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Research Trends and Future Directions in Metacognition, Critical Literacy, and Project-Based Learning in Higher Education: A Bibliometric Analysis

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Abstract. Metacognition, critical literacy, and Project-Based Learning (PjBL) are increasingly important in higher education due to the contribution to higher-order thinking, self-regulated learning, and student-centered learning. Therefore, this research aimed to analyze trends, publication productivity, thematic developments, and gaps through bibliometric analysis. Data were collected from the Scopus database covering publications from 2018 to June 2026. After a systematic screening process, 154 articles were analyzed using VOSviewer. The results showed an increasing publication trend, particularly between 2020–2025, reflecting growing academic interest in metacognitive development and innovative learning approaches. Spain, the United States, and the United Kingdom were the leading contributors, while

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Indonesia and China showed growing participation. Keyword co-occurrence analysis identified metacognition as the most influential concept (TLS = 393), strongly connected to higher education, learning, cognition, psychology, and self-regulated learning. Nine thematic clusters were identified, including learner-centered learning, artificial intelligence, assessment and reflection, project-based learning, learning analytics, and educational innovation. A key result indicates the limited presence of critical literacy within the thematic network despite its inclusion in the search strategy, indicating a significant research gap. Future research should strengthen the integration of critical literacy, metacognition, and PjBL to support the development of critical, reflective, and self-regulated learners in higher education.

Keywords: metacognition; critical literacy; project-based learning; higher education; bibliometric analysis.

1. Introduction

Bibliometric research on metacognition, critical literacy, and project-based learning (PjBL) has become increasingly important in contemporary higher education due to the growing complexity of educational demands in the twenty-first century (Busnawir et al., 2025). These three constructs have been identified as key components of effective pedagogical practice as universities strive to develop graduates with critical thinking, self-regulation, collaboration, and lifelong learning competencies (Adeoye et al., 2024).

Metacognition is understood as learners' awareness, monitoring, and regulation of their own cognitive processes, comprising knowledge of cognition and regulation through planning, monitoring, evaluation, and reflection (Atchley et al., 2024; Cao, 2024; Maryani et al., 2022; Matsumoto-Royo et al., 2022; Radulović et al., 2024; Yildiz Durak & Kamali Arslantaş, 2026). Critical literacy extends beyond basic comprehension by enabling learners to critically analyze information from multiple perspectives while recognizing underlying assumptions, power relations, and ideological influences (Bobrowicz et al., 2022; Hill, 2026; Rüütman, 2019; Shapiro et al., 2026). Meanwhile, project-based learning represents a student-centered approach engaging learners in authentic projects that fosters collaboration, problem-solving, and reflective learning (Cao, 2024; Maryani et al., 2020; Payoungkiattikun et al., 2025; Rüütman, 2019). This research uses PjBL to avoid confusion with problem-based learning. Previous investigations have shown that PjBL is strongly associated with developing critical thinking skills while fostering higher-order thinking (Efendi et al., 2020).

Bibliometric analysis offers a systematic approach for examining scholarly evolution, identifying influential authors, mapping research networks, and uncovering gaps. Recent evidence indicates substantial growth in metacognition research, emphasizing self-regulated learning (Chen et al., 2025). Research on PjBL shows significant growth, particularly within higher education and STEM (Science, Technology, Engineering, and Mathematics) disciplines (Ahmad et al., 2023; Ibrahim, 2025). PjBL has also been consistently associated with critical thinking and metacognitive development through authentic, inquiry-based

experiences (Maryani et al., 2022; Payoungkiattikun et al., 2025; Susanto et al., 2026). Furthermore, global research on PjBL has shown an 800% growth in publications since 2014, with STEM and higher education evolving as frequent areas (Mota et al., 2025).

The three constructs are mutually reinforcing as metacognitive monitoring allows learners to recognize gaps in understanding, motivating critical evaluation of information sources through a cyclical mechanism in which PjBL creates opportunities for both metacognitive regulation and critical judgment. Metacognitive awareness enables learners to regulate processes and become active participants (Bennett et al., 2020; Blaschke & Marín, 2020; Kim et al., 2025). Critical literacy fosters questioning assumptions and making informed judgments (Alawad et al., 2026; Bobrowicz et al., 2022; Hill, 2026; Shapiro et al., 2026), while PjBL provides an authentic environment where these competencies develop simultaneously (Cao, 2024; Payoungkiattikun et al., 2025; Rüütman, 2019).

Integrating PjBL enhances students' critical thinking, metacognitive regulation, and collaborative skills (Payoungkiattikun et al., 2025; Susanto et al., 2026). Research trends indicate increasing focus on technology-assisted learning and digital tools in fostering collaboration (Hikmah et al., 2025), and bibliometric methods help identify underexplored areas, including limited longitudinal studies (Ibrahim, 2025).

Research inquiries. This research addressed four questions, including (1) publication trends and productivity in the domain of metacognition, critical literacy, and PjBL in higher education, (2) distribution of publications across countries, (3) thematic clusters arising from keyword co-occurrence analysis, and (4) research gaps regarding the integration of the three constructs in higher education. Data were collected from Scopus (2018–June 2026) and analyzed using VOSviewer for bibliometric mapping (Chen et al., 2025; Susanto et al., 2026).

2. Literature Review

2.1 Metacognition in Higher Education

Metacognition refers to learners' awareness, monitoring, and regulation of personal cognitive processes, comprising knowledge of cognition and regulation through planning, monitoring, evaluation, and reflection (Atchley et al., 2024; Radulović et al., 2024; Yildiz Durak & Kamali Arslantaş, 2026). In higher education, metacognitive competence is closely linked to self-regulated learning, academic achievement, and adaptation to technology-mediated environments (Larkin, 2023; Railean et al., 2017). Research has shown that metacognitive scaffolding improves academic self-efficacy, while socially shared metacognition has become an important extension in collaborative settings (Valencia-Vallejo et al., 2019; Yildiz Durak & Kamali Arslantaş, 2026).

2.2 Critical Literacy in Higher Education

Critical literacy enables learners to critically analyze and challenge information while recognizing underlying assumptions and power relations (Bobrowicz et al., 2022; Hill, 2026; Shapiro et al., 2026). It is essential for navigating digital

information landscapes and supporting ethical reasoning (Bennett et al., 2020). However, critical literacy remains underdeveloped as an explicit pedagogical target compared to critical thinking or information literacy (Rüütman, 2019).

2.3 Project-Based Learning in Higher Education

Project-based learning (PjBL) is a student-centered approach engaging learners in authentic, inquiry-driven projects that foster collaboration, problem-solving, and reflective learning (Cao, 2024; Maryani et al., 2020; Rüütman, 2019). It is consistently associated with higher-order thinking and metacognitive development (Efendi et al., 2020), as learners plan, monitor, and evaluate throughout the project lifecycle (Maryani et al., 2022; Payoungkiattikun et al., 2025).

2.4 Interconnections Among Constructs

Metacognition, critical literacy, and PjBL are theoretically interdependent. In general, metacognitive awareness enables learners to regulate cognitive processes and evaluate learning strategies (Bennett et al., 2020; Kim et al., 2025), supporting the critical evaluation central to critical literacy (Bobrowicz et al., 2022; Shapiro et al., 2026). PjBL provides an authentic context for exercising both competencies simultaneously (Cao, 2024; Payoungkiattikun et al., 2025). However, empirical research integrating all three constructs remains scarce.

2.5 Bibliometric Approaches

Bibliometric analysis maps research field structures, identifies influential contributors, and uncovers thematic gaps (Mota et al., 2025). Research using VOSviewer has traced the evolution of metacognition and PjBL (Chen et al., 2025; Ibrahim, 2025; Mota et al., 2025), informing curriculum development.

3. Methodology

This research employed a descriptive bibliometric analysis design to systematically investigate scholarly publications related to metacognition, critical literacy, and PjBL in higher education. The adoption of bibliometric methods is consistent with previous investigations, underscoring their effectiveness in mapping the intellectual structure of research fields (Kumar, 2025; Piven & Shvindina, 2024). Data were collected from the Scopus database, selected for its extensive coverage of peer-reviewed literature and high-quality metadata suitable for bibliometric investigations (Ilma & Kuswanto, 2025; Shoustikova et al., 2026). The search strategy focused on publications from 2018 to 2026, with filtering applied based on publication year, subject area, article type, language, and open-access status.

A systematic screening process, consistent with transparent literature selection practices (Chan & Nurrosyidah, 2025), reduced the dataset from 583 initial records to 154 final articles. This involved five sequential stages, first, a publication year restriction (2018–2026) excluded 139 out-of-range records, reducing the dataset to 444 articles. Second, a subject area restriction to Social Sciences, Psychology, and Arts & Humanities excluded 83 records, resulting in 361 articles. Third, article type restriction to articles only excluded 81 records (34 book chapters, 20 reviews,

17 conference papers, 6 books, and 4 notes/editorials/errata), resulting in 280 articles. Fourth, a language restriction to English excluded 29 non-English records (19 Spanish, 4 Portuguese, 2 Russian, 1 Ukrainian, and 3 Serbian/French/Chinese), resulting in 251 articles. Finally, an open access filter excluded 97 subscription-access records, resulting in a final dataset of 154 open-access articles (Gold, Green, Hybrid, and Bronze) eligible for bibliometric analysis. The complete screening procedure is presented in Figure 1.

