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Artificial Intelligence in Cooperative Learning: Mapping the Intellectual Structure and Research Trajectories (2021–2025)

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Abstract

Artificial intelligence (AI) is increasingly transforming cooperative learning environments, offering new possibilities for enhancing collaborative interaction and structured group engagement. This study aims to illuminate current research trends on AI-supported cooperative learning through a bibliometric analysis approach. A comprehensive examination was conducted on relevant academic works sourced from the Scopus database, covering the period from 2021 to 2025. Using the search query “artificial intelligence” AND “cooperative learning,” a total of 183 records were initially identified, with nine peer-reviewed journal articles retained following PRISMA-based screening. Various analytical tools were employed, including biblioMagika® for bibliometric indicators, OpenRefine for metadata harmonisation, and VOSviewer for keyword co-occurrence visualisation. The study analysed annual publication growth, citation patterns, source influence, authorship distribution, and thematic structures. Findings reveal a compact yet influential research base, comprising nine publications and 219 total citations, indicating strong early scholarly uptake. Results also demonstrate interdisciplinary dispersion across educational technology and engineering journals, alongside emerging thematic consolidation around artificial intelligence, cooperative learning, and analytical thinking. The study highlights both the growing academic legitimacy of AI-supported cooperative learning and the need for theoretically grounded and responsible integration within collaborative pedagogical frameworks.

Keywords : Artifial Intelligence, Cooperative Learning, Educational Technology, Bibliometrics

Introduction

Artificial intelligence (AI) has become pervasive, reshaping how people communicate, work, and learn, and education is a highly visible arena where this shift is unfolding. As institutions expand hybrid and online delivery, learning increasingly occurs through platforms that capture interaction data and connect learners across distance. Generative AI has accelerated debate: educators see new forms of support but also risks such as opacity, dependency, inequity, and misuse. Global guidance calls for human-centred AI in education that foregrounds governance, capacity building, and ethical safeguards. Evidence syntheses also report a marked rise in AI-in-education research since 2022, consistent with the mainstreaming of generative tools and renewed urgency around responsible integration (Miao & Holmes, 2023). This shift is especially salient for cooperative learning, where educational value depends on interaction quality, mutual support, and equitable participation—dimensions that AI could either strengthen or distort (Garzón et al., 2025). Collaborative problem solving is increasingly recognized as an important 21st-century skill, yet collaboration can also lead to conflict and inefficiency when poorly managed. Consequently, researchers are asking how AI might support productive talk, coordination, and shared accountability within groups .

Within this broader transformation, cooperative learning remains a foundational pedagogical approach because it treats learning as socially mediated: understanding develops through interaction, shared problem-solving, and mutual support in small groups. Yet cooperative learning is not synonymous with unstructured group work; theory-based designs require intentional structuring so that teams become genuinely interdependent while maintaining individual responsibility. In social interdependence traditions, effective cooperative learning requires five basic elements—positive interdependence, individual accountability, promotive interaction, social skills, and group processing—which together promote equitable participation and reflective improvement. In practice, sustaining these elements is difficult in technology-mediated settings: teachers must monitor participation, address free-riding or marginalization, manage conflict, and protect individual accountability across multiple teams and modalities (Johnson et al., 2018). When facilitation is inconsistent, cooperative learning can drift toward unequal division of labor and superficial consensus, weakening learning gains. These realities make cooperative learning high-impact but coordination-intensive, helping explain why AI is now explored as a partner in orchestrating collaboration.

AI-supported cooperative learning responds to these coordination and regulation challenges by positioning AI not only as a content-focused tutor but also as a mediator of group processes. Synthesis work on AI-enhanced collaborative learning describes a converging toolkit: machine learning and natural language processing to interpret discourse and interaction; recommender approaches to tailor resources and prompts; and predictive or multimodal analytics to model engagement and social presence. Beyond analysis, AI agents can be designed to scaffold metacognition and co-regulation—supporting learners as they plan, monitor, and reflect together—which aligns with research on socially shared regulation of learning (Kovari, 2025). Yet data-driven mediation raises tensions: monitoring heightens privacy risk, recommendations may encode bias or reduce learner autonomy, and opacity can undermine trust and accountability (Edwards et al., 2025). Frameworks for trustworthy AI foreground requirements such as human agency and oversight, transparency, and privacy/data governance. These concerns reinforce the need to balance algorithmic nudges with teacher judgment and learner agency, rather than pursuing full automation (European Commission, 2019).

Literature Review

Theoretical Foundations of Cooperative Learning

Cooperative learning (CL) is grounded in social interdependence theory, which posits that individuals achieve more effectively when their goals are positively linked with the goals of others (Johnson & Johnson, 2009). Core principles such as positive interdependence, individual accountability, promotive interaction, collaborative skills, and group processing distinguish cooperative learning from unstructured group work (Slavin, 2014). Within well-designed cooperative environments, learners construct knowledge through peer explanation, negotiated reasoning, and shared responsibility. Empirical evidence consistently demonstrates that structured cooperative learning enhances academic achievement, higher-order thinking, and socio-cognitive development across diverse educational contexts.

Importantly, cooperative learning requires systematic orchestration. Tasks must be designed to ensure meaningful interdependence, balanced participation, and opportunities for reflection. These structural requirements create conditions in which technological systems—particularly artificial intelligence—may function as supportive mechanisms. However, integration must remain aligned with CL's theoretical foundations to preserve the social and cognitive integrity of collaboration.

Artificial Intelligence as an Enabler of Cooperative Structures

Artificial Intelligence in Education (AIEd) has evolved from early intelligent tutoring systems to adaptive learning architectures capable of modelling learner interaction and generating data-informed instructional support (Chen et al., 2020). While much of the early AI literature emphasised personalised learning pathways, recent developments increasingly recognise the potential of AI to support socially mediated learning processes.

In cooperative contexts, AI can assist in group formation, monitor patterns of participation, and provide scaffolding during collaborative tasks. Learning analytics systems, for example, can detect uneven contribution patterns, highlight disengagement, and support instructors in maintaining individual accountability—an essential principle of cooperative learning (Kovanović et al., 2021). Rather than acting as a substitute for peer interaction, AI operates as an orchestration layer that strengthens structural coherence within collaborative tasks.

Furthermore, AI-supported tools can facilitate structured dialogue by generating reflective prompts, recommending resources, or identifying conceptual inconsistencies within group discussions. These functions align with promotive interaction and shared cognitive engagement, reinforcing the core mechanisms through which cooperative learning enhances understanding.

