INDONESIAN JOURNAL OF SCIENCE AND MATHEMATICS EDUCATION
07 (3) (2024) 505-517
https://ejournal.radenintan.ac.id/index.php/IJSME/index
ISSN: 2615-8639
DOI: 10.24042/ijsme.v5i1.23067
November 2024

Design thinking in science education during the last six years: A bibliometric analysis

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Article history:

Submitted: June 24, 2024
Accepted: November 2, 2024
Published: November 30, 2024

Keywords:

analysis bibliometric, design thinking, science education

ABSTRACT

Design thinking holds significant potential to drive innovation in science education, helping to address complex challenges and advance technological and industrial development. This study aims to analyze trends and research opportunities in design thinking within science education from 2018 to 2023 using a bibliometric approach. Data from 997 articles indexed in Google Scholar were collected through the Publish or Perish application and analyzed using VOSviewer. The results indicate a decline in the number of publications during the study period, although high research activity was recorded in 2018 and 2019. However, opportunities to integrate design thinking with interdisciplinary concepts, such as innovative teaching methods, remain significant. Therefore, the implementation of design thinking in science education can open avenues for broader innovation in teaching and learning. This study implies an enhancement of science education through the integration of design thinking, offering strategic directions for future research and practical applications in curriculum and pedagogy development.

Penerapan design thinking *dalam pendidikan sains selama enam tahun terakhir: Sebuah analisis bibliometrik*

Kata Kunci:

analisis bibliometric, design thinking, *pendidikan sains*

ABSTRAK

Design thinking *memiliki potensi besar untuk mendorong inovasi dalam pendidikan sains, membantu mengatasi tantangan kompleks dan memajukan pengembangan teknologi serta industri. Penelitian ini bertujuan untuk menganalisis tren dan peluang penelitian* design thinking *dalam pendidikan sains selama periode 2018-2023 menggunakan pendekatan bibliometrik. Data dari 997 artikel yang terindeks di Google Scholar dikumpulkan melalui aplikasi Publish or Perish dan dianalisis menggunakan VOSviewer. Hasil penelitian menunjukkan penurunan jumlah publikasi selama periode studi, meskipun aktivitas penelitian tinggi tercatat pada tahun 2018 dan 2019. Namun, peluang untuk mengintegrasikan* design thinking *dengan konsep interdisipliner, seperti metode pengajaran inovatif, tetap signifikan. Dengan demikian, implementasi* design thinking *dalam pendidikan sains dapat membuka ruang untuk inovasi yang lebih luas dalam pengajaran dan pembelajaran. Penelitian ini berimplikasi pada peningkatan pendidikan sains melalui integrasi* design thinking, *memberikan arahan strategis untuk penelitian masa depan dan aplikasi praktis dalam pengembangan kurikulum serta pedagogi.*

Contribution to the literature

This research contributes to:

- Revealing opportunities to integrate design thinking with STEM approaches, project-based learning, and other innovative methods to enhance learning outcomes.
- This research provides specific insights into publication trends of design thinking in science education.
- Identifying interdisciplinary opportunities for the development of design thinking as an innovative approach in education.

1. INTRODUCTION

In line with societal evolution, education has emerged as a fundamental requisite for individuals to cultivate their abilities and unlock their potential for future progression [1], [2]. Moreover, the educational sphere undergoes perpetual advancement to align with contemporary requisites [3]. One such domain experiencing continual expansion and deemed essential for technological and industrial progress is the realm of science education. Science is pivotal, particularly during the industrial era, spearheading endeavors to enhance industrial engineering and technology [4], [5].

Design thinking holds significant potential for advancing development and addressing intricate problems in science and technology [6], [7]. It represents a problem-solving methodology centered around empathy, creativity, and iterative processes to devise inventive solutions [8], [9]. A pivotal element of design thinking is its emphasis on addressing individuals' needs. When employed within science and technology, design thinking aids researchers and innovators in gaining deeper insights into user requirements and desires.

Bibliometric analysis, a research analysis method [10], [11], can assess research development. This analytical approach involves meta-analysis of research data, allowing researchers to examine the bibliographic content and citation patterns of articles published in academic journals and other scientific publications.

Several studies have explored bibliometric analysis in various disciplines, such as chemical engineering [12], chemical research [13], economics [14], educational research [15], special needs education [16], and techno-economic education publications [17]. On the other hand, several studies exploring bibliometric analysis of design thinking have also been conducted [18]–[20]. However, the context of bibliometric analysis of design thinking has yet to be specific to science education. Meanwhile, Science Education is one of the domains that is considered necessary for technological and industrial advancement, and design thinking has significant potential to overcome various complex problems [21] [22] and is a human-centered problem-solving methodology [23].

Therefore, it is necessary to conduct a bibliometric analysis of design thinking in science education using the Vosviewer application. This study aims to determine the research trends and opportunities in design thinking in science education through bibliometric analysis using Vosviewer software. The results of this analysis are expected to provide valuable insights into the development of future research directions. Additionally, this study can serve as a reference for educators and researchers seeking to integrate design thinking into science education effectively.

2. METHOD

This research adopted a bibliometric study [24]. The software used is Vos Viewer. The data used is sourced from publications indexed in Google Scholar journals. Google Scholar was chosen because of its open-source nature. The research data was obtained using the Publish or Perish application for reference management and literature review. After receiving ethics approval, the research was conducted. Some stages in this research method can be seen in Figure 1.