Data analysis was conducted using VOSviewer, a widely used bibliometric visualization tool for examining scientific networks and thematic structures (Mota et al., 2025). Performance analysis focused on annual publication trends, country productivity, institutional contributions, journal distribution, and author productivity indicators commonly employed to identify major contributors within a research field (Hikmah et al., 2025; Mota et al., 2025). Science mapping techniques examined the conceptual structure of the field through keyword co-occurrence analysis and thematic cluster analysis (Hikmah et al., 2025; Kumar V.M & Kumar J.P, 2023).

Total Link Strength (TLS) was used as an indicator of relationship intensity, enabling the identification of keywords occupying central positions within the research network. Specifically, TLS quantifies the aggregate strength of co-occurrence links between a given keyword and all other keywords with which it is connected, rather than merely reflecting how frequently the keyword appears. A higher TLS value indicates that a keyword occupies a more central and densely interconnected position within the conceptual network. The overall network comprised 124 items, 1,143 links, and a TLS of 1,615, distributed across nine thematic clusters.

The final stage involved research gap identification through interpretation of keyword networks and thematic clusters, extending beyond descriptive mapping toward strategic knowledge synthesis (Fu et al., 2023; Mota et al., 2025). By examining both highly connected and underrepresented keywords, this research identified areas of substantial scholarly attention as well as insufficiently explored topics, providing evidence-based recommendations for future investigations on the integration of metacognition, critical literacy, and project-based learning in higher education. The overall data extraction and screening procedure, from the initial database search to the final selection of articles, is presented in Figure 1.

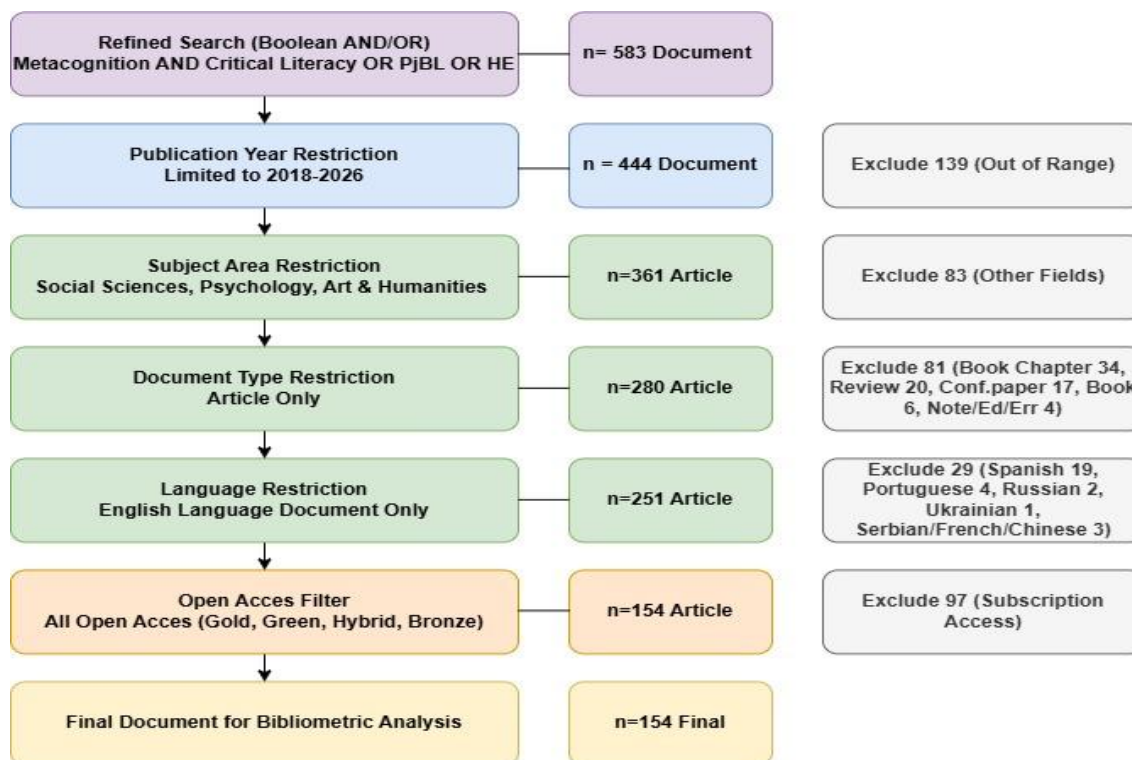


Figure 1: Data Extraction Process of Metadata Collection

4. Results

4.1 Publication Trends and Research Productivity (RQ1)

RQ1: What are the publication trends and research productivity in the domain of metacognition, critical literacy, and project-based learning in higher education (2018–2026)?

Based on data obtained from the Scopus database, research on metacognition, critical literacy, and project-based learning (PjBL) in higher education yielded a total of 154 articles over the observation period. These 154 articles represent publications addressing the intersection of the three constructs within higher education, rather than a simple aggregation of research on each construct independently. A substantially larger body of literature exists on each domain individually, particularly metacognition, which has been the subject of extensive independent bibliometric reviews (Chen et al., 2025).

However, this relatively modest figure underscores the limited extent to which the three constructs have been studied in conjunction. The pattern is further substantiated by the keyword co-occurrence result reported in Section 4.3, where critical literacy fails to emerge as a prominent or well-connected theme, reinforcing the interpretation that combined coverage of all three constructs remains underdeveloped. These results indicate a dynamic development in publication productivity, as shown in Figure 2.

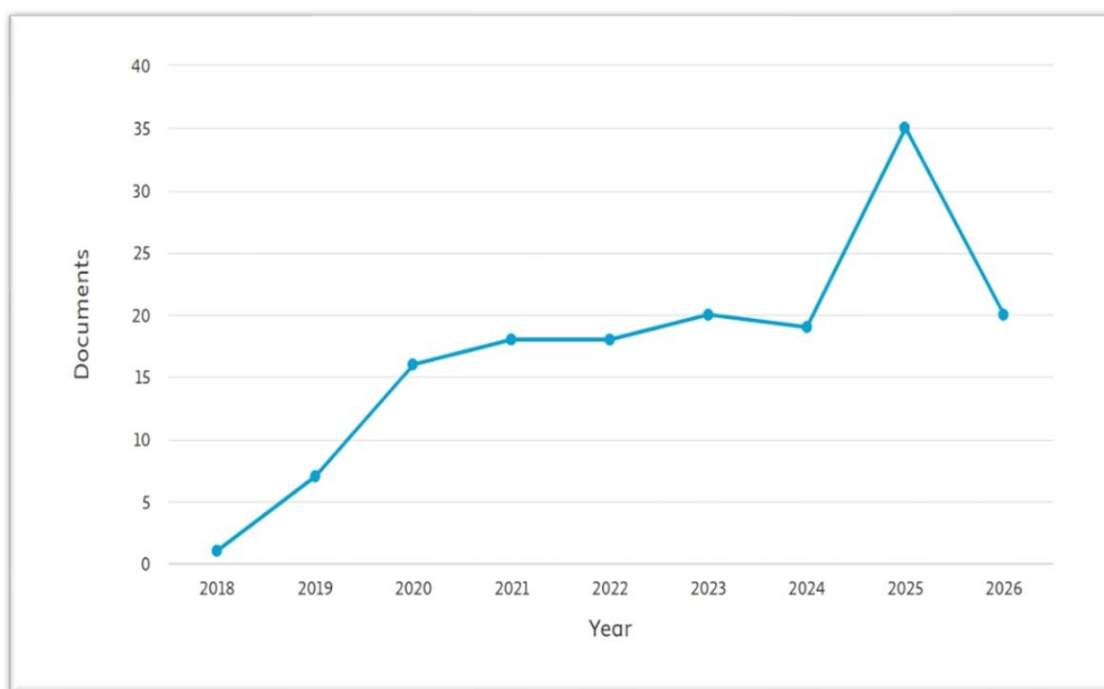


Figure 2: Number of Publications on Metacognition, Critical Literacy, and Project-Based Learning in Higher Education (2018–2026)

As shown in Figure 2, publication trends showed a gradual increase from 2018 to 2020, rising toward more stable growth in subsequent years. From 2020 to 2023, the number of publications increased consistently, reflecting growing academic interest in the integration of the three constructs. In 2024, a slight decline was observed before a significant increase in 2025, with 35 articles, the highest figure in the analysis period. In 2026, the number dropped to 20 articles, although this figure remained provisional as data collection only covered part of the current year. Overall, this pattern indicates that research in the field has experienced fluctuations while still demonstrating a long-term growth trend, reflecting a field actively developing with strong potential for further investigations.

4.2 Distribution of Research Publications Across Countries (RQ2)

RQ2: How are research publications on metacognition, critical literacy, and PjBL in higher education distributed across countries?