AI as a Catalyst for Higher-Order Thinking

Cooperative learning is particularly effective in fostering analytical reasoning, argumentation, and problem-solving (Slavin, 2014). The integration of generative AI and conversational systems further expands these cognitive opportunities. Large language models can simulate alternative viewpoints, generate counterarguments, and summarise complex information to stimulate deeper group discussion (Kasneci et al., 2023).

Positioned appropriately, AI functions not as an answer provider but as a dialogic catalyst that provokes critical reasoning. By identifying conceptual gaps or posing elaborative questions, AI systems can stimulate epistemic engagement and reduce cognitive loafing within groups. This approach aligns with constructivist assumptions that knowledge is co-constructed through dialogue and negotiated meaning.

Nevertheless, scholars caution against uncritical dependence on AI-generated content. Learners must be encouraged to evaluate automated outputs critically to avoid superficial consensus or passive acceptance. Maintaining cognitive agency within AI-supported cooperative environments is therefore essential for preserving educational integrity.

Research Gap and the Need for Bibliometric Synthesis

Artificial intelligence (AI) research in education has expanded rapidly. Publications on AI in higher education nearly tripled by 2022 (Crompton & Burke, 2023), and bibliometric analyses document a similar surge in AIEd literature (Durak et al., 2024). However, much of this work focuses on individual adaptation or AI-driven tutors rather than structured group pedagogy. For example, Crompton and Burke (2023) found that AIEd applications cluster around "Intelligent Tutoring Systems" and "AI assistants" (Crompton & Burke, 2023), while formal cooperative learning frameworks, which emphasize interdependence and defined roles (Tan et al., 2022), receive little attention. Indeed, Tan et al. (2022) note that AI-supported collaborative learning is an emerging phenomenon lacking comprehensive review, and recent meta-analyses specifically call for study of AI-enhanced cooperative group learning. These observations indicate a clear gap: AI-augmented cooperative learning has not yet been systematically synthesized or its development mapped.

Bibliometric analysis offers a systematic method to address this gap by comprehensively mapping research trends, key contributors, thematic clusters, and connections. It combines performance analysis (tracking publication and citation counts) with science mapping (co-citation and keyword networks) to visualize how a field evolves. For example, Durak et al. (2024) applied bibliometrics to 1,726 AIEd articles and documented rapid field expansion along with emerging thematic foci. Bibliometric reviews thus provide a "one-stop overview" of a research area and help uncover hidden knowledge gaps. A similar bibliometric synthesis focused on AI-supported cooperative learning would also consolidate scattered studies, highlight influential authors and journals, and reveal conceptual structures. This approach can chart the intellectual evolution of AI-augmented cooperative pedagogy and illuminate emerging trajectories in this niche field of research.

Table 1
Previous Studies on Artificial Intelligence in Cooperative Learning

Authors & Year	**Objective**	**Data Source & Year Coverage**	**TDE**	**Analytical Techniques**
Zawacki-Richter et al. (2019)	To systematically review research trends and applications of AI in higher education, including collaborative contexts.	Scopus (2007–2018)	146	Systematic review, content categorisation
Chen et al. (2020)	To examine research gaps and thematic orientations in AI in education literature.	Scopus (2000–2019)	1,463	Bibliometric analysis, keyword mapping
Bond et al. (2020)	To map digital transformation research in higher education, including AI-related collaborative learning themes.	Scopus & WoS (2000–2019)	738	Bibliometric mapping, network analysis
Tan et al. (2022)	To review AI applications in collaborative/cooperative learning environments and identify emerging directions.	Scopus & WoS (2010–2021)	89	Systematic review, thematic synthesis
García-Peñalvo & Seoane (2023)	To analyse AI-enhanced collaborative learning systems focusing on online interaction and group scaffolding.	Multiple databases (2015–2022)	112	Systematic review, meta-synthesis
Li & Zhu (2023)	To investigate how AI agents support peer dialogue and shared cognitive engagement in CSCL.	Scopus (2012–2023)	64	Bibliometric analysis, co-occurrence mapping
Kovanović et al. (2024)	To assess how learning analytics and AI mediate collaborative knowledge building in blended environments.	Scopus & WoS (2015–2023)	97	Bibliometric mapping, topic modelling

*TDE: Total Documents Examined

Research Questions

This paper presents a bibliometric analysis of research on artificial intelligence in cooperative learning environments, addressing six interrelated research questions:

RQ1: What is the current structural and citation profile of research on AI-supported cooperative learning?
RQ2: How has research activity and scholarly impact evolved over time in this domain?
RQ3: Which journals and publication sources play central roles in disseminating AI-supported cooperative learning research?
RQ4: Which highly cited publications function as intellectual anchors shaping discourse in AI-supported cooperative learning?

RQ5: What thematic patterns and conceptual clusters characterise the evolution of AI applications within cooperative learning frameworks?

The overarching aim of this study is to provide a comprehensive and evidence-based understanding of how artificial intelligence is being integrated into cooperative learning frameworks across educational contexts. Using bibliometric and network-based analyses, the study maps the structural configuration of scholarship at the intersection of AI and collaborative pedagogy, identifying influential contributors, key publication venues, citation patterns, and emerging thematic orientations. Rather than treating AI as a standalone technological innovation, this analysis situates it within cooperative learning theory and digitally mediated instructional design, highlighting how research in the domain is evolving from exploratory experimentation toward early scholarly consolidation. By clarifying the field's developmental trajectory and intellectual anchors, the study contributes to a more theoretically grounded and responsible integration of artificial intelligence within cooperative learning environments, offering a structured foundation for future research and pedagogical advancement.

Methods

This study utilised data extracted from the Scopus database as of 9 February 2026. Scopus was selected intentionally due to its reputation as one of the most comprehensive and rigorously curated abstract and citation databases for peer-reviewed scholarly literature. Its extensive disciplinary coverage—including computer science, social sciences, linguistics, educational technology, and applied human–computer interaction—makes it particularly suitable for research examining the integration of artificial intelligence in English speaking education. The database's wide geographical reach and stringent indexing standards ensure a reliable and representative dataset of global academic output. Moreover, Scopus provides rich bibliometric metadata, including citation counts, author affiliations, publication venues, and keyword descriptors, enabling detailed analyses of productivity patterns, collaborative networks, research impact, and thematic trends. These features collectively positioned Scopus as the most appropriate and robust data source for conducting the bibliometric and co-occurrence analyses in this study. The retrieved dataset encompassed essential publication attributes such as document type, source title, subject areas, yearly publication growth, authorship patterns, institutional contributions, country-level distributions, citation performance, and dominant research keywords.