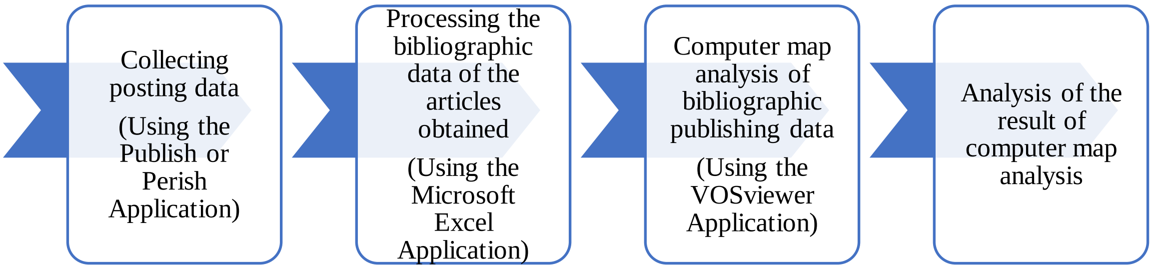


Figure 1. Four-Step Bibliometric Analysis Method

The article data search was conducted with Publish or Perish filtered publications using keywords "Design Thinking" OR "Science Education," focusing on publication titles and abstracts. The selected articles spanned from 2018 to 2023, with data collection completed on June 26, 2023. These articles were gathered and assessed against the research analysis criteria. The research analysis criteria are based on the title and abstract areas that match the search keywords. Subsequently, the research findings were exported in two formats: Research Information System (.ris) and Comma Separated Values (.csv). Additionally, VOSviewer was employed to visualize and analyze trends using three types of publication maps: network visualization, density visualization, and network-based overlay visualization (co-citation).

3. RESULTS AND DISCUSSION

3.1 Research Trends of Design Thinking in Science Education

The Publish or Perish, reference manager application, conducted a data search within the Google Scholar database, resulting in 997 articles aligned with the research criteria. These data were acquired as article metadata, encompassing author names, titles, publication years, journal names, publishers, citation counts, article links, and associated URLs. Table 1 provides examples of the published data utilized in the VOSviewer analysis for this study, specifically focusing on the top 20 articles with the highest citation counts. The cumulative citations for all articles utilized in this study amount to 82,431, with an average annual citation count of 24,117.66. The average citation count per author is 43,297, with an average of 2.93 authors per article included in the analysis.

Table 1. The Top 20 Articles with the Highest Citation Counts on Publication Data of Design Thinking In Science Education

No	Authors	Year	Cites
1	KS Taber [25]	2018	7314
2	N Cross [26]	2023	2253
3	G DeBoer [27]	2019	2022
4	M Stickdorn, ME Hormess, A Lawrence, J Schneider [28]	2018	928
5	V Braun, V Clarke [29]	2022	645
6	KD Elsbach, I Stigliani [30]	2018	508
7	P Micheli, SJS Wilner, SH Bhatti, M Mura [7]	2019	471
8	J Liedtka [31]	2018	402

9	T Martín-Páez, D Aguilera [32]	2019	378
10	S Bal-Taştan, SMM Davoudi, AR Masalimov [33]	2018	371
11	M Lewrick, P Link, L Leifer [34]	2018	358
12	M Altman, TTK Huang, JY Breland [35]	2018	350
13	M Chowdhury [36]	2018	349
14	J Gess-Newsome, JA Taylor, J Carlson [37]	2019	347
15	L Claus [38]	2019	347
16	J Carlson, KR Daehler, AC Alonzo [39]	2019	346
17	S Grover, R Pea [40]	2018	335
18	T Brown [41]	2019	332
19	S Zubaidah [42]	2018	309
20	M Kalogiannakis, S Papadakis, AI Zourmpakis [43]	2021	304

Figure 2 illustrates the development trend of design thinking research in Science Education covering the last six years, from 2018 to 2023.

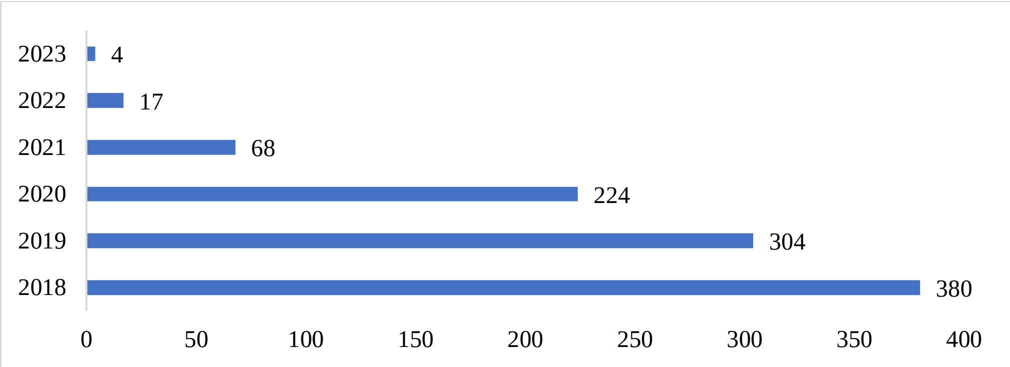


Figure 2. Trends in the Development of Design Thinking Research in Science Education

As illustrated in Figure 2, the trajectory of research on design thinking in Science Education has decreased over this period. The volume of research on design thinking in Science Education totaled 997 articles spanning from 2018 to 2023. The data illustrates that research activities in the field were highly productive in 2018 and 2019 but gradually reduced in subsequent years.

