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Bibliometric Analysis of Cooperative Learning's Impact on Critical Thinking Skills in Computer Applications Courses in Vocational Education

Elsa Sabrina[1*], Rosma Siregar[2] and Saras Pratama[2]

[1] Department of Family Welfare Education, Faculty of Engineering, Universitas Negeri Medan, Medan, **Indonesia**
[2] Department of Electrical Engineering Education, Faculty of Engineering, Universitas Negeri Medan, Medan, **Indonesia**

*Corresponding Author Email: elsasabrina@unimed.ac.id
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Abstract: This study aims to map the trends and developments in the literature regarding the influence of Cooperative Learning on enhancing students' Critical Thinking skills within the context of Vocational Education, using a bibliometric approach and a systematic literature review (SLR). The bibliometric analysis was conducted using R Studio, while keyword network visualization was performed using VOSviewer. The findings indicate that the peak of citations occurred in 2016, and the highest number of publications was recorded in 2022, with an average of 2.7 authors per article, reflecting significant multidisciplinary collaboration. The keyword visualization reveals a strong interrelation between cooperative learning, critical thinking, and vocational education, forming the core cluster of the research. These findings highlight the importance of cooperative learning as a strategic approach in developing vocational students' critical thinking skills and recommend the development of evidence-based implementation guidelines, contextual field research, and cross-sector collaboration to optimize its application in educational practice.

Keywords: Cooperative Learning; Critical Thinking; Vocational Education; Bibliometric Analysis; Systematic Literature Review.

1. Introduction

In the 21st century, vocational education not only emphasizes mastery of technical skills but also the strengthening of critical thinking abilities as a core competency for addressing the complex and dynamic challenges of the workforce [1], [2]. Critical thinking involves the ability to deeply analyze information, objectively evaluate arguments, identify underlying assumptions, and make logical, evidence-based decisions [3]. Recent studies indicate that critical thinking is one of the key indicators of job readiness across various

industrial sectors [4], [5]. In the context of vocational education, this skill is essential to ensure that students are not only technically proficient but also capable of responding to problems analytically, reflectively, and adaptively [6]. Specifically, in computer application courses, critical thinking is crucial so that students are not merely able to operate software but can also analyze user needs, solve problems systematically, and evaluate technological solutions using a reflective and logical approach [7]–[9].

One effective instructional approach for developing critical thinking skills is Cooperative Learning [10]. This approach involves structured group interactions that encourage students to actively construct arguments, evaluate ideas, and build understanding collaboratively. Numerous studies have shown that Cooperative Learning can enhance both academic performance and critical thinking skills. For instance, [11] found that the implementation of Cooperative Learning significantly improved the critical thinking abilities of vocational polytechnic students in an introductory programming course. Similarly, [12] demonstrated the effectiveness of Cooperative Learning in enhancing analytical and problem-solving skills among vocational high school students in Information and Communication Technology subjects. However, a deeper mapping is still needed to understand how this approach is applied and developed specifically within vocational education. Therefore, further studies are essential to identify best practices and the challenges encountered in this context.

As the number of scholarly publications exploring the relationship between Cooperative Learning and critical thinking skills continues to grow, bibliometric analysis has become a suitable method for tracing research trends and directions in this field. This approach enables researchers to identify publication patterns, dominant keywords, as well as the contributions of leading authors and institutions. Moreover, bibliometric analysis can reveal underexplored areas or research gaps. With this information, researchers can systematically and strategically map the development of knowledge, thereby promoting more focused and impactful studies. Addressing these gaps requires a deeper and more detailed bibliometric analysis. Such analysis is crucial for understanding patterns of author collaboration, influential journals, and publication trends related to the development of critical thinking through Cooperative Learning. By adopting this approach, research can be more accurately directed and comprehensive, ultimately contributing significantly to vocational education.

2. Research Methods

This study adopts the Systematic Literature Review (SLR) method to systematically and thoroughly explore existing literature [13]. The focus is directed toward an in-depth analysis of various studies that investigate the impact of Cooperative Learning on students' critical thinking skills, particularly

within the context of vocational education. Through this approach, the research aims to present a holistic overview of evolving trends, key findings, and existing research gaps in the field. The results of this review are expected to provide a solid theoretical foundation and serve as a valuable reference for educators and researchers in designing more effective instructional strategies in the future.