4.2.1 Distribution by country

Distribution of publications by country includes Spain 20, United States 14, United Kingdom 13, China 10, Indonesia 10, Netherlands 10, Australia 9, Mexico 9, Malaysia 8, and Finland 7 (Figure 3). Spain was identified as the leading contributor, followed by the United States and the United Kingdom. China, Indonesia, and the Netherlands each produced ten articles, Australia and Mexico contributed nine each, while Malaysia and Finland recorded eight and seven, respectively. These results indicate that European and North American countries are the primary contributors, while Asian countries, particularly Indonesia and China, also demonstrate significant contribution.

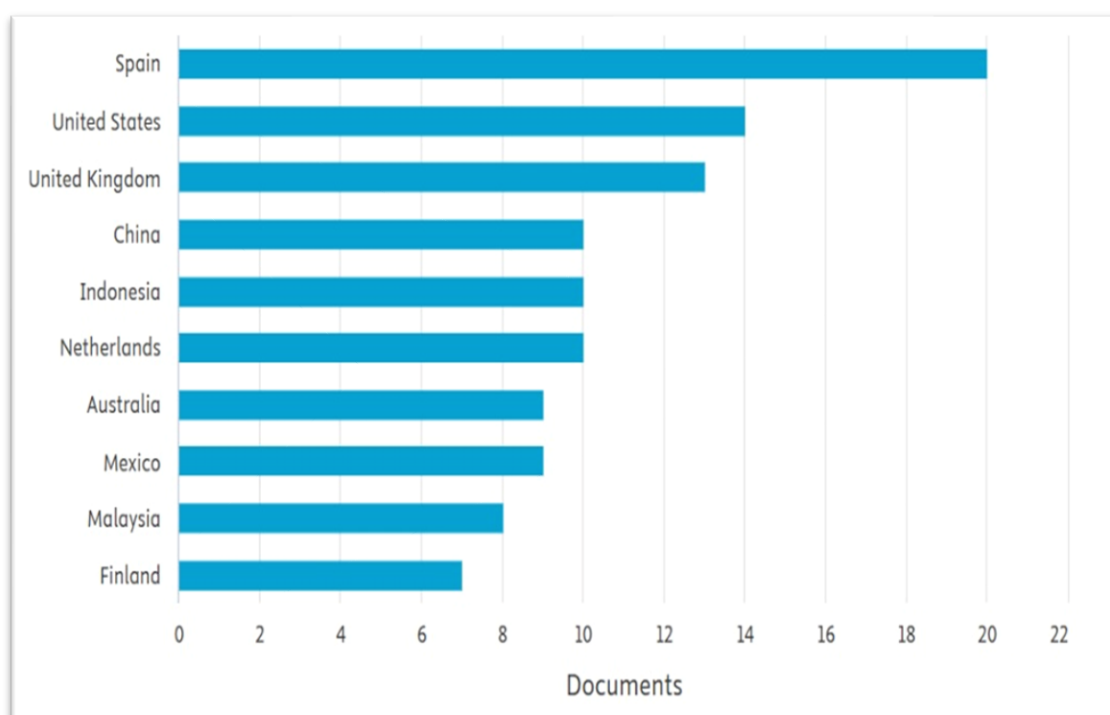


Figure 3: Number of Articles per Country in the Top 10

4.2.2 Network collaboration analysis

Using VOSviewer, the researchers analyzed relationships among countries to support future research design (Figure 4). Spain, the United States, the United Kingdom, Indonesia, and Malaysia demonstrated the highest levels of connectivity, with Spain as the most central node and Indonesia actively connected to multiple partners. The visualization showed several collaborative clusters linked through bridge countries, indicating that research was developed through cross-regional collaboration spanning Europe, Asia, the Americas, and Oceania.

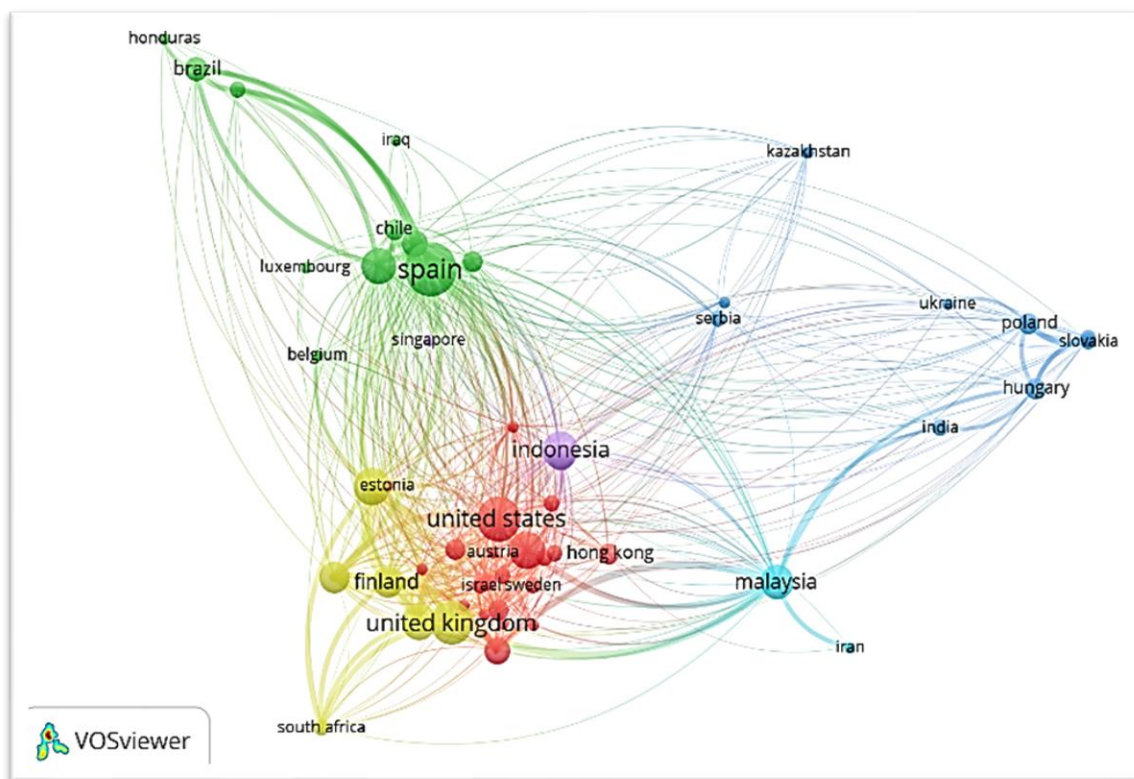


Figure 4: Network Country Visualization

4.2.3 Distribution by institutional affiliation

The most productive publications by institutional affiliation included ten academic institutions from six countries, totaling 29 publications (Figure 5). Oulun Yliopisto (Finland) and Monash University (Australia) were the most productive institutions with four publications each, followed by Tecnológico de Monterrey, Instituto Politécnico Nacional, Universidad Rey Juan Carlos, Universidad de Granada, and the University of Melbourne with three each. Universidad de Murcia, Chalmers University of Technology, and Universiteit van Amsterdam each contributed two. These results indicate that research was not concentrated in any single institution but developed through diverse contributions across Europe, Australia, and Latin America.

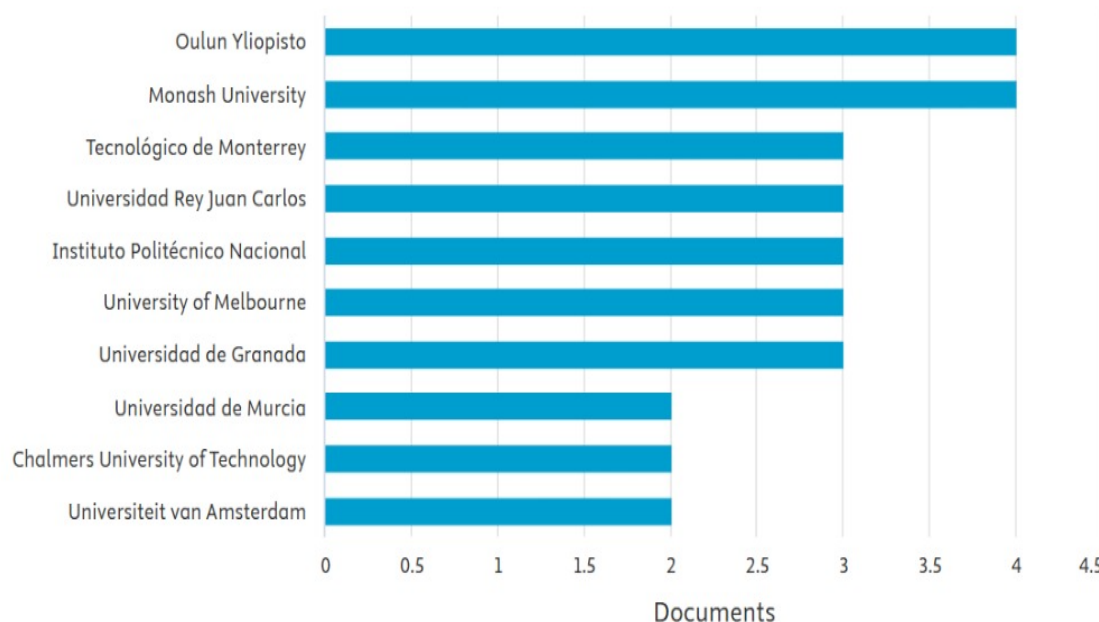


Figure 5: Affiliation Distribution

4.2.4 Distribution by publication sources

Frontiers in Education led with nine articles, followed by Psychology (8), Sustainability (7), Education Sciences (6), Higher Education (5), and Educational Technology Research and Development (4) (Figure 6). Beyond these five, the complete Scopus source list also shows Educational Technology Research and Development with four publications, followed by Higher Education Pedagogies and the International Journal of Evaluation and Research in Education with three publications each. The diversity of publication sources across education, psychology, and educational technology journals confirmed the multidisciplinary relevance of this topic.