3.2 The Research Opportunities of Design Thinking in Science Education

Research opportunities for design thinking in science education were analyzed by computational mapping of article data using VOSviewer. The computational mapping conducted with VOSviewer involves a minimum of 3 occurrences and covers 484 terms. The results of the mapping on design thinking in science education were categorized into 12 clusters, as follows:

i. Cluster 1 has 63 items marked with a Dark red color. Sixty-three items are age, citizen science, classroom, college student, community, competence, computer science, computing, course, covid, cs1, culture, data, data science, data science education, decision, e-learning, empirical evidence, engineering student, examination, factor, future research, gender, gender difference, higher education, home inclusion, individual, instructor, an introductory programming course, lesson, level, medium, online, online learning, outcome, pair programming, pandemic, perception, person, popularity, prevalence, programming language, reason, relevance, retention, school, self-efficacy, source, stem filed, student, student perception, students perception, student perception, survey, theory, united state, university, value, video, web, woman, word, young person.

ii. Cluster 2 has 55 items and is marked green. The 55 items are addition, area, Australia, body, case, coding, comparison, complex system, computational thinking, computer science education, curricula, diversity, early childhood, effort, elementary school, empirical study, engineering design, engineering education, equity, example, framework, game goal, idea, investigation, k12 science education, language, learner, literature, meaning, mode, paper, part, place, policy, potential, pre, recent decade, reform, science classroom, science education policy, science instruction, science learning, south Africa, stem discipline, subject, system, systems thinking, teaching, thinking, united states, USA, variety, workforce, world.
iii. Cluster 3 has 53 items and is marked blue. The 53 items are ability, access, adoption, belief, biology, career, chemistry, combination, complex problem, concern, design thinking approach, design thinking method, energy, engineering, environment, experience, exploratory study, faculty, growth, identity, importance, Indian institute, involvement, issue, lack, math, mathematics, medical education, methodology, organization, participation, phenomena, physical science, physics, power, presence, range, science subject, secondary school student, self, sense, state, stem, stem career, strategy, students problem, teaching material, technology, translanguaging, user, virtual reality, way.
iv. Cluster 4 has 51 items and is marked yellow. The 51 items are 21st century, academic achievement, argument, argumentation, collaboration, communication technology, creativity, critical thinking, daily life, early childhood science, epistemic agency, epistemic tool, form, future, imagination, implication, Indonesia, information, inquiry, learning process, life, opinion, pedagogy, period, play, pre-service science teacher, preschool science education, professional development, prospective teacher, research, researcher, school science, science education reform, science education scholar, science teacher, science teaching, scientific inquiry, scientific knowledge, scientific literacy, skill, socio-scientific issue, socioscientific issue, ssi, teaching science, text, Thailand, theoretical framework, time, tool, uncertainty, vision.
v. Cluster 5 has 51 items and is marked purple. The 51 items are acceptance, approach, art, book, challenge, change, child, component, concept, creative thinking, design thinking, digital transformation, dimension, earth, ecosystem, effect, emotion, empirical research, era, everyone, evolution, focus, globe, guide, health, important role, indigenous knowledge, industry, innovation, leadership, learning, link, management, multimedium, number, perspective, practical approach, practice, principal, process, product, property, scale, science education research, service, society, steam, student engagement, sustainability, team, understanding.
vi. Cluster 6 has 43 items and is marked light blue. The 43 items are accounts, action, aspect, augmented reality, benefit, class, cognitive, conception, content, demand, development, discipline, discovery, emphasis, empowerment, experiment, flipped classroom, formation, girl, grade, hand, health science education, high school, interaction, interest, intervention, lean startup, mindset, model, module, practitioner, preschool, recognition, scholar, scholarship, science identity, science process skill, simulation, study, teaching strategy, type, validation, view.
vii. Cluster 7 has 38 items and is marked orange. The 38 items are 21st-century skills, academic performance, application, assessment, attention, attitude, characteristic, cof, company, covalent organic frameworks, critical thinking skill, decade, effectiveness, evaluation, frame, group, high school student, impact, important aspect, machine, machine learning, mean, meta-analysis, new approach, opportunity, pbl, performance,

present study, problem, progression, project, protein, question, recent advance, structure, student motivation, synthesis, topic.

viii. Cluster 8 has 37 items and is marked brown. The 37 items are analysis, article, chapter, contribution, curiosity, curriculum, education, educator, ethic, history, a key element, light, measurement, multiple representations, nature, next-generation science standards, nos, overview, peer, philosophy, possibility, principle, psychology, rationale, reality, relation, science, science curriculum, science education, science education community, science education literature, science teacher education, scientific practice, set, smartphone, sociology, teacher education.

ix. Cluster 9 has 32 items and is marked pink. 32 items are active learning, case study, climate change, computer, construction, elementary school student, enactment, environmental science education, implementation, important goal, instruction, integration, learning approach, limitation, matter, motivation, need, order, production, quality, reflection, regard, requirements engineering, response, role, science education researcher, software engineering, student learning, style, teacher, teaching practice, training

x. Cluster 10 has 28 items and is marked red. 28 items are conceptual framework, content analysis, context, design thinking process, domain, education research, field, gamification, journal, literature review, measure, novice, publication, recent year, research trend review, series, sigcse, stage, statistic, stem education, systematic literature review, systematic review, test, trend, use, visualization, year

xi. Cluster 11 is marked light green and has 21 items. The 21 items are activity, assignment, association, behavior, block, country, efficacy, engagement, engineer, exploration, influence, middle school, Pisa, program, programming, science achievement, scientist, term, variable, works, and youth.

xii. Cluster 12 has 12 items and is marked dark green. The 12 items are achievement, consequence, content knowledge, education system, evidence, knowledge, participant, PCK, pedagogical content knowledge, relationship, research question, and special issue.

Each cluster demonstrates the interrelation between different terms, with each term represented by a labeled colored circle. The size of these circles varies by the frequency of occurrence of each term. A larger circle denotes a higher frequency of term occurrence within the title and abstract. The mapping visualization analyzed in this study comprises three components: network visualization (refer to Figure 3), density visualization (refer to Figure 4), and overlay visualization (refer to Figure 5) [37], [38].