Search Strategy

The review was conducted in accordance with the modified Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework to ensure transparency, procedural rigour, and replicability. The initial database search was performed in Scopus using the query: TITLE-ABS-KEY ("artificial intelligence" AND "cooperative learning"), with filtering parameters applied to restrict results to the Social Sciences and Computer Science subject areas. This search yielded 183 records, forming the preliminary corpus for screening (see Fig. 2).

During the identification phase, 32 records were automatically excluded due to subject-area misalignment, as they were not classified under Social Sciences or Computer Science. No duplicate records were detected. Following this automated filtering process, 151 records proceeded to the screening stage.

At the screening stage, document-type refinement resulted in the exclusion of 96 records, as these were not classified as peer-reviewed journal articles (e.g., editorials, notes, or other non-article formats). The remaining 55 reports were subsequently sought for full-text retrieval. However, 38 reports could not be accessed due to open-access limitations, despite being initially identified within the database search parameters. Consequently, 17 full-text reports were retrieved and assessed for eligibility.

During the eligibility assessment, six articles were excluded based on refined inclusion criteria. Specifically, one publication was not written in English, and five articles were deemed irrelevant to the study’s focus on AI-supported cooperative learning, as they did not substantively engage with cooperative learning frameworks. After applying all exclusion criteria, nine studies were retained for inclusion in the final review.

The final corpus of nine publications constitutes the dataset used for bibliometric, source-level, and thematic analyses in this study. By implementing a structured, multi-stage screening process consistent with PRISMA guidelines, the review ensures methodological transparency and conceptual alignment with the research objective of examining artificial intelligence applications within cooperative learning environments.

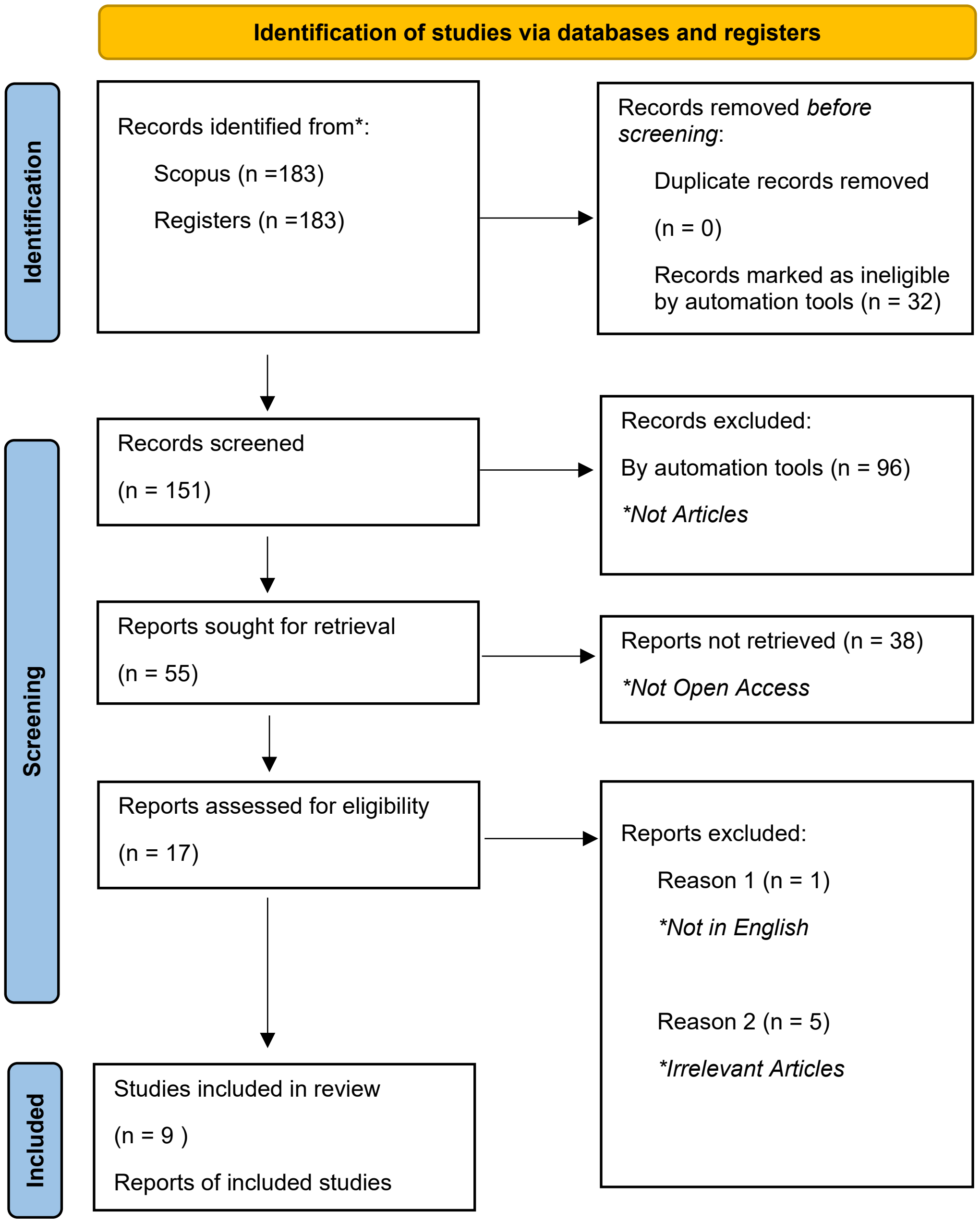

Fig. 2. Flow diagram of the search strategy (Page et al., 2021).

Data Cleaning and Harmonisation

Data cleaning and harmonisation constituted a critical methodological stage in this bibliometric study, ensuring the accuracy, consistency, and transparency of the final analytical dataset. Following the identification phase, a total of 183 records were retrieved from the Scopus database based on predefined search terms related to artificial intelligence and cooperative learning. Initial automated screening resulted in the exclusion of 32 records that were classified as ineligible, primarily because they did not fall within the Social Sciences and Computer Science subject categories. As no duplicate records were detected, all remaining entries proceeded to the screening stage.

During title and document-type screening, 151 records were examined, leading to the exclusion of 96 records that did not meet the inclusion criteria, particularly those that were not journal articles. Subsequently, 55 records were sought for retrieval. Of these, 38 articles could not be accessed due to open-access limitations. The remaining 17 full-text articles were assessed for eligibility, resulting in the exclusion of six studies, including one non-English publication and five articles that were not substantively aligned with the focus on AI-supported cooperative learning. Ultimately, nine studies met all inclusion criteria and were retained for bibliometric analysis.

