinking in science education based on the keyword index.

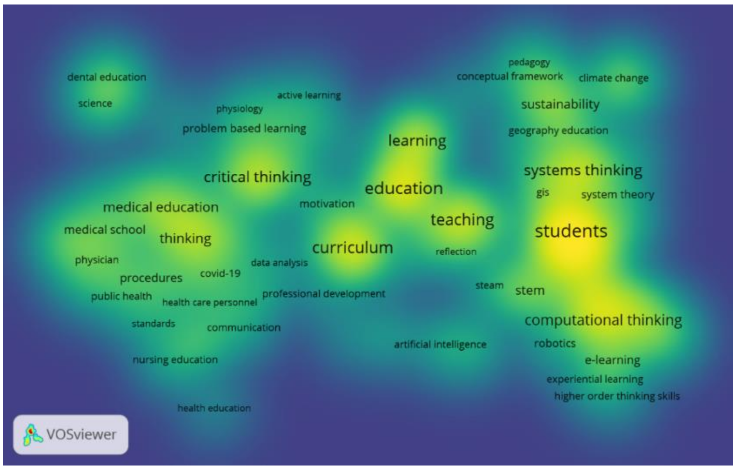

Figure 11. Density visualization of systems thinking in science education based on the keyword index.

CONCLUSION

This study underscores the growing importance of systems thinking in science education, highlighting its critical role in enhancing students' abilities to navigate and manage complex systems. The bibliometric analysis of 328 documents from 2014 to 2023 reveals a steady increase in research interest, with notable contributions from the United States, China, and Malaysia. Leading journals such as Sustainability Switzerland and the Journal of Chemical Education have significantly advanced the discourse in this field. Prominent institutions like the University of Colorado Boulder and Harvard Medical School, along with key authors including Yehudit Judy Dori and Jed D. Gonzalo, have driven impactful research efforts. The most cited work, Grover et al.'s 2015 study, emphasizes the integration of systems thinking in computer science education, demonstrating its widespread relevance. Research trends highlight popular topics such as students, education, curriculum, learning, and teaching. Despite these advancements, gaps remain in connecting systems thinking with emerging areas like artificial intelligence, problem-solving, problem-based learning, decision-making, and STEM. Addressing these gaps through interdisciplinary research and innovative approaches is essential for fostering a more comprehensive understanding and application of systems thinking in education. This study provides valuable insights for guiding future research priorities, optimizing resource allocation, and formulating evidence-based strategies to enhance educational practices and outcomes. Continued exploration and integration of systems thinking principles will be vital in preparing students to tackle the multifaceted challenges of the modern world.

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