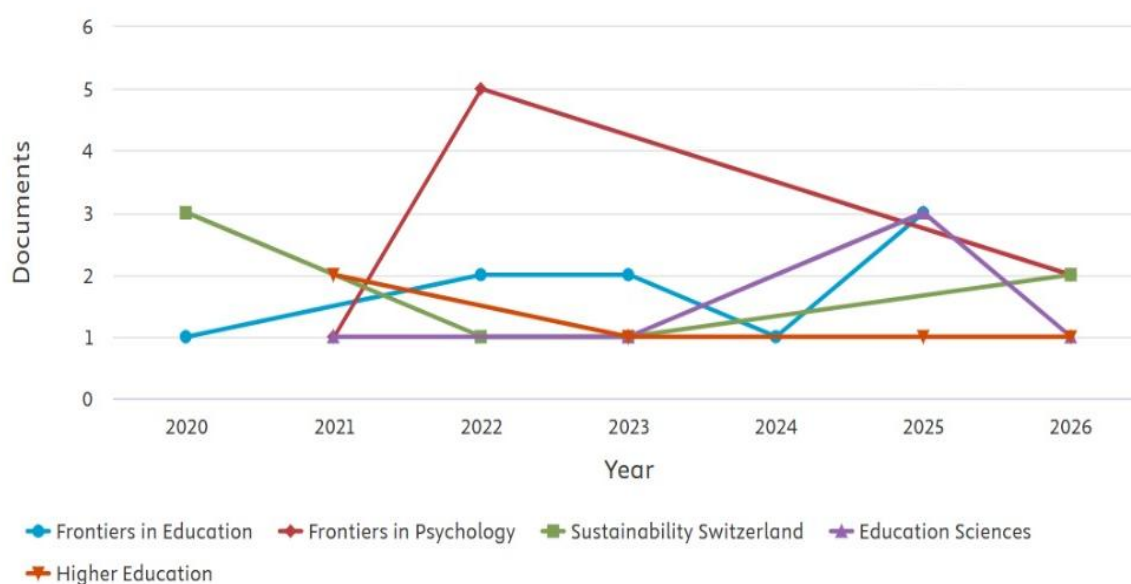


Figure 6: Number of Articles by Sources (Top 5)

4.2.5 Distribution by authors

Acosta-Gonzaga, Järvelä, Marín, and Ortega-Ruipérez were the most productive authors with three publications each, while Anthonysamy, Bannert, Bennett, Dindar, Frankland, and Gašević each contributed two (Figure 7). The relatively even distribution indicated collaborative knowledge development across diverse researchers and institutions.

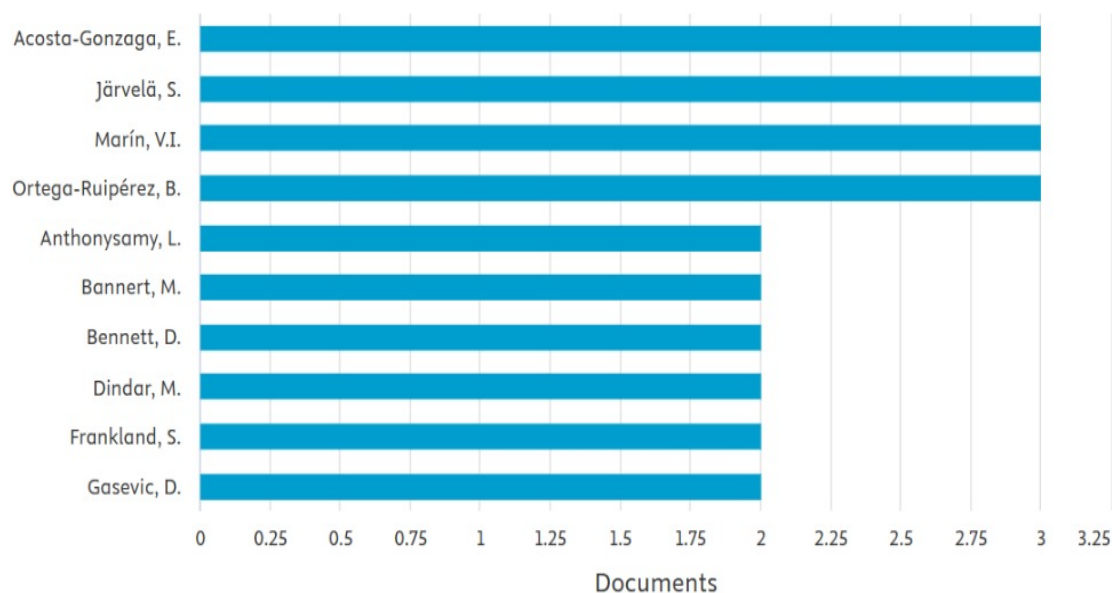
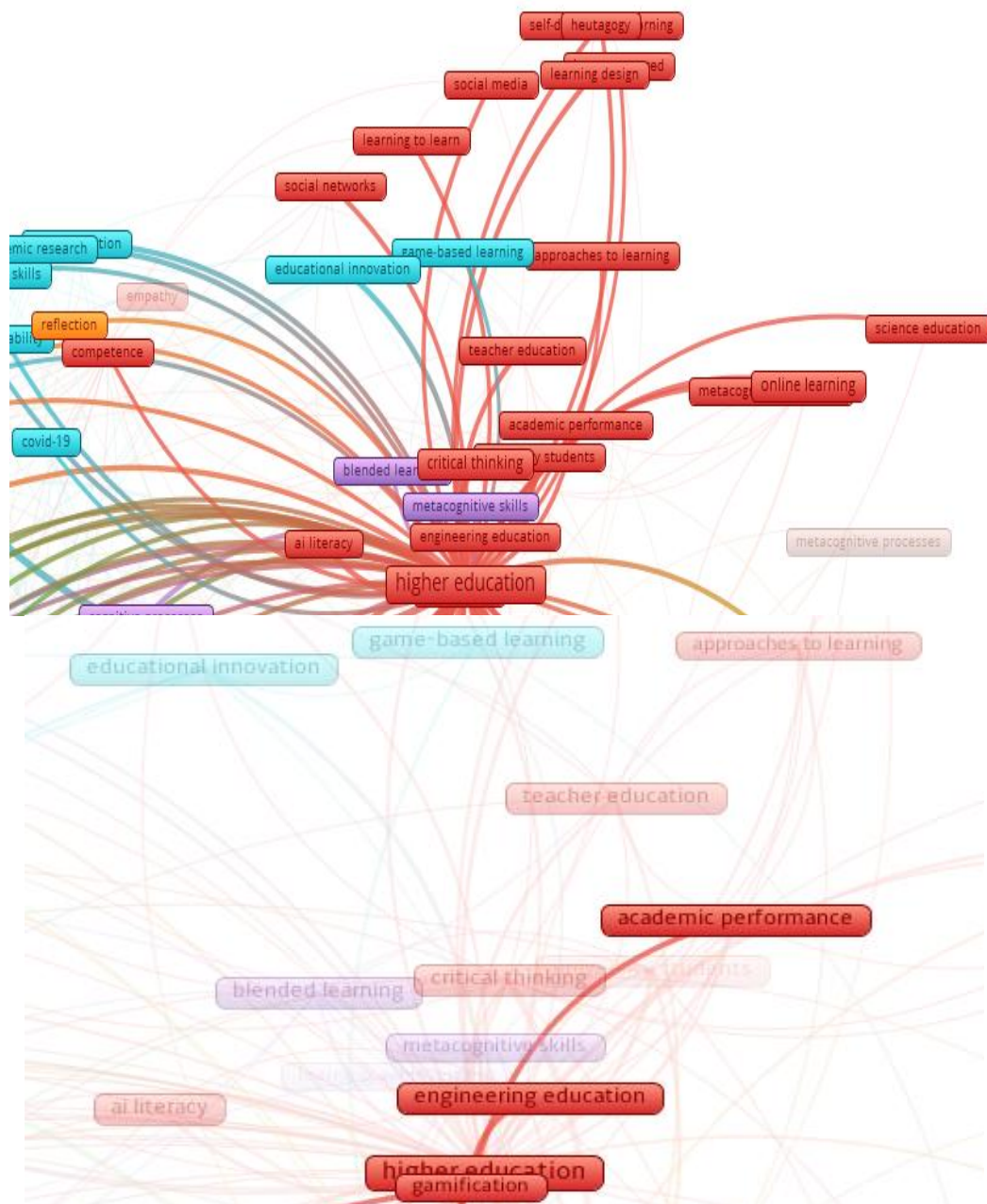


Figure 7: Author Distribution

4.3 Thematic Clusters (RQ3)

RQ3: What thematic clusters emerge from keyword co-occurrence analysis on metacognition, critical literacy, and PjBL in higher education?