To support systematic data cleaning and metadata harmonisation across the included studies, the dataset was processed using OpenRefine in combination with biblioMagika® (Ahmi, 2023). OpenRefine was employed to standardise bibliographic metadata such as author names, source titles, and keywords, thereby reducing inconsistencies arising from variations in naming conventions and indexing practices. The clustering and reconciliation functions were particularly useful in ensuring uniform representation of cooperative learning constructs and AI-related terminologies across records. All refinements were conducted on Scopus records exported in CSV format to maintain transparency and traceability throughout the data preparation process.

Following harmonisation, biblioMagika® was utilised to generate core bibliometric descriptors, including Total Publications (TP), Number of Contributing Authors (NCA), Number of Cited Publications (NCP), and productivity-based indicators such as authors per publication. Given the recency of the included studies, citation-based metrics were retained at zero to avoid premature interpretation of scholarly impact. Impact indices, including the h-index, g-index, and m-index, were computed using publication-based criteria and citable years to ensure methodological consistency. Collectively, these procedures ensured that the final dataset was methodologically robust and appropriately scoped, providing a reliable foundation for analysing publication patterns, source activity, and the structural development of research on artificial intelligence–supported cooperative learning.

Data Analysis

The data analysis was structured to address the research questions guiding this bibliometric study on artificial intelligence in cooperative learning. The analytical approach mapped the research landscape by examining publication characteristics, annual trends, leading authors, institutional and country contributions, source influence, and citation performance. A range of bibliometric indicators—including total publications, total citations, citations per publication, h-index, g-index, and m-index—was applied to assess scholarly impact and intellectual consolidation within the field. In addition, keyword co-occurrence analysis using VOSviewer was conducted to identify dominant themes and conceptual linkages shaping AI-supported cooperative learning research. This integrated analytical framework provides a systematic overview of publication growth, citation dynamics, and the evolving intellectual structure of the domain.

Tools

The study employed a range of specialised tools to ensure a rigorous bibliometric analysis, with each tool selected for its role in enhancing data accuracy and interpretability. Microsoft Excel was used for initial data cleaning and organisation, allowing efficient sorting and structuring of Scopus data. biblioMagika® standardised metadata, resolving inconsistencies in author names, institutional affiliations, and country attributions. OpenRefine was utilised to harmonise authors' keywords, ensuring uniformity in co-occurrence analysis. VOSviewer facilitated the visualisation of bibliometric networks, mapping keyword trends, author collaborations, and citation relationships.

Results

In the subsequent results section, the analysis presents a comprehensive overview of the current state of research on artificial intelligence in cooperative learning. Each component of the results is organised to directly address the research questions, providing an evidence-based account of publication trends, citation patterns, source influence, and thematic structures within the domain. Through this systematic examination, the study clarifies how AI technologies are being conceptualised and integrated within cooperative pedagogical frameworks, particularly in supporting collaborative interaction, group regulation, and structured knowledge construction. The resulting synthesis offers valuable insights for researchers, educators, and policymakers seeking to understand and advance AI-supported cooperative learning in increasingly technology-mediated educational environments.

Current State of Research

To address the first research question (RQ1), which examines the structural development and scholarly influence of research within the domain of artificial intelligence–supported cooperative learning, bibliometric indicators generated through biblioMagika® were analysed to capture the field's intellectual profile over the period 2021 to 2025. Although the corpus remains modest in size, the citation-based metrics provide meaningful insights into research productivity, collaborative structures, and the extent to which the literature has begun to exert scholarly influence.

Within the five-year span, the dataset comprises nine publications, reflecting a focused but developing body of research. These publications involve 37 contributing authors, resulting in an average of 4.11 authors per paper, which indicates a relatively high level of collaboration. Such authorship patterns are typical of interdisciplinary research areas where expertise from artificial intelligence, educational technology, and pedagogical theory converges to address complex learning designs. All publications are categorised as citable documents, demonstrating formal recognition within indexed scholarly outlets despite the field's emerging status.

In contrast to earlier exploratory phases, the corpus has accumulated a substantial level of citation activity, recording 219 total citations during the analysis period. This corresponds to an average of 24.33 citations per paper and 24.33 citations per cited paper, indicating that the included studies have achieved notable visibility and uptake within the academic community. The annual citation rate of 54.75 citations per year further suggests sustained scholarly engagement and an accelerating diffusion of knowledge related to AI-supported cooperative learning approaches.

Authorship-based indicators reinforce this pattern of emerging influence. The average of 5.92 citations per author reflects a moderate dispersion of impact across contributors, while the citation sum within the h-core (217 citations) highlights the presence of a concentrated group of influential publications anchoring the field's development. These findings suggest that, although the literature base is still relatively small, several studies have already attained a central role in shaping subsequent research.

The evaluative indices provide additional evidence of scholarly consolidation. The h-index of 5 indicates that a subset of publications has achieved consistent citation performance, while the g-index of 9 reflects the strong citation pull of the most influential works. When normalised by time, the m-index of 0.833 signals steady annual growth in scholarly impact, which is notable given the short temporal window of analysis. Together, these indices suggest that the field has progressed beyond a purely emergent phase and is moving toward early consolidation.

Collectively, the citation metrics presented in Table 2 position research on AI-supported cooperative learning at an early-to-intermediate stage of intellectual development, characterised by (i) a focused yet influential publication base, (ii) strong collaborative authorship patterns, and (iii) a rapidly accumulating citation profile. While the field has not yet reached large-scale maturity, the observed indicators demonstrate that foundational studies have begun to shape scholarly discourse, supporting the conclusion that this domain is gaining increasing academic legitimacy and momentum.

Table 2
Citation Metric

Main Information	Data
Publication Years	2021 - 2025
Total Publications	9
Citable Year	6
Number of Contributing Authors	37
Number of Cited Papers	9
Total Citations	219
Citation per Paper	24.33
Citation per Cited Paper	24.33
Citation per Year	54.75
Citation per Author	5.92
Author per Paper	4.11
Citation sum within h-Core	217
h-index	5
g-index	9
m-index	0.833

Source: Generated by the author(s) using biblioMagika® (Ahmi, 2024)

Publication Trends

To address the second research question (RQ2), the temporal evolution of research activity and scholarly influence in AI-supported cooperative learning was examined through annual publication and citation patterns from 2021 to 2025, as presented in Fig. 3 and Table 3. Beyond descriptive growth trends, this analysis offers insight into the pace, intensity, and structural consolidation of the field over time.