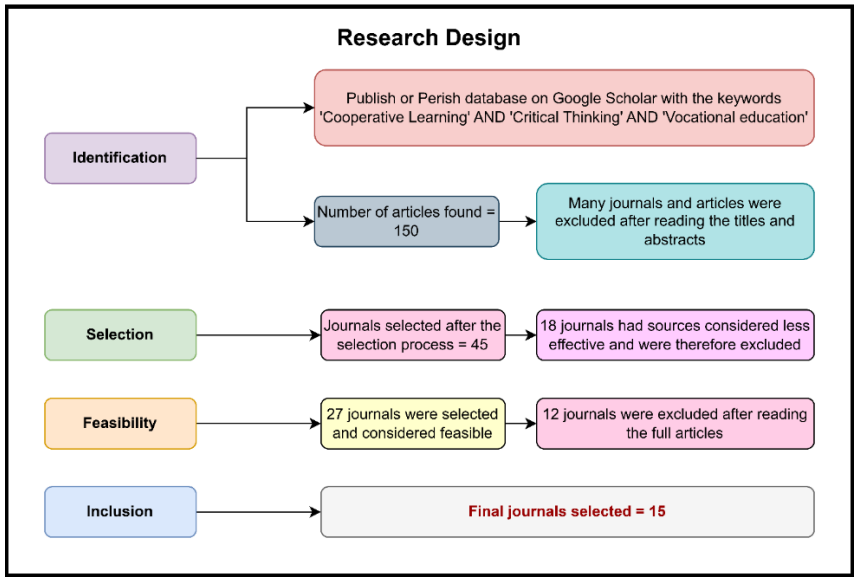

Figure 1. Research Design Flow

Figure 1 illustrates the research design flow that employs the Systematic Literature Review (SLR) method to examine the relationship between Cooperative Learning, Critical Thinking, and Vocational Education. The identification process began with article retrieval through the Publish or Perish tool using Google Scholar and relevant keywords, yielding an initial total of 150 articles. After reviewing titles and abstracts, a large number of articles were excluded for not meeting the inclusion criteria. During the selection phase, 45 journals were retained, of which 18 were eliminated due to low relevance or methodological limitations. From the remaining 27 journals, another 12 were excluded following an in-depth review. The final result of this selection process was 15 high-quality journals that met all criteria and were subsequently analyzed further in this study.

The data processing in this research was conducted through a bibliometric approach, with VOSviewer version 1.6.20 employed for visualizing the mapping outcomes. The bibliometric analysis encompassed four key stages: data collection via the Publish or Perish 8 tool, initial data handling using Microsoft Excel, visual mapping with VOSviewer, and subsequent interpretation of the visual outputs. Data obtained from Publish or Perish were saved in .csv and .ris formats; the .csv files were used to analyze the distribution of articles per year and keyword trends through Excel, while the .ris files were

utilized for visual mapping to illustrate the relationships among concepts. The generated visualizations enabled researchers to observe the interconnections between terms and the clustering of dominant research themes. From this mapping, the development of literature related to the impact of Cooperative Learning on students' critical thinking skills—particularly in the context of vocational education—could be systematically traced. These findings are expected to provide a strong foundation for shaping future research directions and advancing instructional development.

3. Results and discussion

3.1 Search results matrix

In the academic world, the number of citations received by a publication is often considered a key indicator of its influence, quality, and scholarly contribution within a particular discipline. Publications with high citation counts typically reflect recognition, usage, and reference by many other researchers. This indicates that the study holds strong relevance and plays a significant role in advancing knowledge. In this research, a total of 150 articles related to Cooperative Learning, Critical Thinking, and Vocational Education were identified, published between 2021 and 2025. These publications collectively recorded 30,739 citations, highlighting the considerable attention this topic has received within the academic community. This finding underscores that the topic is not only relevant but also promising for continued investigation in the field of vocational education.