Figure 3 illustrates the interrelationship between various terms, presenting them in a connected network. This figure showcases clusters of terms frequently researched and associated with the research theme of design thinking in science education. The clusters in the network visualization make it apparent that research on design thinking in science education can be categorized into four main areas. Firstly, "design thinking" is situated within cluster 5, encompassing 235 links, with a combined link strength of 707, and appearing 144 times (refer to Figure 6a). Secondly, "science education" is featured in cluster 8, with 370 links, a total link strength of 1498, and 232 occurrences (refer to Figure 6b). Thirdly, "education" is present in cluster 8 with 278 links, a total link strength of 737, and 107 occurrences (refer to Figure 6c). Lastly, "science" is included in cluster 8, boasting 346 links, a total link strength of 1307, and 169 occurrences (refer to Figure 6d). These findings highlight the interconnectedness and multidisciplinary nature of design thinking within the field of science education.

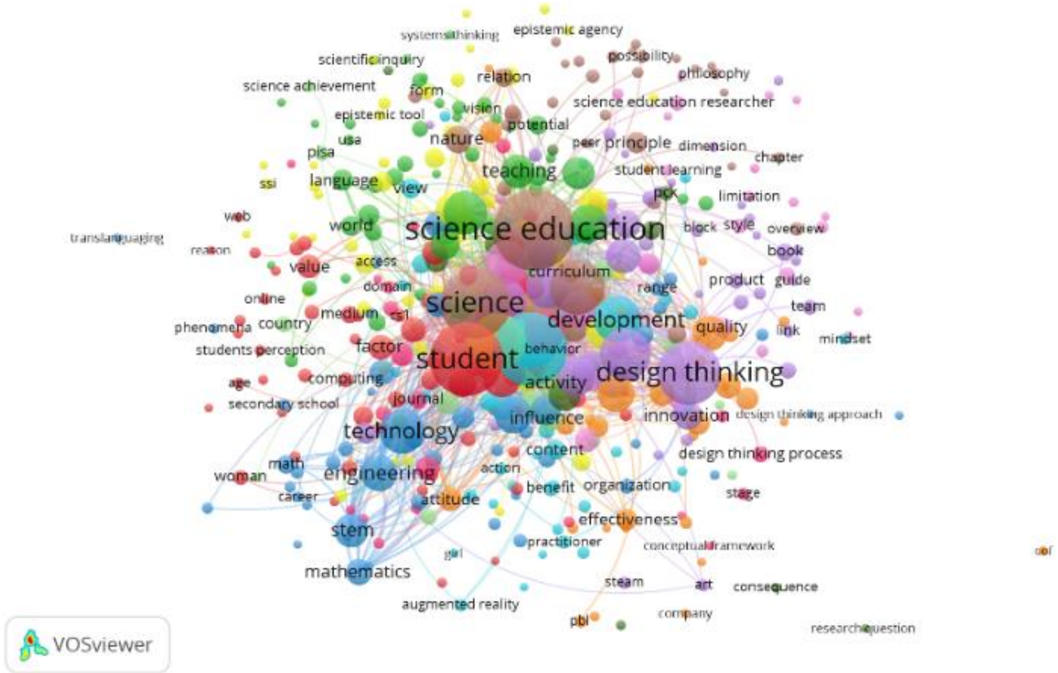


Figure 3. Network Visualization of the Keywords "Design Thinking" or "Science Education"

Figure 4 illustrates a density visualization, wherein the brightness of the yellow hue and the size of the term label circle indicate the frequency of the term's occurrence. This suggests significant research activity on brighter terms with larger circles [44]. Conversely, terms blending into the background color signify limited research attention. Figure 3 reveals a substantial body of research concerning science education, education, science, students, and design thinking. These findings highlight the focal areas that have garnered significant scholarly interest within the analyzed body of research.