The publication trajectory reveals a staged developmental pattern rather than simple linear growth. The field commenced with two publications in 2021, followed by one publication in both 2022 and 2023, signalling an exploratory phase characterised by conceptual positioning and early empirical experimentation. Notably, citation performance during this foundational period was disproportionately strong. The 2021 publications accumulated 57 citations (C/P = 28.50), while the single 2022 study attracted 54 citations (C/P = 54.00), representing the highest citation density across the dataset. Such early citation concentration suggests that foundational contributions achieved rapid intellectual visibility and may have established conceptual anchors for subsequent research.

A structural shift becomes evident in 2024, where publication output increased to two studies and total citations peaked at 90 (C/P = 45.00). This inflection point indicates intensified scholarly uptake and suggests that research on AI-supported cooperative learning began transitioning from isolated contributions toward broader academic diffusion. The convergence of increased output and heightened citation velocity reflects early-stage consolidation, wherein emerging research themes gain recognition within adjacent educational and technological discourses.

In 2025, publication productivity reached its highest level with three outputs; however, citation accumulation declined to 14 citations (C/P = 4.67). This apparent reduction should be interpreted within the context of citation latency, as recently published works have had limited exposure time. Rather than signalling diminished impact, the 2025 pattern likely represents an expansion phase in which production outpaces immediate citation consolidation.

Impact indices corroborate this developmental interpretation. The cumulative h-index of 5 and g-index of 9 indicate that several publications have achieved sustained citation performance, while the progressive increase in the m-index from 0.333 (2021) to 1.000 (2025) reflects accelerating annualised influence. Importantly, the concentration of 217 citations within the h-core underscores the presence of influential studies that disproportionately structure the field's emerging intellectual landscape.

Cumulatively, the corpus of nine publications generated 219 citations, yielding an overall citation average of 24.33 per paper—an indicator of strong scholarly traction relative to the field's size. The temporal pattern suggests a trajectory moving from foundational articulation (2021–2022), through transitional consolidation (2024), toward expansion and diversification (2025). This progression aligns with bibliometric models of emerging educational technology domains, where rapid citation accumulation in early anchor studies precedes broader publication growth.

Taken together, the evidence positions AI-supported cooperative learning research within an early consolidation phase marked by concentrated intellectual influence and increasing productivity. While the publication base remains compact, the intensity of citation engagement indicates that the domain has surpassed mere exploratory status and is beginning to establish a recognisable and influential scholarly footprint.

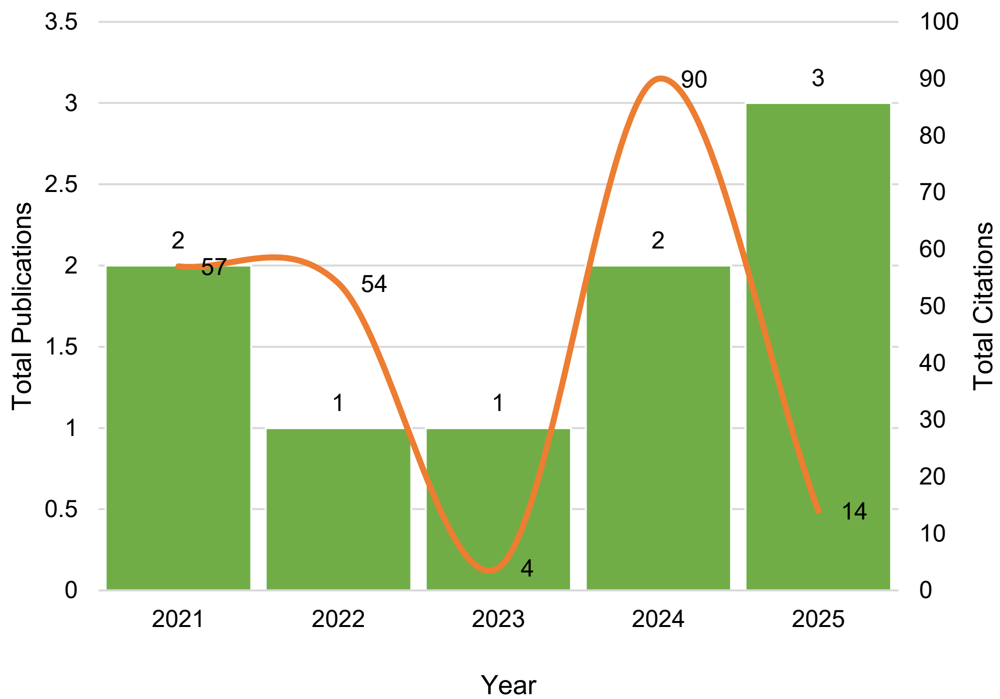

Fig. 3. Total publications and citations by year

Table 3
Publication by year

Year	TP	NCA	NCP	TC	C/P	C/CP	h	g	m
2021	2	10	2	57	28.50	28.50	2	2	0.333
2022	1	6	1	54	54.00	54.00	1	1	0.200
2023	1	1	1	4	4.00	4.00	1	1	0.250
2024	2	15	2	90	45.00	45.00	2	2	0.667
2025	3	5	3	14	4.67	4.67	2	3	1.000
Total	9	37	9	219	24.33	24.33	5	9	0.833

Notes: TP = total number of publications; NCA = number of contributing authors; NCP = number of cited publications; TC = total citations; C/P = average citations per publication; C/CP = average citations per cited publication; h = h-index; g = g-index; m = m-index.

Publications by Source Titles

Figure 4 and Table 4 present the distribution of publication output and citation performance across the source titles contributing to research on AI-supported cooperative learning. Unlike fields dominated by a small cluster of core journals, the present dataset reveals a structurally dispersed publication landscape in which each of the nine identified journals contributed a single publication. While this pattern reflects limited concentration of output, it simultaneously underscores the interdisciplinary diffusion of the research topic across educational technology, engineering education, computer science, and applied AI venues.

Despite equivalent publication counts, citation impact varies substantially across source titles, indicating uneven scholarly influence. Computers and Education Open records the highest citation volume with 88 citations (C/P = 88.00), representing a disproportionately large share of the total citation pool. This suggests that research disseminated through this venue achieved strong academic visibility and may have functioned as an intellectual anchor within the emerging field. Similarly, Journal of Engineering Education accumulated 54 citations (C/P = 54.00), while Computers and Education: Artificial Intelligence generated 51 citations (C/P = 51.00), further signalling that journals positioned at the intersection of pedagogy and AI innovation serve as key conduits for influential scholarship.