Table 1. Citation Metrics

Paper	150
Citations	30.739
Cites/year	7.684,75
Cites/paper	204,93
Authors/paper	2.69
h-index	91
g-index	150

Based on the bibliometric analysis of 150 articles discussing Cooperative Learning, Critical Thinking, and Vocational Education presented in Table 1, several metrics were obtained that reflect the academic strength and influence of these publications. A total of 30,739 citations were recorded, with an average of 7,684.75 citations per year, indicating that the topic continues to attract significant attention and relevance within the scientific community. The average number of citations per article was 204.93, suggesting that each publication made a notable contribution to knowledge development in the field. Additionally, the average number of authors per article was 2.69, indicating a trend toward collaborative research. The h-index of 91 shows that at least 91

articles have been cited a minimum of 91 times, while the g-index of 150 reinforces the fact that these publications are not only frequently cited but also have a well-distributed citation pattern across key articles. Overall, these metrics reflect the high quality and scientific impact of the analyzed literature.

Table 2. 15 articles with the highest number of citations

No	Number of Citations	Authors	Title	Year	Source
1	835	L Lipponen	Exploring foundations for computer-upported collaborative learning [14]	2023	Computer support for collaborative learning
2	832	LI González-Pérez, MS Ramírez-Montoya	Components of Education 4.0 in 21st century skills frameworks: systematic review [15]	2022	Sustainability
3	634	MA Qureshi, et al.	Factors affecting students' learning performance through collaborative learning and engagement [16]	2023	Interactive Learning Environments
4	599	B Thornhill-Miller, et al.	Creativity, Critical Thinking, Communication, and Collaboration: Assessment, Certification, and Promotion of 21st Century Skills for the Future of Work and Education [17]	2023	Journal of Intelligence
5	577	T Rasul, et al.	The role of ChatGPT in higher education: Benefits, challenges, and future research directions [18]	2023	Journal of Applied Learning & Teaching
6	539	SA Seibert	Problem-based learning: A strategy to foster generation Z's critical thinking and perseverance [19]	2021	Teaching and Learning in Nursing
7	457	P Kwangmuang, et al.	The development of learning innovation to enhance higher order	2021	Heliyon

No	Number of Citations	Authors	Title	Year	Source
			thinking skills for students in Thailand unior high schools [20]		
8	436	J Kim, H Lee, YH Cho	Learning design to support student-AI collaboration: Perspectives of leading teachers for AI in education [21]	2022	Education and information technologies
9	424	SZ Salas-Pilco, Y Yang, Z Zhang	Student engagement in online learning in Latin American higher education during the COVID-19 pandemic: A systematic review [22]	2022	British Educational Research Association
10	267	MÁ Herrera-Pavo	Collaborative learning for virtual higher education [23]	2021	Learning, culture and social interaction
11	211	F Mutohhari, et al.	Difficulties in Implementing 21st Century Skills Competence in Vocational Education Learning [24]	2021	International Journal of Evaluation and Research in Education (IJERE)
12	206	S Nahar	Improving Students' Collaboration Thinking Skill under the Implementation of the Quantum Teaching Model [25]	2022	International Journal of Instruction
13	198	SF Rivas, C Saiz, C Ossa	Metacognitive strategies and development of critical thinking in higher education [26]	2022	Frontiers in psychology
14	195	RN Indah, et al.	The research competence, critical thinking skills and digital literacy of Indonesian EFL students [27]	2022	Journal of Language Teaching and Research

No	Number of Citations	Authors	Title	Year	Source
15	168	E Xu, W Wang, Q Wang	The effectiveness of collaborative problem solving in promoting students' critical thinking: A meta-analysis based on empirical literature [28]	2023	Humanities and social sciences communications