Cluster 1 Learner-centered learning and higher-order competencies:



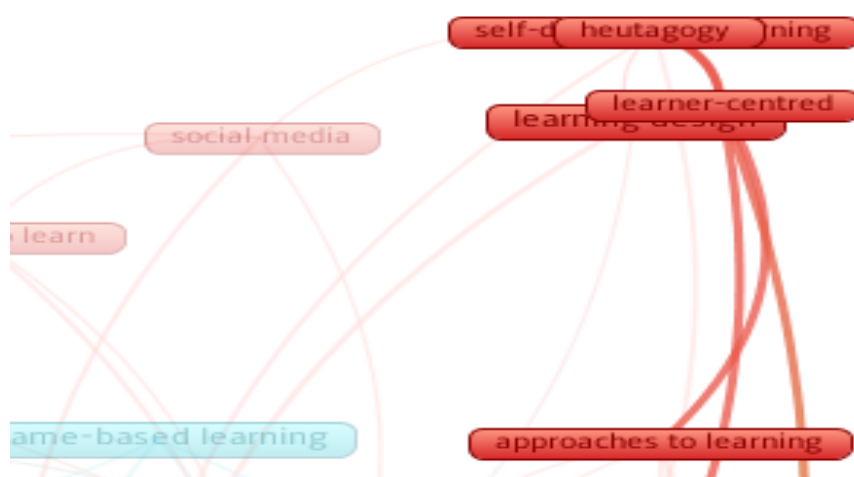
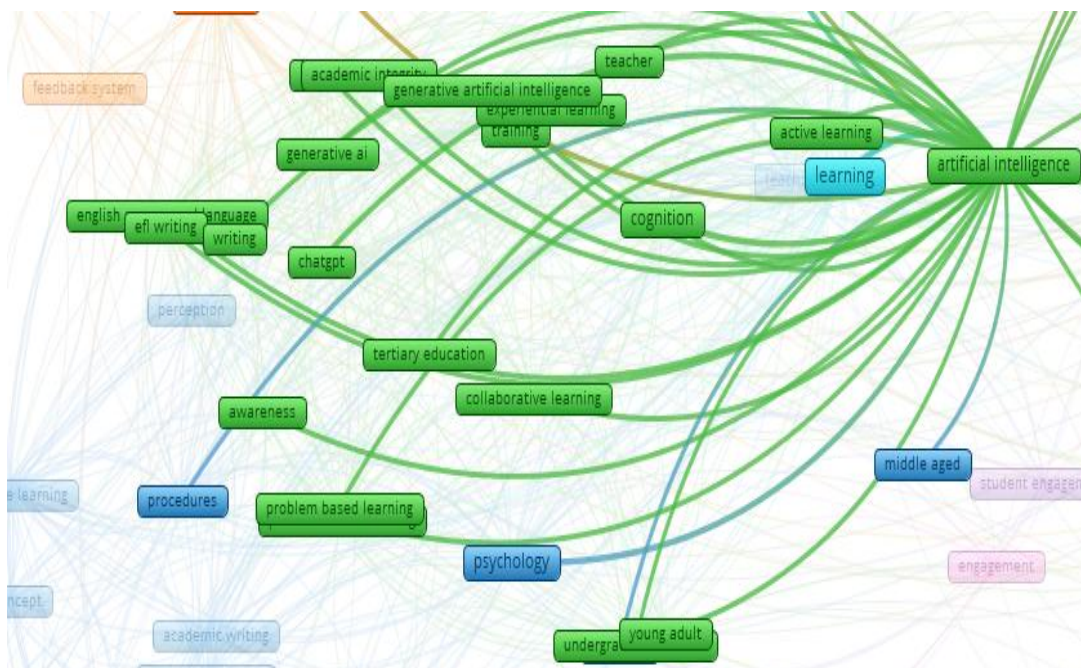


Figure 9: Keyword Co-occurrence Network of Cluster 1: Learner-Centered Learning and Higher-Order Competencies

Comprising 21 items, Cluster 1 focuses on autonomous learning capacity through critical thinking, metacognitive strategies, self-determined learning, and heutagogy. The presence of AI literacy and social media reflects a growing link between metacognition and digital technology, consistent with heutagogical theory positioning learners as primary agents of their own learning (Blaschke & Marín, 2020). The co-occurrence of AI literacy with metacognitive strategies suggests digital technologies are increasingly viewed as tools that scaffold, rather than replace, self-regulatory capacity (Shapiro et al., 2026), implying curriculum design should embed opportunities for autonomous, reflective technology use.

Cluster 2 Artificial intelligence and transformative learning:



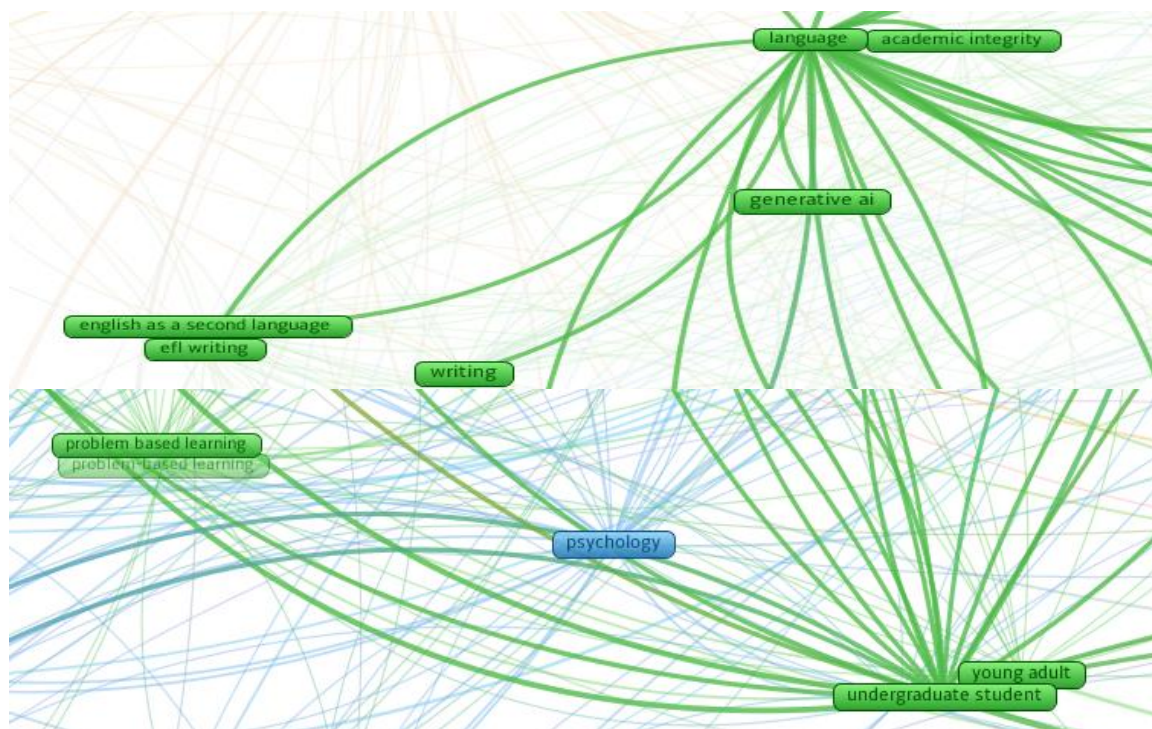


Figure 10: Keyword Co-occurrence Network of Cluster 2: Artificial Intelligence and Transformative Learning

Cluster 2 shows strong connections between metacognition and generative AI, ChatGPT, academic integrity, and collaborative learning, indicating research moving toward AI as a metacognitive scaffold while addressing ethical concerns. This corroborates Larkin (2023) assertion that intelligent systems can support real-time metacognitive reflection, supporting concerns raised by Atchley et al. (2024) about human-AI collaboration risks. The juxtaposition of AI-related terms with "academic integrity" suggests a dual research trajectory exploring both pedagogical potential and ethical challenges (Kim et al., 2025), implying instructional design must balance AI-assisted scaffolding with integrity safeguards.