In contrast, other source titles—including IEEE Access, International Journal of Interactive Mobile Technologies, and International Journal on Advanced Science, Engineering and Information Technology—exhibit comparatively modest citation counts ranging between two and three citations. Although these figures are lower, they nonetheless indicate initial uptake within their respective disciplinary communities. The presence of citations across nearly all outlets demonstrates that the research is not isolated but is being recognised across multiple academic ecosystems.

Source-level impact indices further reinforce this differentiated influence structure. While each journal records an h-index of 1 due to single-publication contributions, variations in the m-index reflect differing citation velocities relative to publication age. Journals such as IEEE Access, Education Sciences, and International Journal of Interactive Mobile Technologies display m-index values of 0.500, suggesting steady annualised citation accrual. In contrast, journals with higher citation concentration exhibit lower m-index values due to publication recency effects, indicating that citation momentum is still stabilising.

Collectively, the patterns presented in Fig. 4 and Table 4 depict a field characterised by intellectual dispersion combined with selective citation concentration. Although no single journal dominates publication output, influence is unevenly distributed, with a small subset of outlets contributing the majority of citation impact. This structure is characteristic of early consolidating domains, where influential studies are embedded within established interdisciplinary journals rather than clustered within a dedicated niche outlet.

Taken together, the evidence suggests that AI-supported cooperative learning research is achieving visibility across diverse academic venues while simultaneously beginning to generate concentrated scholarly impact in strategically positioned journals. The distributed yet citation-active landscape reflects a domain transitioning from exploratory expansion toward structured intellectual consolidation within the broader educational technology ecosystem.

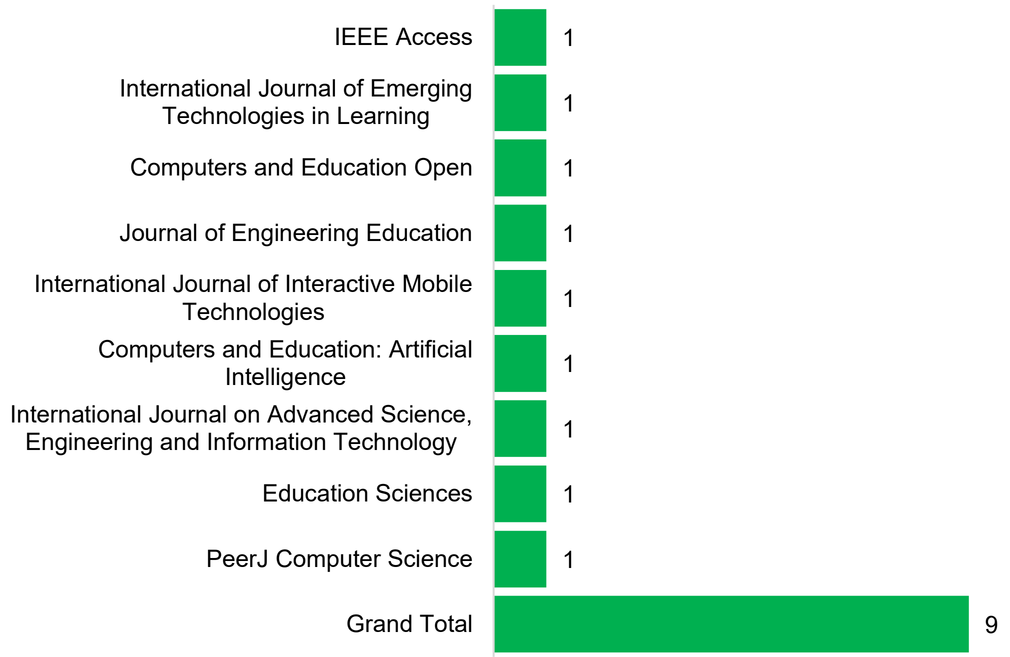

Fig. 4. The Most Productive Source Titles

Table 4
The Most Active Source Titles

Source Title	TP	NCA	NCP	TC	C/P	C/CP	h	g	m
IEEE Access	1	1	1	2	2.00	2.00	1	1	0.500
International Journal of Emerging Technologies in Learning	1	1	1	4	4.00	4.00	1	1	0.250
Computers and Education Open	1	12	1	88	88.00	88.00	1	1	0.333
Journal of Engineering Education	1	6	1	54	54.00	54.00	1	1	0.200
International Journal of Interactive Mobile Technologies	1	3	1	3	3.00	3.00	1	1	0.500
Computers and Education: Artificial Intelligence	1	5	1	51	51.00	51.00	1	1	0.167
International Journal on Advanced Science, Engineering and Information Technology	1	3	1	2	2.00	2.00	1	1	0.333
Education Sciences	1	1	1	9	9.00	9.00	1	1	0.500
PeerJ Computer Science	1	5	1	6	6.00	6.00	1	1	0.167
Grand Total	9	37	9	219	24.33	24.33	9	9	

Note: TP=total number of publications; NCA=number of contributing authors; NCP=number of cited publications; TC=total citations; C/P=average citations per publication; C/CP=average citations per cited publication; h=h-index; g=g-index; m=m-index.

Highly cited Documents

Table 5 identifies the most highly cited publications within the dataset, thereby revealing the studies that have exerted disproportionate influence on the intellectual formation of research in AI-supported cooperative learning. Rather than merely indicating popularity, citation concentration provides insight into the conceptual anchors and methodological trajectories that are shaping the domain's emerging research agenda.

The leading publication, authored by Tzirides et al. (2024) and published in Computers and Education Open, accounts for the highest citation share (88 citations). Its prominence signals strong scholarly interest in AI literacy and human–AI collaboration as foundational dimensions of AI integration in education. By positioning AI not only as a tool but as a pedagogical co-agent within instructional design, the study contributes to a broader reconceptualisation of digital competence and collaborative knowledge construction in higher education.

Similarly, Magana et al. (2022) and Hsu et al. (2021), with 54 and 51 citations respectively, reinforce the centrality of structured collaboration, instructional scaffolding, and AI-enabled learning environments. Their citation performance suggests that research at the intersection of cooperative learning frameworks and AI-enhanced instructional systems resonates strongly across disciplinary boundaries. Notably, these influential studies do not isolate AI as a purely technical intervention; instead, they embed it within pedagogical processes, learner interaction dynamics, and institutional transformation.

A second tier of cited works—including studies published in Education Sciences, PeerJ Computer Science, and International Journal of Emerging Technologies in Learning—reflects the interdisciplinary diffusion of AI-supported educational research. Although citation counts are comparatively lower, these contributions expand the discourse into areas such as algorithmic development, online interaction modalities, smart classroom design, and generative AI implementation in applied learning contexts. The breadth of journals represented underscores the field's permeability across educational technology, engineering education, computer science, and digital pedagogy.