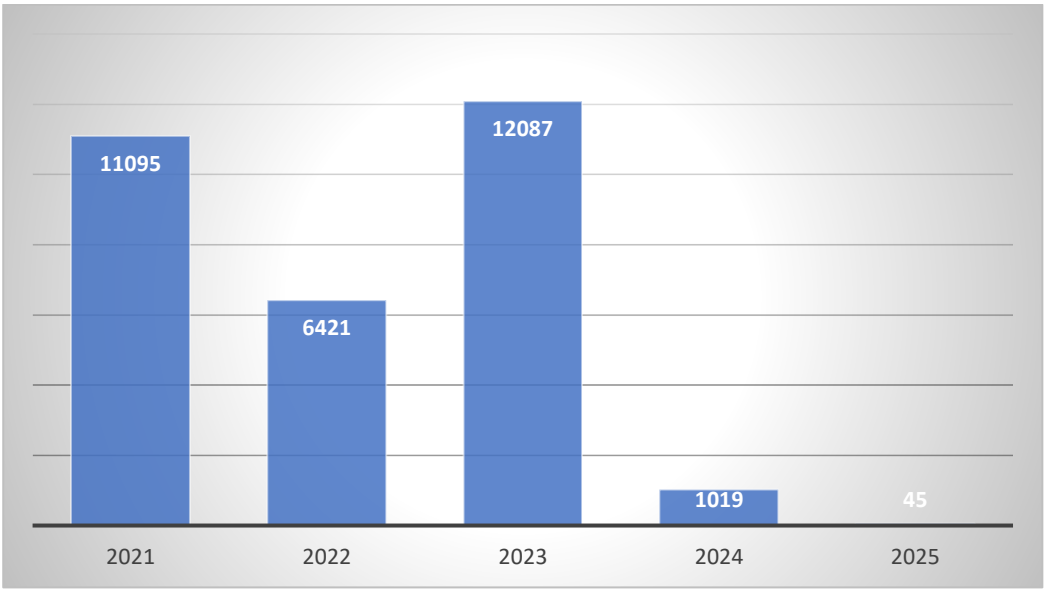

Figure 2. The highest number of citations based on publication year

Figure 2 illustrates the distribution of citation counts according to the publication years of the articles reviewed in this study. It is evident that 2023 recorded the highest number of citations, with a total of 12,087, followed by 2021 with 11,095 citations. In contrast, there was a notable decline in 2022, which recorded only 6,421 citations. This downward trend continued more sharply in 2024 and 2025, with just 1,019 and 45 citations respectively. The lower citation counts in the last two years are most likely due to the recency of those publications, which have not yet had sufficient time to be widely cited. This graph suggests that articles published in earlier years—particularly in 2023 and 2021—have had a greater impact and made significant contributions to the development of studies on Cooperative Learning, Critical Thinking, and Vocational Education. These findings highlight the ongoing academic interest and high relevance of these topics in the context of vocational education and the advancement of critical thinking skills through collaborative learning approaches.

3.2 Publication Trend Analysis

Over the years, the publication trend of studies on the impact of Cooperative Learning on students' Critical Thinking in Vocational Education has shown a dynamic and evolving pattern. As illustrated in Figure 3, the number of indexed publications during the period from 2021 to 2025 shows notable fluctuations. The highest number of publications occurred in 2021, with a total of 59 articles, reflecting strong interest from researchers at the beginning of the timeframe. However, a significant decline followed, with 41 publications in 2022 and a slight decrease to 39 in 2023. A sharper drop is observed in 2024, with only 9 publications, and 2025 records the lowest figure, with just a single publication. This decline is likely due to the proximity of these years to the time of analysis, meaning that many recent articles may not yet be fully documented or widely disseminated. Despite this, the trend underscores that the study of Cooperative Learning, Critical Thinking, and Vocational Education has been a key focus in academic literature, especially at the start of the analysis period, and holds considerable potential for continued growth as attention toward innovation in vocational education increases.