Cluster 3 Psychological and medical education perspectives:

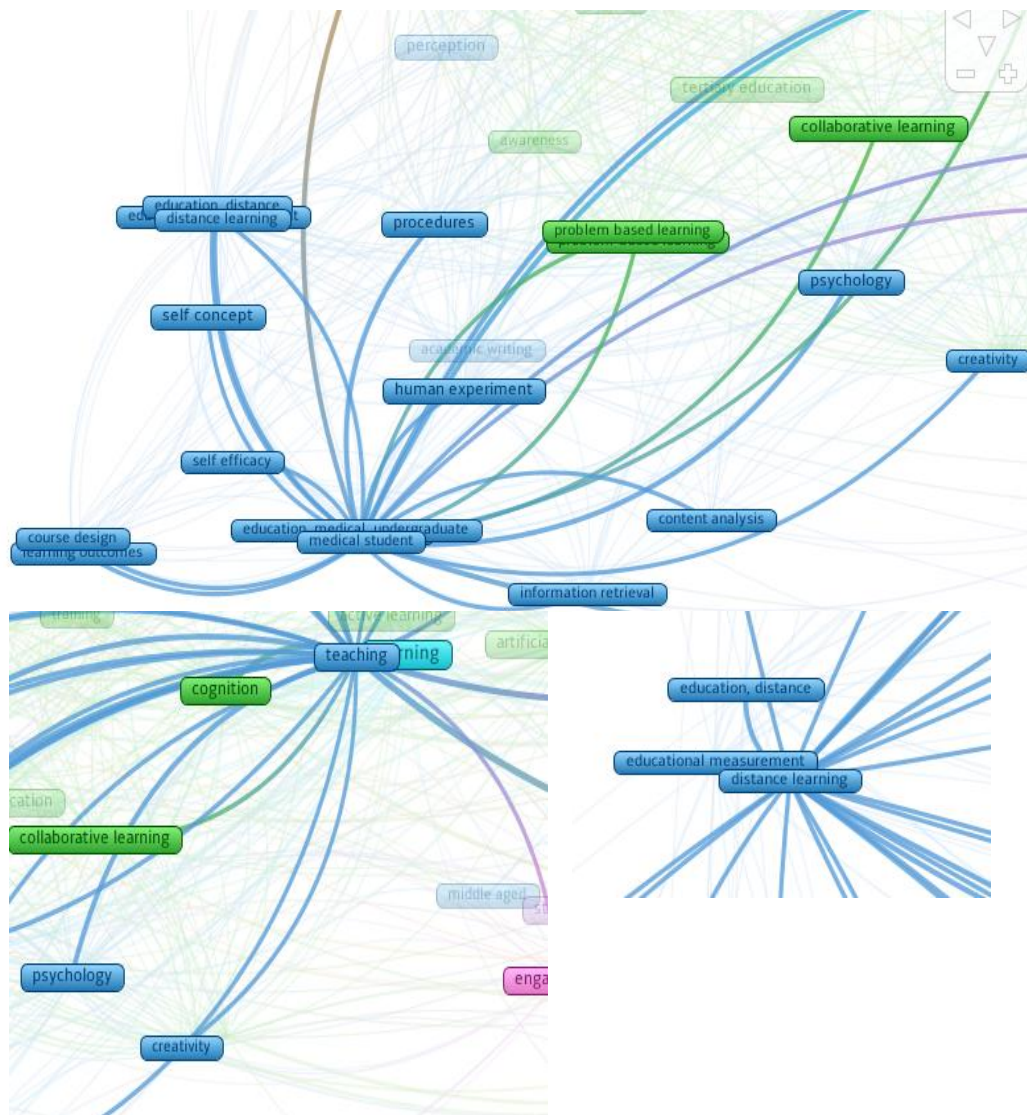
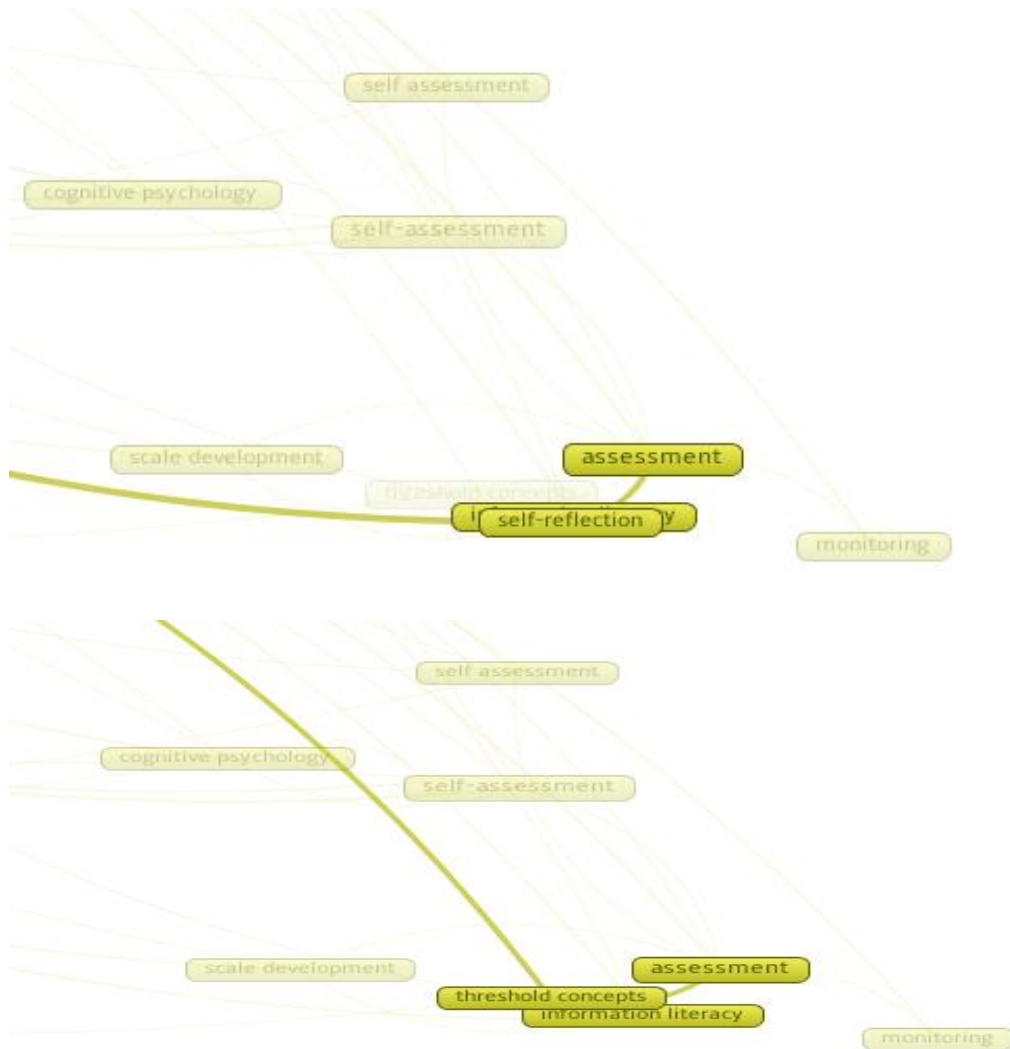


Figure 11: Keyword Co-occurrence Network of Cluster 3: Psychological and Medical Education Perspectives

Cluster 3 connects metacognition to educational psychology and health education through self-efficacy, self-concept, educational measurement, and instructional design, the theoretical foundation where most measurement instruments originate. This is consistent with Flavell conceptualization of metacognition as knowledge and regulation of cognition, still underpinning contemporary instruments (Sánchez-Munilla et al., 2025). Evidence has also shown that metacognitive scaffolding enhances self-efficacy and achievement, particularly in e-learning (Valencia-Vallejo et al., 2019). This implies assessment tools from clinical contexts may offer transferable frameworks for other disciplines, an avenue underexplored beyond health-related fields (Osman et al., 2025).

Cluster 4 Assessment, reflection, and metacognitive regulation:



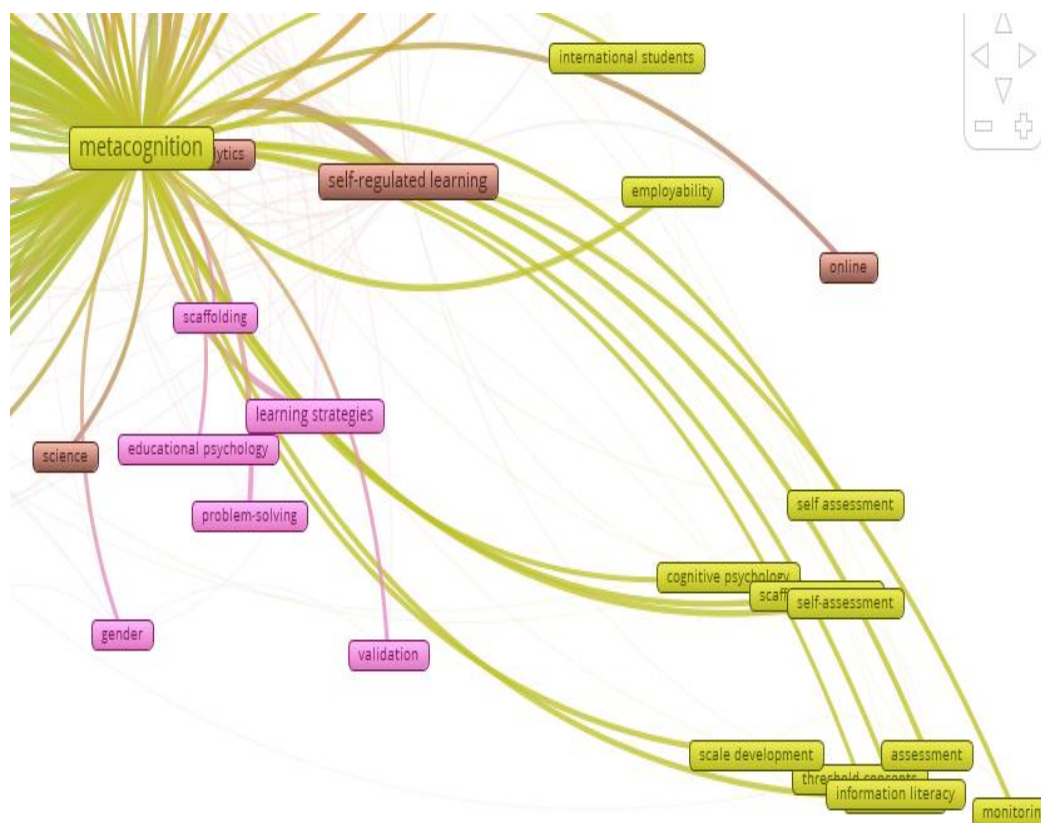


Figure 12: Keyword Co-occurrence Network of Cluster 4: Assessment, Reflection, and Metacognitive Regulation

Cluster 4 includes monitoring, self-assessment, self-reflection, and cognitive psychology, with metacognition as the foundational connector across all clusters and emerging links to information literacy. Chen et al. (2025) topic-modeling results identified metacognition, self-assessment, and reflection as densely interconnected. In addition, Damkam and Chano (2024) map shows metacognition as the dominant hub keyword. The emphasis on monitoring and self-assessment reflects the classical distinction between knowledge and regulation of cognition (Sánchez-Munilla et al., 2025), implying future instruments should combine metacognitive and information-literacy indicators.