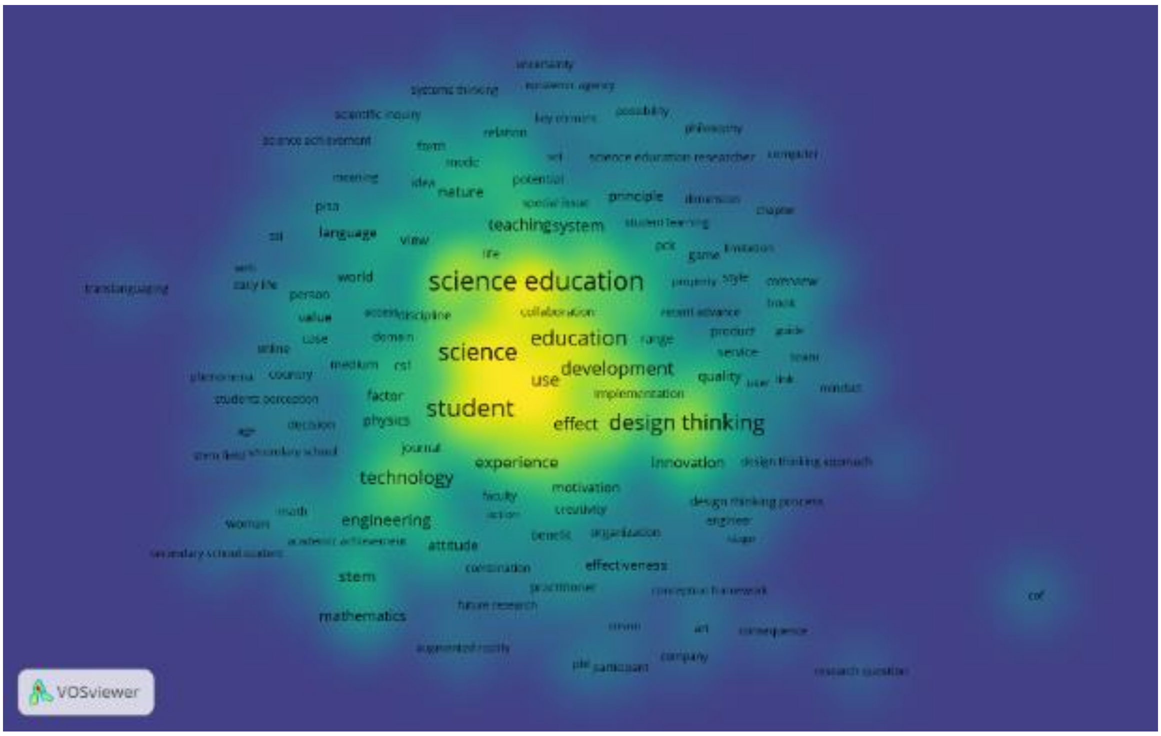


Figure 4. Density Visualization of the Keywords "Design Thinking" or "Science Education"

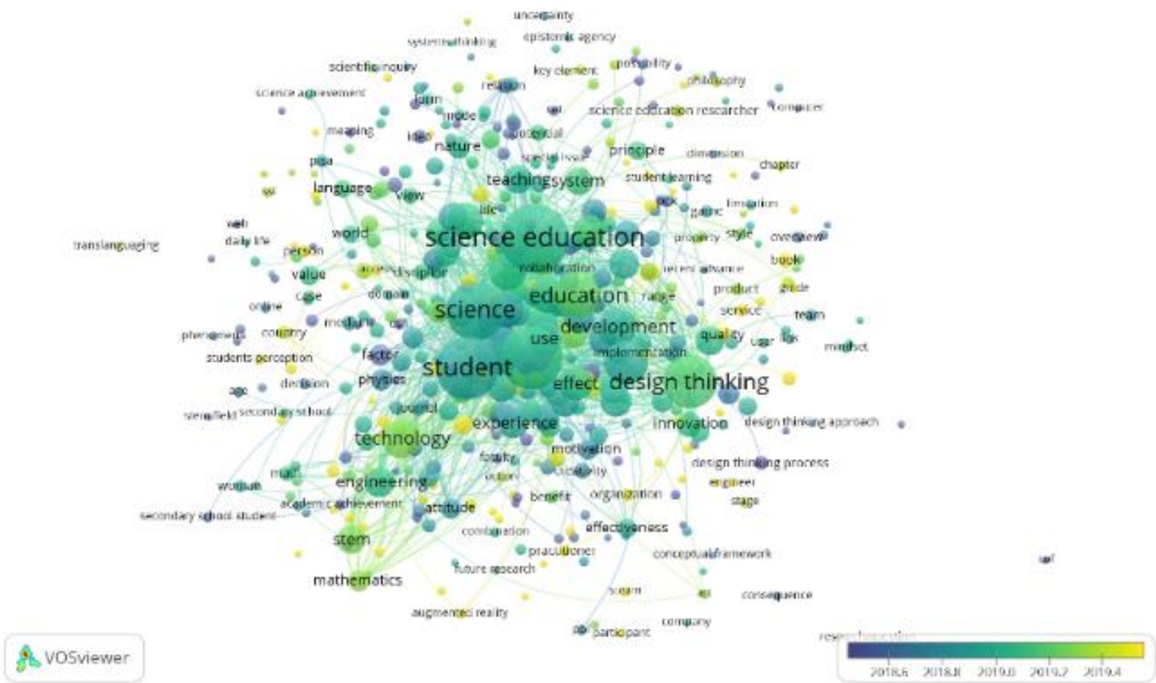
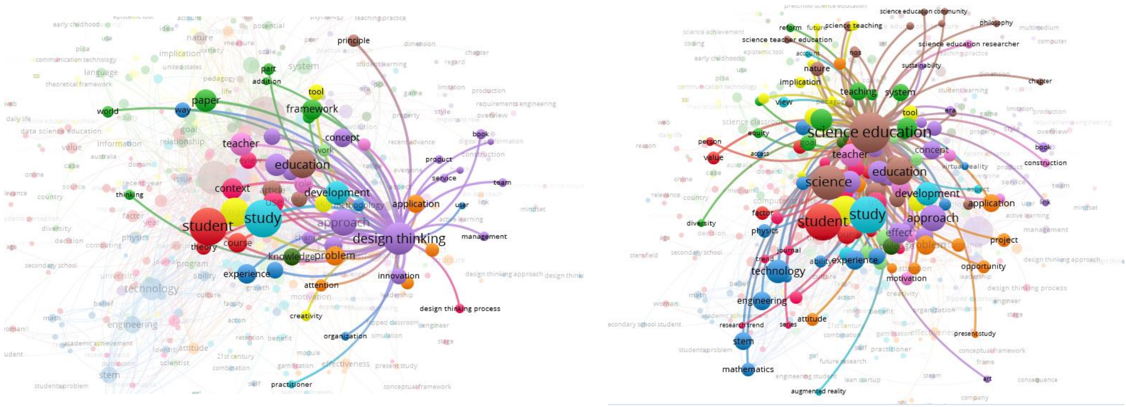
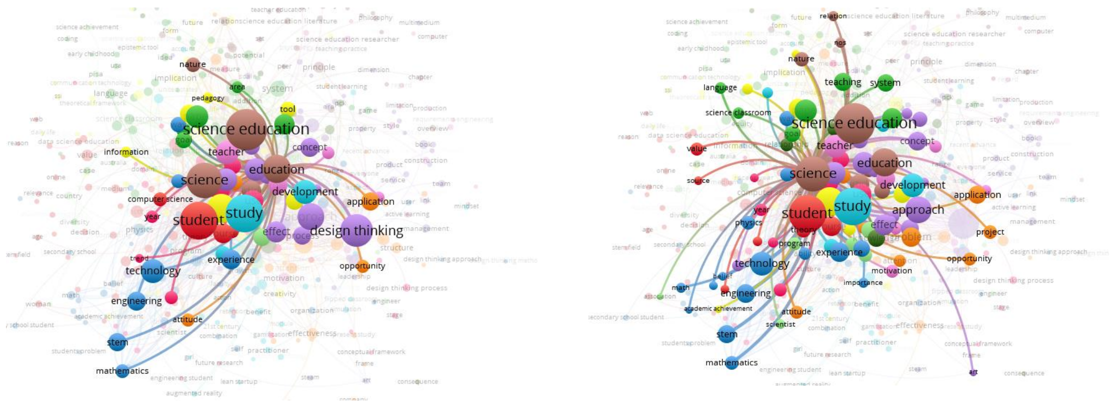