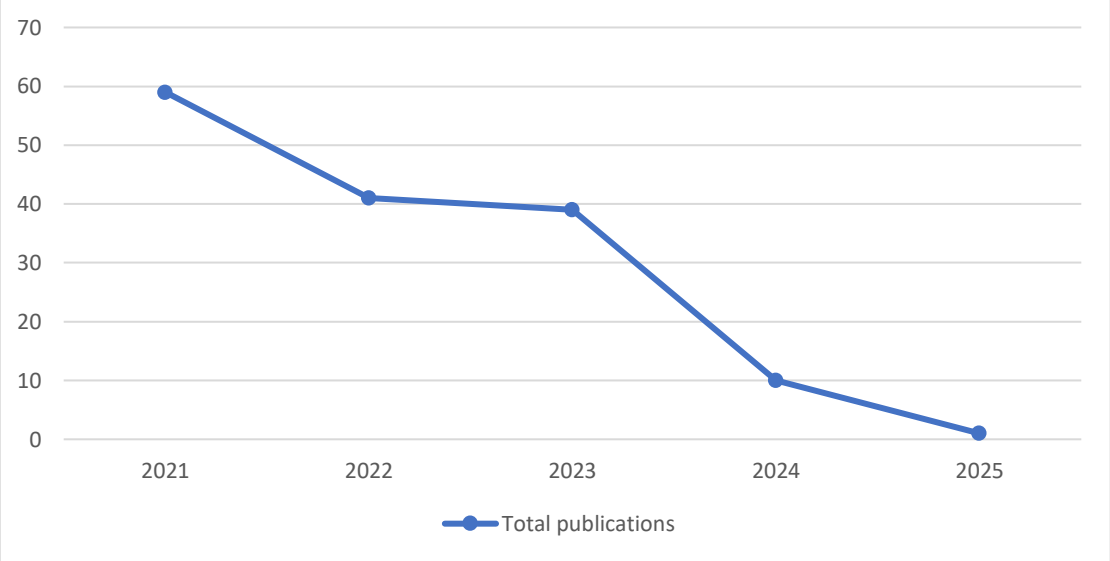

Figure 3. Total Publications by Year

3.3 Keyword Trend Analysis

Co-word analysis is an effective method for exploring and understanding the relationships between keywords that frequently appear together in academic literature. This technique not only provides a comprehensive overview of the direction and focus of research within a specific field but also reveals the interconnections between overlapping topics. In the context of studies examining the impact of Cooperative Learning on Critical Thinking in Vocational Education, the analysis process began with the collection of keyword data from relevant articles sourced from various academic databases. These

keywords were then analyzed using VOSviewer software to construct a co-occurrence matrix and visualize the data in the form of a keyword network. Figure 4 presents the results of the Co-word analysis.