Importantly, the distribution of citations reveals a pattern of selective concentration rather than uniform dispersion. A small number of publications account for a substantial proportion of total citations, indicating the emergence of intellectual focal points within a still-compact literature base. This structure is characteristic of early consolidating domains, where foundational works rapidly accumulate influence and begin to stabilise theoretical and methodological orientations.

Taken together, the citation hierarchy illustrated in Table 5 suggests that AI-supported cooperative learning research is coalescing around several thematic pillars: AI literacy development, structured collaborative learning design, AI-mediated instructional systems, and the pedagogical implications of generative technologies. The presence of highly cited anchor studies indicates that the field has moved beyond exploratory experimentation and is entering a phase of conceptual consolidation. While the overall corpus remains limited in scale, the intensity of citation engagement reflects increasing scholarly legitimacy and a maturing research trajectory within the broader educational technology landscape.

Table 5
Highly cited articles

No.	Author(s)	Title	Source Title	TC
1	Tzirides, A.O.O.; Zapata, G.; Kastania, N.P.; Saini, A.K.; Castro, V.; Ismael, S.A.; You, Y.-L.; Santos, T.A.D.; Searsmith, D.; O'Brien, C.; Cope, B.; Kalantzis, M. (2024)	Combining human and artificial intelligence for enhanced AI literacy in higher education	Computers and Education Open	88
2	Magana, A.J.; Karabiyik, T.; Thomas, P.; Jaiswal, A.; Perera, V.; Dworkin, J. (2022)	Teamwork facilitation and conflict resolution training in a HyFlex course during the COVID-19 pandemic	Journal of Engineering Education	54
3	Hsu, T.-C.; Abelson, H.; Lao, N.; Tseng, Y.-H.; Lin, Y.-T. (2021)	Behavioral-pattern exploration and development of an instructional tool for young children to learn AI	Computers and Education: Artificial Intelligence	51
4	Cabanillas-García, J.L. (2025)	The Application of Active Methodologies in Spain: An Investigation of Teachers' Use, Perceived Student Acceptance, Attitude, and Training Needs Across Various Educational Levels	Education Sciences	9
5	Kim, T.; Vecchietti, L.F.; Choi, K.; Sariel, S.; Har, D. (2021)	Two-stage training algorithm for AI robot soccer	PeerJ Computer Science	6
6	Wang, P. (2023)	Effects of Different Educational Interaction Modes on Students' Independent Online Learning Ability	International Journal of Emerging Technologies in Learning	4
7	Rattanakha, R.; Chatwattana, P.; Piriyasurawong, P. (2025)	AI-Powered Smart Classrooms for C-PBL: Enhancing Mobile and Virtual Learning Technologies	International Journal of Interactive Mobile Technologies	3
8	Kim, H.A. (2025)	A Case Study on SAL-Based Teaching and Learning in a Functional Clothing and Materials Course Using Generative AI	IEEE Access	2
9	Seo, S.H.; Kim, M.Y.; Kim, Y. (2024)	A Design and Implementation of an Online Video Lecture System based on Facial Expression Recognition	International Journal on Advanced Science, Engineering and Information Technology	2

Notes: TC = Total Citations: C/Y = Average Citations By Year

Co-occurrence Analysis

To address the final research question (RQ6), which explores the key themes shaping the development of artificial intelligence in cooperative learning, a keyword co-occurrence analysis was conducted using author-supplied terms. Figure 6 presents the resulting network visualised through VOSviewer, illustrating the conceptual structure of the field and the relationships among frequently used keywords. The network highlights several thematic clusters that together represent the dominant research orientations within AI-supported cooperative learning scholarship.

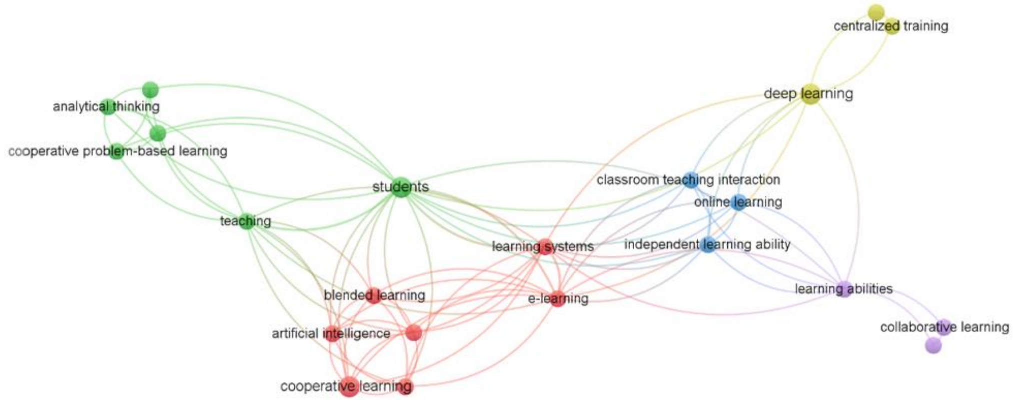

Fig. 6. Co-occurrence network of the author's keywords with at least two occurrences.

The green cluster connects keywords such as students, teaching, analytical thinking, and cooperative problem-based learning, reflecting a strong pedagogical emphasis on higher-order cognition and structured group problem-solving. The red cluster centres on artificial intelligence, cooperative learning, e-learning, and blended learning, indicating that AI is primarily conceptualised within digitally mediated collaborative environments. The blue cluster, comprising terms such as classroom teaching interaction, independent learning ability, and learning systems, highlights attention to instructional processes and learner development within AI-supported settings. Meanwhile, the yellow cluster links deep learning and centralized training, signalling the technical and algorithmic foundations underlying AI deployment in education.

Overall, the network reveals a balanced integration of technological innovation and cooperative pedagogy. Rather than being dominated by purely computational terminology, the field is structured around the interplay between AI systems, collaborative learning design, and learner-centred development, indicating early thematic consolidation within this emerging research domain.

Discussion

Through a bibliometric examination of research on artificial intelligence–supported cooperative learning, this study reveals a compact yet intellectually influential body of scholarship that is progressing toward early consolidation. Although the publication base remains limited, citation concentration within a small subset of studies indicates the emergence of intellectual anchors stabilising theoretical and methodological orientations in the domain. Such citation asymmetry is characteristic of emerging research areas undergoing structured diffusion, where foundational works disproportionately shape subsequent discourse (Donthu et al., 2021). Rather than reflecting fragmented exploratory activity, the observed citation patterns suggest growing academic visibility and conceptual alignment within educational technology scholarship.