Figure 5. Overlay Visualization of the Keywords “Design Thinking” OR “Science Education”

Figure 5 shows an overlay visualization of design thinking research in science education. This overlay visualization shows the novelty of research on related terms [38]-[41]. Figure 4 shows that research on design thinking was mainly conducted in 2019. The time of popularity of the term design thinking in science education has yet to be visible. It can be seen from the fact that there is no direct connection between the term design thinking and science education. However, the connection is in several words, such as education, approach, application, problem, process, change, knowledge, research, teacher, book, project, study, student, etc. Thus, we can easily use the term design thinking in science education. Thus, we can easily create new research on design thinking in science education. This gap presents an opportunity for further exploration to bridge the connection between design thinking and science education. By identifying interdisciplinary intersections, researchers can innovate new approaches to teaching and learning in science education. Future studies could focus on integrating design thinking frameworks to address contemporary educational challenges effectively.



(a) (b)



(c) (d)

Figure 6. (a) Network Visualization of Design Thinking Term, (b) Network Visualization of Science Education Term, (c) Network Visualization of Education Term, and (d) Network Visualization of Science Term

Figure 6 shows the relationships between design thinking, science education, education, science, and other terms. Based on Figures 3 and 6, the relationship between design thinking and Science Education is not visible. This indicates a potential gap in the integration of design thinking within the context of science education that warrants further exploration.

However, the relationship between design thinking in science education terms occurs indirectly, or in other words, the relationship between design thinking and science education occurs through several terms, including education, approach, application, problem, process, change, knowledge, research, teacher, book, project, study, student. Research opportunities for design thinking in science education are still wide open if it is connected with other terms, such as education, approach, application, problem, process, change, knowledge, research, teacher, book, project, study, and student.

The findings of this study align with those reported by Bhandari [18] and demonstrate that design thinking has significant potential for application across various disciplines, including education, business, and technology, with research trends peaking in 2019 before declining in subsequent years. This study supports those findings with a more specific focus on science education, identifying a similar decline in publication numbers while highlighting opportunities for interdisciplinary integration. Furthermore, Bhandari emphasized the importance of further exploration into thematic diversification and future research opportunities, which aligns with this study's recommendations for the development of innovative teaching methods based on design thinking. Thus, this research complements Bhandari's insights by providing specific context within science education while advocating for the importance of design-based approaches in addressing complex challenges in learning.

This study's main strength lies in offering a bibliometric analysis focused on the context of science education, filling a gap in the literature that has predominantly addressed design thinking in a general sense. Additionally, the use of keyword network analysis successfully identified relevant interdisciplinary opportunities for future research. However, there are limitations in the study's database coverage, which is restricted to Google Scholar, likely excluding significant literature from other databases such as Scopus or Web of Science. Moreover, the relatively short analysis period (2018–2023) limits the understanding of long-term trend dynamics. Future research is recommended to utilize more comprehensive databases, extend the time frame, and conduct a deeper exploration of the relationship between design thinking and specific learning outcomes in science education, providing more holistic and applicable insights.

4. CONCLUSION

This study aims to determine the research trends of design thinking in science education and the research opportunities of design thinking in science education. The theme of the publications taken in this research is "Design Thinking in Science Education." The articles were retrieved from the Google Scholar database through Publish or Perish. The bibliometric data used in this study include titles and abstracts. From the search results, 997 relevant articles were published from 2018 to 2023. The results showed that design thinking research in Science Education has decreased from 2018 to 2023. The results show that research opportunities on design thinking in science education are still relatively high when associated with other terms. This study has implications for improving science education through design thinking, providing direction for future research and practical applications in curriculum development and pedagogy that can ultimately encourage creative and critical thinking in students.

AUTHOR CONTRIBUTION STATEMENT

MAF contributed to concept generation, methodology design, data mining, manuscript writing, and finalization. IH contributed to conceptualization, manuscript review, validation, and supervision. AS1 contributed to conceptualization and validation. AS2 contributed to supervision and validation.