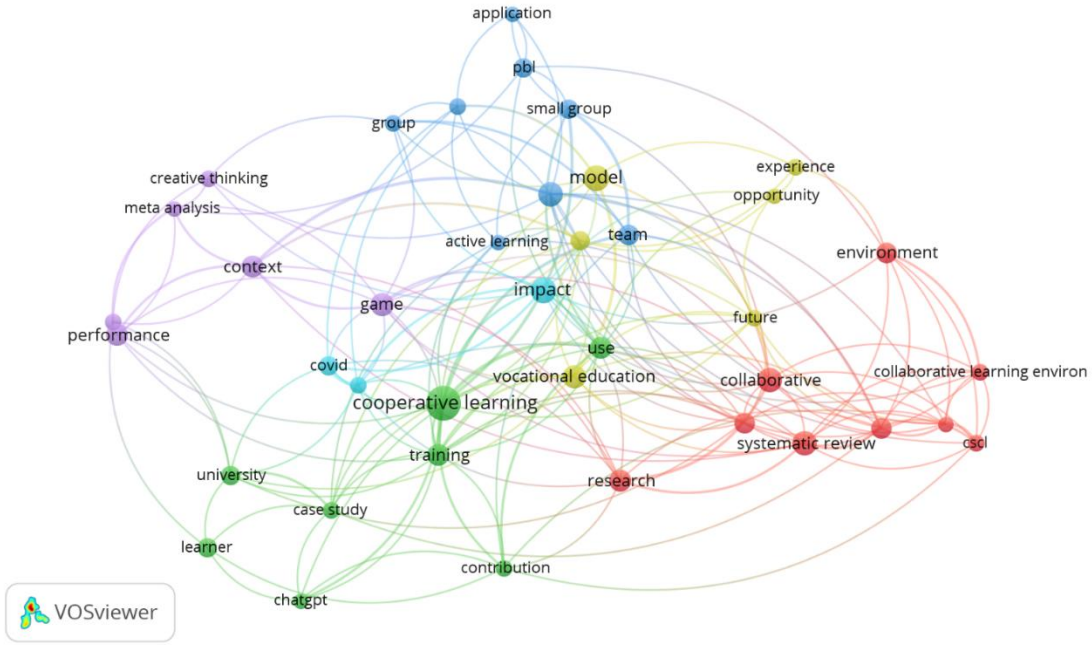

Figure 4. Network visualization based on Co-word

Figure 4, which presents the visualization of the co-word analysis using VOSviewer, reveals key trends in research related to cooperative learning, critical thinking, and vocational education. These three keywords form the central hub of interrelated topics, surrounded by terms such as training, impact, active learning, and case study. This reflects the widespread examination of cooperative learning approaches within vocational education, particularly in relation to enhancing critical thinking skills and improving learning effectiveness. The colored clusters in the visualization indicate various sub-themes, such as the application of cooperative learning in vocational training, its contribution to the development of higher-order thinking skills, and its integration with technology and active learning models. Additional terms like research, learner, and university further suggest that this line of inquiry extends beyond secondary vocational schools to include higher education and professional training. Overall, the visualization highlights that the intersection of cooperative learning, critical thinking, and vocational education represents a highly relevant and strategic research area for advancing 21st-century education.

The results of the co-word analysis offer important implications for both research development and educational practice, particularly in optimizing the role of cooperative learning to enhance critical thinking within vocational education. The strong interconnection between these three concepts reinforces

the idea that cooperative learning is not merely a collaborative method, but also an effective pedagogical strategy for shaping the critical thinking abilities of vocational students. Practically, this suggests that educators and curriculum designers must deliberately design cooperative learning activities that promote discussion, reflection, and collective problem-solving. Furthermore, the associations with keywords such as active learning, impact, and training indicate that this approach aligns with workforce demands and the competencies required in 21st-century education. From a research perspective, these findings open up opportunities to further explore how cooperative learning models can be designed in a more contextualized and adaptive manner to strengthen critical thinking across various vocational disciplines. Thus, the analysis not only maps keyword relationships but also provides strategic direction for developing innovative, collaborative, and higher-order thinking-oriented instructional practices.

3.4 Discussion

The bibliometric and co-word analyses conducted in this study demonstrate the growing academic attention toward the intersection of cooperative learning, critical thinking, and vocational education. The dataset of 150 publications generated 30,739 citations, an average of 204.93 citations per paper, supported by an h-index of 91 and g-index of 150. These quantitative indicators reflect the depth and influence of the discourse surrounding the integration of collaborative instructional methods with cognitive skill development in vocational learning contexts [29].

The citation landscape suggests that cooperative learning is not simply an alternative pedagogical model but a strategic tool for developing students' higher-order thinking abilities, especially in practical and technical domains. Research has shown that structured group learning can foster essential 21st-century skills such as critical analysis, reflective judgment, and adaptive reasoning [30]. In particular, publications from 2023 and 2021 recorded the highest number of citations, indicating that this theme reached significant scholarly prominence during those periods.

The keyword trend and co-occurrence network analysis further validate this relevance. As visualized in the co-word map, central terms such as cooperative learning, critical thinking, and vocational education were frequently associated with clusters that include active learning, training, and impact, which collectively emphasize the educational community's shift toward experiential and learner-centered strategies [31]. The emergence of adjacent keywords like research, university, and technology also suggests that the discourse extends into higher education and professional development environments.

These findings support the notion that cooperative learning, when contextually adapted and intentionally structured, enhances student engagement and

promotes cognitive complexity through peer interaction, role distribution, and shared responsibility. This aligns with multimedia and constructivist learning theories, which emphasize the value of dialogic and social learning for cognitive development. However, the implementation of such models must be rooted in pedagogical intentionality to avoid superficial collaboration or misalignment with instructional goals.