Temporal trends further reinforce this interpretation. Early foundational publications attracted substantial citation uptake, signalling rapid conceptual resonance within the broader AI-in-education community. As highlighted in prior reviews of AI in higher education (Zawacki-Richter et al., 2019), emerging domains often exhibit early citation concentration before broader publication expansion. The distributed journal landscape observed in this study reflects interdisciplinary permeability, with AI-supported cooperative learning research embedded across education, engineering, and digital learning venues. This diffusion pattern aligns with bibliometric models of thematic expansion in technology-enhanced learning fields.

The keyword co-occurrence network further clarifies the field's conceptual architecture. The centrality of artificial intelligence, students, and cooperative learning suggests that AI is framed as an enabling infrastructure within collaborative pedagogical systems rather than as a standalone technical solution. The coexistence of pedagogical constructs; analytical thinking, classroom interaction, alongside system-oriented terminology; deep learning reflects a synthesis between instructional theory and technological innovation. This integration corresponds with broader arguments that AI in education should augment, rather than replace, human-centred pedagogy (Luckin et al., 2016; Holmes et al., 2022). Collectively, the findings position AI-supported cooperative learning within an early consolidation phase marked by increasing structural coherence and theoretical integration.

Conclusion

This study provides a structured bibliometric overview of research on artificial intelligence in cooperative learning, revealing a domain that is progressively gaining scholarly attention despite its relatively modest publication base. Patterns of productivity and citation suggest increasing academic engagement and early intellectual consolidation, consistent with developmental trajectories observed in emerging digital learning fields. The interdisciplinary distribution of contributing journals indicates that AI-supported cooperative learning is embedded across diverse scholarly conversations rather than restricted to a single niche. Conceptually, the findings demonstrate a growing alignment between AI technologies and collaborative pedagogical frameworks, reinforcing the integration of technological systems within learner-centred and interaction-driven instructional models. Such developments resonate with broader calls for human-centred and pedagogically grounded AI adoption in education (Holmes & Tuomi, 2022). Sustained theoretical refinement and context-sensitive implementation will be critical to ensuring that AI-supported cooperative learning enhances both collaborative processes and overall educational quality.

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References

Chen, X., Xie, H., Zou, D., & Hwang, G.-J. (2020). Application and theory gaps during the rise of artificial intelligence in education. *Computers and Education: Artificial Intelligence*, *1*, 100002. https://doi.org/10.1016/j.caeai.2020.100002

Crompton, H., & Burke, D. (2023). Artificial intelligence in higher education: the state of the field. *International Journal of Educational Technology in Higher Education*, *20*(1). https://doi.org/10.1186/s41239-023-00392-8

Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., & Lim, W. M. (2021). How to conduct a bibliometric analysis: An overview and guidelines. *Journal of Business Research*, *133*, 285–296. https://doi.org/10.1016/j.jbusres.2021.04.070

Durak, G., Çankaya, S., Özdemir, D., & Can, S. (2024). Artificial Intelligence in Education: A Bibliometric Study on Its Role in Transforming Teaching and Learning. In *International Review of Research in Open and Distributed Learning* (Vol. 25).

Edwards, J., Nguyen, A., Lämsä, J., Sobocinski, M., Whitehead, R., Dang, B., Roberts, A. S., & Järvelä, S. (2025). Human-AI collaboration: Designing artificial agents to facilitate socially shared regulation among learners. *British Journal of Educational Technology*, *56*(2), 712–733. https://doi.org/10.1111/bjet.13534

European Commission. (2019). *Ethics guidelines for trustworthy AI | Shaping Europe's digital future*. https://digital-strategy.ec.europa.eu/en/library/ethics-guidelines-trustworthy-ai

Garzón, J., Patiño, E., & Marulanda, C. (2025). Systematic Review of Artificial Intelligence in Education: Trends, Benefits, and Challenges. *Multimodal Technologies and Interaction*, *9*(8), 84. https://doi.org/10.3390/mti9080084

Holmes, W., & Tuomi, I. (2022). State of the art and practice in AI in education. *European Journal of Education*, *57*(4), 542–570. https://doi.org/10.1111/ejed.12533

Johnson, D. W., & Johnson, R. T. (2009). An educational psychology success story: Social interdependence theory and cooperative learning. *Educational Researcher*, *38*(5), 365–379. https://doi.org/10.3102/0013189X09339057

Johnson, D. W., Johnson, R. T., Johnson, D. W., & Johnson, R. T. (2018). Cooperative Learning: The Foundation for Active Learning. *Active Learning - Beyond the Future*. https://doi.org/10.5772/intechopen.81086

Kasneci, E., Sessler, K., Küchemann, S., Bannert, M., Dementieva, D., Fischer, F., & Kasneci, G. (2023). ChatGPT for good? On opportunities and challenges of large language models for education. *Learning and Individual Differences*, *103*, 102274. https://doi.org/10.1016/j.lindif.2023.102274

Kovanović, V., Joksimović, S., & Siemens, G. (2021). Learning analytics for collaborative learning: Current directions and future challenges. *Educational Technology & Society*, *24*(4), 1–13.

Kovari, A. (2025). A systematic review of AI-powered collaborative learning in higher education: Trends and outcomes from the last decade. *Social Sciences & Humanities Open*, *11*(1), 101335. https://doi.org/10.1016/j.ssaho.2025.101335

Miao, F., & Holmes, W. (2023). *Guidance for generative AI in education and research | UNESCO*. https://www.unesco.org/en/articles/guidance-generative-ai-education-and-research

Page, M. J., Moher, D., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., Mcdonald, S., …

Mckenzie, J. E. (2021). PRISMA 2020 explanation and elaboration: Updated guidance and exemplars for reporting systematic reviews. *The BMJ*, *372*. https://doi.org/10.1136/bmj.n160

Slavin, R. E. (2014). Cooperative learning and academic achievement: Why does groupwork work? *School Psychology International*, *35*(1), 5–21. https://doi.org/10.1177/0143034313496469

Tan, S. C., Lee, A. V. Y., & Lee, M. (2022). A systematic review of artificial intelligence techniques for collaborative learning over the past two decades. In *Computers and Education: Artificial Intelligence* (Vol. 3). Elsevier B.V. https://doi.org/10.1016/j.caeai.2022.100097

Zawacki-Richter, O., Marín, V. I., Bond, M., & Gouverneur, F. (2019). Systematic review of research on artificial intelligence applications in higher education. *International Journal of Educational Technology in Higher Education*, *16*, 39. https://doi.org/10.1186/s41239-019-0171-0