REFERENCES

[1] A. Abulibdeh, E. Zaidan, and R. Abulibdeh, "Navigating the confluence of artificial intelligence and education for sustainable development in the era of industry 4.0: Challenges, opportunities, and ethical dimensions," *J. Clean. Prod.*, vol. 437, no. 1, pp. 1-8, 2024, doi: 10.1016/j.jclepro.2023.140527

[2] Z. Deng, "Powerful Knowledge, Educational potential and knowledge-rich curriculum: Pushing the boundaries," *J. Curric. Stud.*, vol. 54, no. 5, pp. 599–617, 2022, doi : 10.1080/00220272.2022.2089538

[3] F. X. L. L. Flower and J. T. Sugirtha, "Education 4.0: Revisiting contemporary paradigms in social work education," in *Industry 4.0 Technologies for Education*, Auerbach Publications, 2022, ch.10, pp. 359–368, doi: 10.1201/9781003318378-22

[4] K. Rawboon, A. K. Yamazaki, W. Klomklieng, and W. Thanomsub, "Future competencies for three demanding careers of industry 4.0: Robotics engineers, data scientists, and food designers," *J. Competency-Based Educ.*, vol. 6, no. 2, pp. 1-12, 2021, doi: 10.1002/cbe2.1253

[5] N. Rosenberg, "Technological change in the machine tool industry, 1840–1910," *J. Econ. Hist.*, vol. 23, no. 4, pp. 414–443, 1963, doi: 10.1017/S0022050700109155

[6] A. Buhl *et al.*, "Design thinking for sustainability: Why and how design thinking can foster sustainability-oriented innovation development," *J. Clean. Prod.*, vol. 231, no. 1, pp. 1248–1257, 2019, doi; 10.1016/j.jclepro.2019.05.259

[7] P. Micheli, S. J. S. Wilner, S. H. Bhatti, M. Mura, and M. B. Beverland, "Doing design thinking: Conceptual review, synthesis, and research agenda," *J. Prod. Innov. Manag.*, vol. 36, no. 2, pp. 124–148, 2019, doi: 10.1111/jpim.12466

[8] H. J. Kim, P. Yi, and B. W. Ko, "Deepening students' experiences with problem identification and definition in an empathetic approach: Lessons from a university design-thinking program," *J. Appl. Res. High. Educ.*, vol. 15, no. 3, pp. 852–865, 2023, doi: 10.1108/JARHE-03-2022-0083

[9] W.-L. Yeung and O.-L. Ng, "Using empathy maps to support design-thinking enhanced transdisciplinary STEM innovation in K-12 setting," *Int. J. Technol. Des.*

Educ., vol. 34, no. 1, pp. 1–26, 2023, doi: 10.1007/s10798-023-09861-7
[10] N. Donthu, S. Kumar, D. Mukherjee, N. Pandey, and W. M. Lim, "How to conduct a bibliometric analysis: An overview and guidelines," *J. Bus. Res.*, vol. 133, no. 1, pp. 285–296, 2021, doi: 10.1016/j.jbusres.2021.04.070
[11] A. H. ALSHARIF, N. Salleh, and R. BAHARUN, "Bibliometric analysis," *J. Theor. Appl. Inf. Technol.*, vol. 98, no. 15, pp. 2948–2962, 2020.
[12] Y. Y. Chun, "Bibliometric analysis of journal articles published by southeast asian chemical engineering researchers," *Malaysian J. Libr. Inf. Sci.*, vol. 14, no. 3, pp. 1–13, 2009.
[13] P. Grandjean, M. L. Eriksen, O. Ellegaard, and J. A. Wallin, "The matthew effect in environmental science publication: A bibliometric analysis of chemical substances in journal articles," *Environ. Heal.*, vol. 10, no. 1, pp. 1–8, 2011, doi: 10.1186/1476-069X-10-96
[14] C. A. Bonilla, J. M. Merigó, and C. Torres-Abad, "Economics in Latin America: A bibliometric analysis," *Scientometrics*, vol. 105, no. 1, pp. 1239–1252, 2015, doi : 10.1007/s11192-015-1747-7
[15] D. F. Al Husaeni, A. B. D. Nandiyanto, and R. Maryanti, "Bibliometric analysis of educational research in 2017 to 2021 using Vosviewer: Google Scholar indexed research," *Indones. J. Teach. Sci.*, vol. 3, no. 1, pp. 1–8, 2023, doi: 10.17509/ijotis.v3i1.43182
[16] D. N. Al Husaeni, A. B. D. Nandiyanto, and R. Maryanti, "Bibliometric analysis of special needs education keyword using vosviewer indexed by Google Scholar," *Indones. J. Community Spec. Needs Educ.*, vol. 3, no. 1, pp. 1–10, 2023, doi: 10.17509/ijcsne.v3i1.43181
[17] R. Ragadhita and A. B. D. Nandiyanto, "Computational bibliometric analysis on publication of techno-economic education," *Indones. J. Multidiciplinary Res.*, vol. 2, no. 1, pp. 213–222, 2022, doi: 10.17509/ijomr.v2i1.43180
[18] A. Bhandari, "Design thinking: From bibliometric analysis to content analysis, current research trends, and future research directions," *Journal of the Knowledge Economy*, vol. 14, no. 3. pp. 3097-3152, 2023. doi: 10.1007/s13132-022-00920-3, doi: 10.1007/s13132-022-00920-3
[19] N. M. Aris *et al.*, "Evaluating the academic trends on design thinking research: A bibliometric analysis from 2000 to 2021," *J. Posit. Sch. Psychol.*, vol. 6, no. 4, pp. 1022–1038, 2022.
[20] N. Dragičević, G. Vladova, and A. Ullrich, "Design thinking capabilities in the digital world: A bibliometric analysis of emerging trends," *Front. Educ.*, vol. 7, no. 1, pp. 1–18, 2023, doi: 10.3389/feduc.2022.1012478
[21] R. Razzouk and V. Shute, "What is design thinking and why is it important?," *Rev. Educ. Res.*, vol. 82, no. 3, pp. 330–348, 2012, doi : 10.3102/0034654312457429
[22] D. Pusca and D. O. Northwood, "Design thinking and its application to problem solving," *Glob. J. Eng. Educ.*, vol. 20, no. 1, pp. 48–53, 2018.
[23] E. E. Inglesis Barcellos and G. Botura, "Design thinking: User-centered multidisciplinary methodology based on people and innovation," in *Advances in Human Factors, Business Management and Leadership: Proceedings of the AHFE 2017 International Conferences on Human Factors in Management and Leadership, and Business Management and Society, July 17− 21, 2017, The Westin Bonaventure Hotel, Los* , 2018, pp. 173–182, doi: 10.1007/978-3-319-60372-8_17
[24] N. Suprapto, A. Kholiq, B. K. Prahani, and U. A. Deta, "Research on physics of photography: A bibliometric study (2000-2020)," in *Journal of Physics: Conference*