Despite its contributions, this study has limitations. The scope of the bibliometric analysis was limited to articles indexed between 2021 and 2025, potentially omitting foundational studies or non-indexed innovations. Additionally, while citation metrics offer insight into academic influence, they do not measure actual classroom effectiveness or long-term student impact.

Future studies should therefore incorporate empirical classroom-based evaluations, longitudinal designs, and cross-institutional comparisons to measure the sustained effects of cooperative learning on critical thinking. Research should also explore the integration of this method with digital learning platforms, learning analytics, and artificial intelligence systems to personalize instruction and monitor student collaboration in real time. Furthermore, professional development programs for vocational teachers must be designed to equip them with the capacity to facilitate cooperative learning effectively and evaluate its cognitive outcomes systematically.

In conclusion, cooperative learning emerges not only as a relevant pedagogical approach but also as a scalable and impactful strategy for building critical thinking skills in vocational education. The bibliometric evidence affirms its scientific momentum, while the co-word analysis highlights its theoretical coherence and practical potential. However, further empirical validation and pedagogical innovation are needed to ensure its effectiveness and sustainability in diverse educational settings.

4. Conclusion

This co-word analysis underscores the strategic relevance of cooperative learning as a transformative instructional approach for enhancing students' critical thinking skills, particularly in vocational education. The interrelationship between cooperative learning, critical thinking, and vocational contexts demonstrates that collaborative pedagogical practices—centered on interaction, shared responsibilities, and joint problem-solving—are strongly associated with the development of higher-order cognitive abilities that are essential for 21st-century workforce readiness. However, this potential is not inherently realized; its effectiveness is highly contingent on the pedagogical design, contextual adaptation, and sustained integration within instructional frameworks.

The findings suggest that cooperative learning, when intentionally structured and supported by trained instructors, can serve not only as a learning strategy but also as a capacity-building mechanism aligned with real-world industry competencies. In this respect, the study provides a critical lens on prevailing educational models that prioritize individual academic outcomes over collaborative intellectual growth, urging stakeholders to reimagine vocational education through more socially constructed and cognitively engaging methodologies.

Despite its contributions, this study has several limitations. It primarily relies on co-word bibliometric analysis without empirical classroom validation, which limits the generalizability of its pedagogical implications. Additionally, the analysis is constrained to published literature, which may omit emerging practices and informal innovations within vocational institutions.

Future research should adopt mixed-method approaches, including experimental and longitudinal designs, to empirically examine the implementation of cooperative learning and its sustained effects on students' critical thinking abilities in diverse vocational settings. Furthermore, cross-disciplinary collaboration between educational researchers, vocational practitioners, and industry experts is recommended to develop robust implementation models and evaluation frameworks. These should incorporate indicators such as cognitive engagement, team dynamics, knowledge transfer, and long-term professional adaptability. Strengthening teacher training programs and policy-level support will also be vital in ensuring that cooperative learning becomes a sustainable and impactful component of vocational education reform.

Author's declaration

Author contribution

Elsa Sabrina led the conceptualization, study design, methodology development, data analysis, drafting of the manuscript, supervision, and acted as the corresponding author. **Rosma Siregar** handled data curation, software utilization (R Studio and VOSviewer), visualization, result validation, and contributed to the manuscript's review and editing. **Saras Pratama** was involved in literature search, investigation, sourcing relevant materials, and assisted in reviewing, editing, and interpreting the findings. All authors reviewed and approved the final manuscript for publication.

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Competing interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

Ethical clearance

The authors declare no competing financial or personal interests that could have influenced the outcomes of this research.

AI statement

The grammatical structure of this article was enhanced using ChatGPT to ensure clarity and academic tone. All AI-assisted outputs were thoroughly reviewed, validated, and cross-checked by the authors to ensure consistency with the research topic and data. Furthermore, the language and content of the article were verified by an English language expert, and no AI-generated sentences were included without critical revision and authorial oversight.

Publisher's and Journal's note

Universitas Negeri Padang as the publisher and Editor of Jurnal Vokasi Informatika (JAVIT) state that there is no conflict of interest towards this article publication.

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