Cluster 6 Educational innovation and future skills:

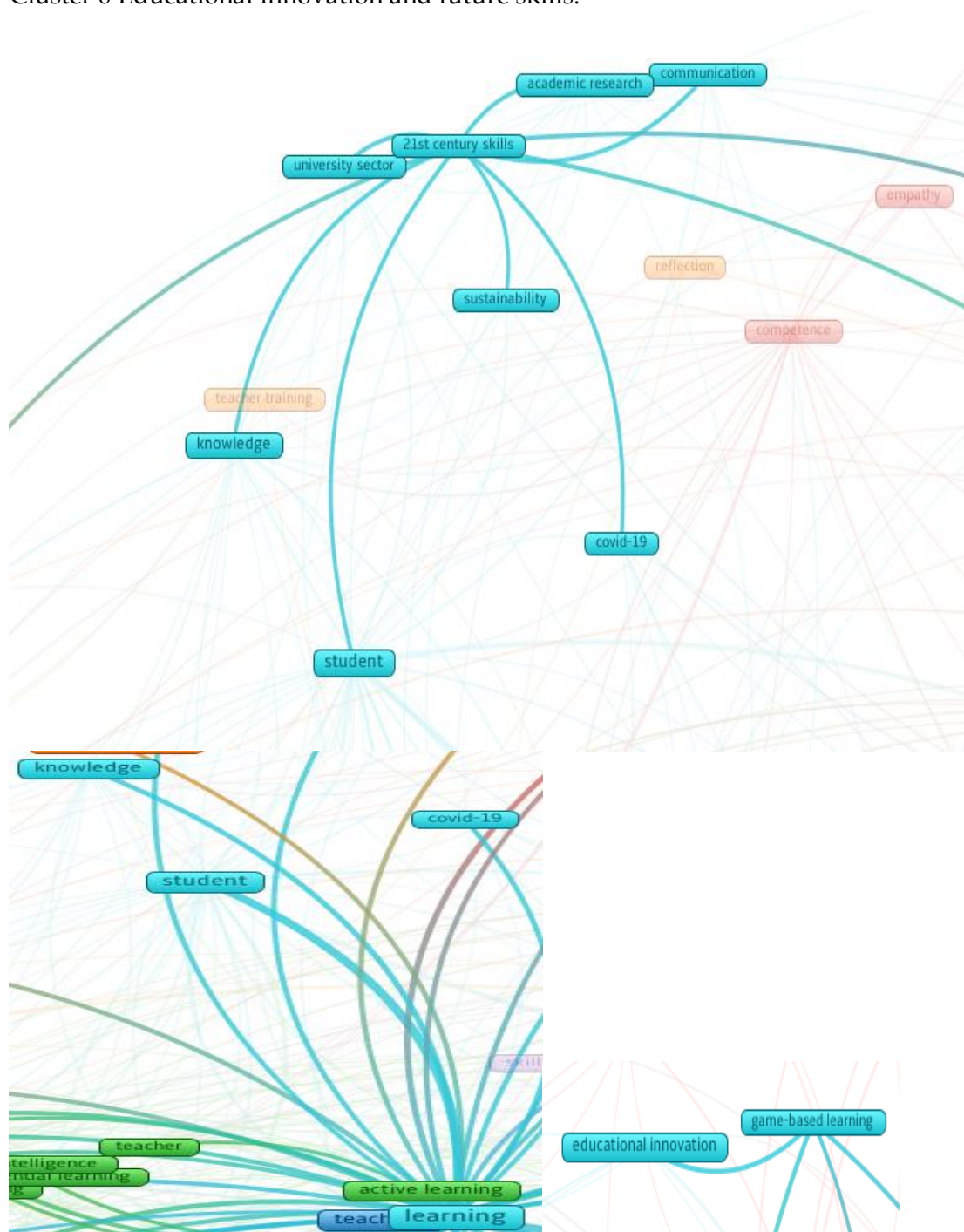


Figure 14: Keyword Co-occurrence Network of Cluster 6: Educational Innovation and Future Skills

Cluster 6 connects metacognition to 21st-century skills, sustainability, game-based learning, and COVID-19, reflecting a trajectory toward adaptive, responsive education. The prominence of COVID-19 is consistent with evidence that pandemic-driven online learning intensified the need for self-regulation strategies (Faza & Lestari, 2025). Meanwhile, the connection with sustainability and game-

based learning supports Chen et al. (2025) observation of diversification into applied domains, implying metacognitive competence is being reconceptualized as a transferable, future-oriented capacity.

Cluster 7 Socially shared metacognition and collaborative reflection:

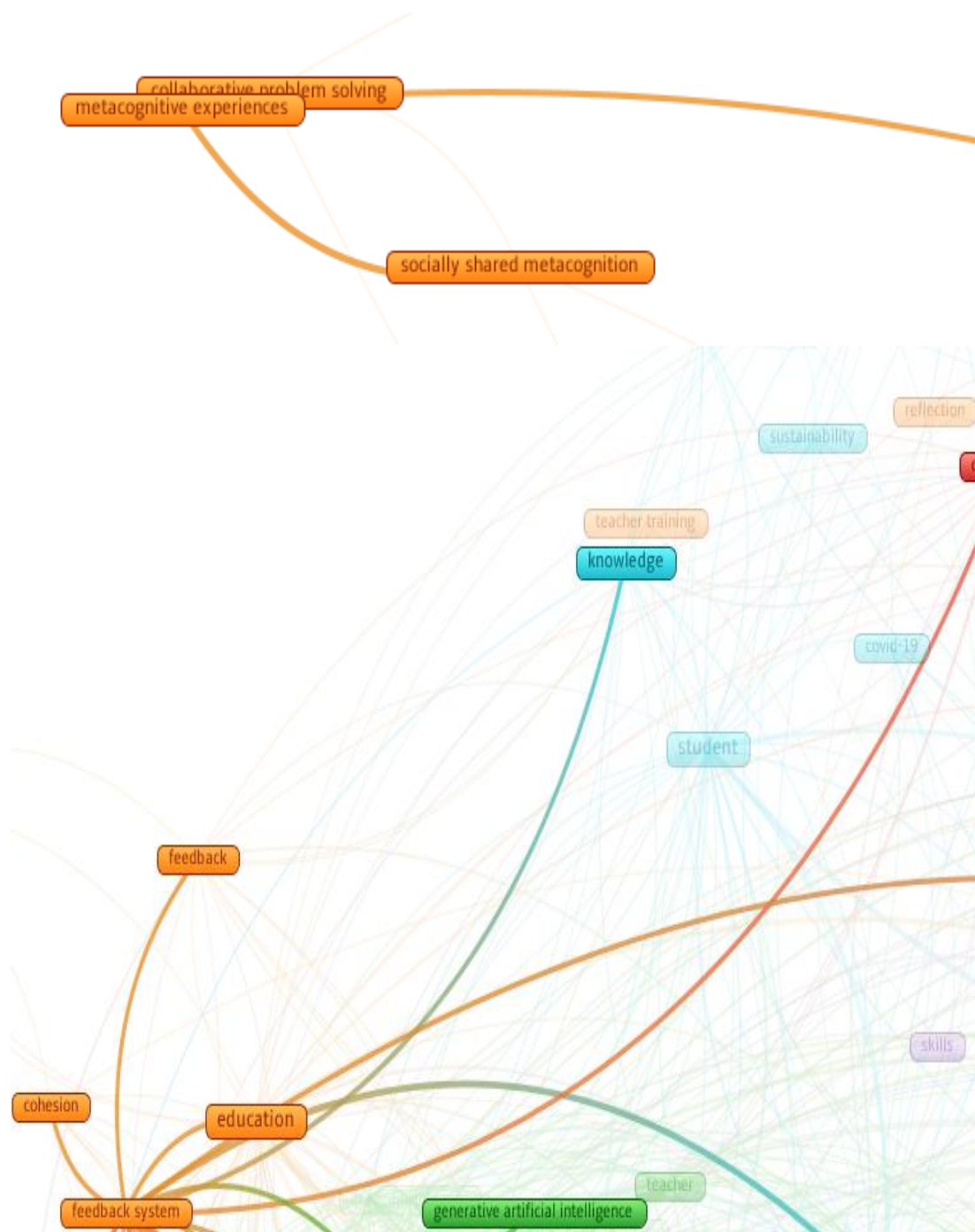


Figure 15: Keyword Co-occurrence Network of Cluster 7: Socially Shared Metacognition and Collaborative Reflection