Series, vol. 2110, no. 1, 2021, pp. 1-8, doi: 10.1088/1742-6596/2110/1/012017
[25] K. S. Taber, "The use of Cronbach's Alpha when developing and reporting research instruments in science education," *Res. Sci. Educ.*, vol. 48, no. 1, pp. 1273–1296, 2018, doi: 10.1007/s11165-016-9602-2
[26] N. Cross, *Design thinking: Understanding how designers think and work*. New York: Bloomsbury Publishing, 2023, doi: 10.5040/9781350305090
[27] G. DeBoer, *A history of ideas in science education*. New York: Teachers college press, 2019.
[28] M. Stickdorn, M. E. Hormess, A. Lawrence, and J. Schneider, *This is service design doing: Applying service design thinking in the real world*. Sebastopol : O'Reilly media, 2018.
[29] V. Braun and V. Clarke, "Conceptual and design thinking for thematic analysis," *Qual. Psychol.*, vol. 9, no. 1, pp. 3-26, 2022, doi : 10.1037/qup0000196
[30] K. D. Elsbach and I. Stigliani, "Design thinking and organizational culture: A review and framework for future research," *J. Manage.*, vol. 44, no. 6, pp. 2274–2306, 2018, doi: 10.1177/0149206317744252
[31] J. Liedtka, "Why design thinking works," *Harv. Bus. Rev.*, vol. 96, no. 5, pp. 72–79, 2018.
[32] T. Martín-Páez, D. Aguilera, F. J. Perales-Palacios, and J. M. Vílchez-González, "What are we talking about when we talk about STEM education? A Review of Literature," *Sci. Educ.*, vol. 103, no. 4, pp. 799–822, 2019, doi: 10.1002/sce.21522
[33] S. Bal-Taştan, S. M. M. Davoudi, A. R. Masalimova, A. S. Bersanov, R. A. Kurbanov, A. V. Boiarchuk, A. A. Pavlushin, "The impacts of teacher's efficacy and motivation on student's academic achievement in science education among secondary and high school students," *EURASIA J. Math. Sci. Technol. Educ.*, vol. 14, no. 6, pp. 2353–2366, 2018, doi : 10.29333/ejmste/97832
[34] M. Lewrick, P. Link, and L. Leifer, *The design thinking playbook: Mindful digital transformation of teams, products, services, businesses and ecosystems*. Spanyol: Scrum Manager, 2018.
[35] M. Altman, T. T. K. Huang, and J. Y. Breland, "Peer reviewed: Design thinking in health care," *Prev. Chronic Dis.*, vol. 15, no. 117, pp. 1-13, 2018, doi: 10.5888/pcd15.180128
[36] M. Chowdhury, "Emphasizing morals, values, ethics, and character education in science education and science teaching," *MOJES Malaysian Online J. Educ. Sci.*, vol. 4, no. 2, pp. 1–16, 2018.
[37] J. Gess-Newsome, J. A. Taylor, J. Carlson, A. L. Gardner, C. D. Wilson, and M. A. M. Stuhlsatz, "Teacher pedagogical content knowledge, practice, and student achievement," *Int. J. Sci. Educ.*, vol. 41, no. 7, pp. 944–963, 2019, doi: 10.1080/09500693.2016.1265158
[38] L. Claus, "HR disruption time already to reinvent talent management," *BRQ Bus. Res. Q.*, vol. 22, no. 3, pp. 207–215, 2019, doi: 10.1016/j.brq.2019.04.002
[39] J. Carlson *et al.*, "The refined consensus model of pedagogical content knowledge in science education," *Repositioning Pedagog. content Knowl. Teach. Knowl. Teach. Sci.*, vol. 1, no. 1, pp. 77–94, 2019.
[40] S. Grover and R. Pea, "Computational thinking: A competency whose time has come," *Comput. Sci. Educ. Perspect. Teach. Learn. Sch.*, vol. 19, no. 1, pp. 19–38, 2018, doi : 10.5040/9781350057142.ch-003
[41] T. Brown, "Change by design. revised and updated," *How Des. Think. Transform. Organ.* California: Inspires Innov. Harperbus., 2019.

[42] Siti Zubaidah, "Mengenal 4C: learning and innovation skills untuk menghadapi era revolusi industri 4.0," *2nd Sci. Educ. Natl. Conf.*, no. September, vol. 12, no. 2, pp. 1–18, 2018.
[43] M. Kalogiannakis, S. Papadakis, and A.-I. Zourmpakis, "Gamification in science education: A systematic review of the literature," *Educ. Sci.*, vol. 11, no. 1, pp. 1-36, 2021, doi: 10.3390/educsci11010022
[44] L. Judijanto, Y. Yuanti, and S. Supriandi, "Population health management: A bibliometric analysis of literature on data analytics and public health interventions," *West Sci. Interdiscip. Stud.*, vol. 2, no. 4, pp. 778–788, 2024, doi: 10.58812/wsis.v2i04.796