This is a highly detailed and dense mind map visualization. The central node is "higher education", which branches out into several major categories: "metacognition", "self-regulated learning", "learning strategies", "problem-solving", "gender differences", "retrieval practice", "student engagement", and "active learning". Each of these main branches further subdivides into numerous related terms. For example, "metacognition" connects to "self-regulation", "motivation", and "cognitive processes". "Self-regulated learning" links to "international students", "employability", and "online". "Learning strategies" includes "validation", "reading processes", and "intelligence". The map also features nodes for "engineering education", "ai literacy", "critical thinking", "academic performance", "teacher education", "science education", "online learning", "metacognitive processes", "employment", "self-assessment", "cognitive psychology", "performance", "science", "scaffolding", "problem-solving", "learning strategies", "gender", "gender differences", "motivation", "intelligence", "engagement", "processes", "active processes", "young adult", "technology", "knowledge", "student", "covid-19", "empathy", "competence", "approaches to learning", "educational innovation", and "21st century skills". The nodes are color-coded and connected by thick, flowing lines, creating a complex web of interrelated concepts.

<http://ijlter.org/index.php/ijlter>

Cluster 8 emphasizes learning analytics, retrieval practice, and self-regulated learning, signaling a new data-driven approach. Viberg et al. (2020) review of 54 articles showed that analytics research concentrated on forethought and performance phases while neglecting reflection. The review also showed that learning analytics was more frequently used to measure than support self-regulation, implying future tools should close the loop between data collection and reflective feedback.

Cluster 9 Learning strategies and individual differences:

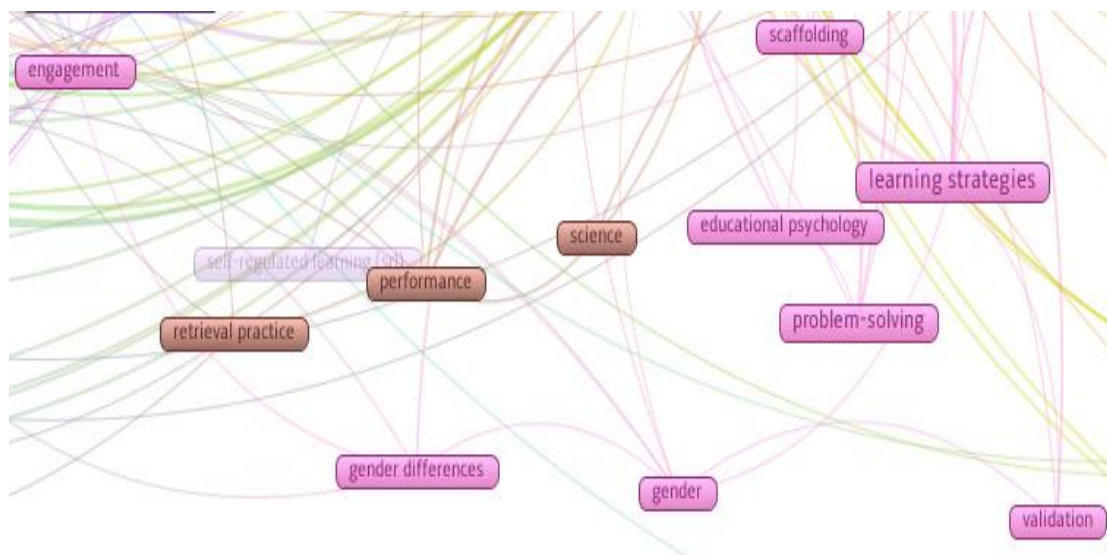


Figure 17: Keyword Co-occurrence Network of Cluster 9: Learning Strategies and Individual Differences

Cluster 9 examines how learning strategies, scaffolding, gender differences, and engagement influence metacognitive development, reinforcing that success depends on personal and contextual factors. This supports Rusyati et al. (2021) review emphasizing inconsistencies in moderating variables and supports Zohar and Barzilai (2013) call for attention to learner diversity, implying interventions may need to be adapted to diverse learner profiles.

4.4 Research Gap Analysis (RQ4)

RQ4: What research gaps can be identified regarding the integration of metacognition, critical literacy, and PjBL in higher education?

Although the initial search query explicitly included "critical literacy," the keyword co-occurrence analysis showed this term did not appear as a dominant keyword in any of the nine thematic clusters. This indicates that although critical literacy is an important theoretical construct, its conceptual integration with metacognition and PjBL remains very limited in higher education literature. Related aspects such as critical thinking (Cluster 1) and information literacy (Cluster 4) appeared, but not critical literacy as a specific concept, showing a significant research gap. Despite the strong theoretical relevance of all three constructs, literature explicitly integrating all three remains very scarce.

Research on the topic was predominantly concentrated in Western countries. Future investigations are needed from Asian and other countries to fill existing gaps and produce novel results capable of making a meaningful impact on the field of education.

5. Discussion

This bibliometric analysis overviews research on metacognition, critical literacy, and PjBL in higher education from 2018 to 2026. The results show growth in publication productivity, rising international collaboration, thematic diversification, and significant gaps. Output rose from single digits early on to a peak of 35 articles in 2025, while collaboration spanned at least ten countries across Europe, Asia, the Americas, and Oceania (Section 4.2). Thematic diversification appeared in nine clusters, from established foundations such as assessment and metacognitive regulation to new domains, including artificial intelligence and learning analytics, consistent with Chen et al. (2025) observation that metacognition research has broadened toward technology-mediated and socially situated learning.

Metacognition remains the dominant conceptual foundation, while critical literacy stays marginal. This is confirmed by the keyword co-occurrence results (Figure 8). Metacognition recorded the highest TLS at 393, while critical literacy did not appear among the top ten keywords despite being an explicit search term. Similarly, Utomo et al. (2024) review found critical literacy research scarce relative to broader literacy and cognitive-skill investigation, an opportunity for future integrative frameworks.

5.1 Publication Growth and Research Productivity

The 154 publications found indicate sustained academic interest. The 2020–2025 upward trend reflects growing recognition of metacognitive development as key to effective learning (Chen et al., 2025; Railean et al., 2017). Chen et al. (2025) identified metacognition, students, and self-regulated learning as the most frequent co-occurring concepts. Damkam and Chano (2024) also reported a map of metacognition as the dominant hub keyword. The post-pandemic increase may reflect demand for pedagogies promoting learner autonomy. Metacognitive competencies help students adapt to technology-rich environments (Larkin, 2023), while self-regulated learning became essential after the shift to online learning during COVID-19 (Faza & Lestari, 2025).

5.2 International Research Distribution and Collaboration Patterns

Spain, the United States, and the United Kingdom were the most productive contributors, consistent with broader trends favoring institutions with well-established research infrastructures. Meanwhile, Indonesia and China emergence reflects growing recognition of higher-order thinking and self-regulated learning in evolving educational systems (Rusyati et al., 2021). Network visualization showed extensive collaboration, particularly among Spain, the US, the UK, Indonesia, and Malaysia. Oulun Yliopisto and Monash University were the most productive institutions, with distribution across Europe, Australia, and Latin America confirming distributed knowledge production (Mota et al., 2025).

Publication sources were dominated by *Frontiers in Education* and *Frontiers in Psychology*, alongside *Sustainability* and *Educational Technology Research and Development*. The results confirm multidisciplinary relevance (Hikmah et al., 2025). Author productivity was evenly distributed, led by Acosta-Gonzaga, Järvelä, Marín, and Ortega-Ruipérez, suggesting the field advances collaboratively (Chen et al., 2025).

5.3 Metacognition as the Core Intellectual Structure

Metacognition highest TLS (393), indicating strong conceptual links with higher education, learning, cognition, psychology, and self-regulated learning. Learners generally plan, monitor, and evaluate better, improving performance and problem-solving (Railean et al., 2017). Metacognitive scaffolding improves ability, self-efficacy, and achievement (Valencia-Vallejo et al., 2019), reinforcing the link between metacognition and self-regulation among effective learners (Larkin, 2023; Osman et al., 2025).

5.4 Thematic Diversification and Emerging Research Areas

The nine clusters show the field multidimensional nature. Cluster 2 shows growing interest in artificial intelligence, generative AI, ChatGPT, and active learning, reflecting concerns about AI role in cognitive and metacognitive development (Larkin, 2023). Integration with self-regulated learning is presently prominent, spanning SRL theory, AI design, and instructional design with large language models (Kim et al., 2025; Shapiro et al., 2026). Cluster 5 links PjBL with self-regulated learning, engagement, and self-efficacy, supporting PjBL as an effective framework for active learning and metacognitive development (Nunn et al., 2016).

Success in project-based environments requires setting goals, monitoring progress, and reflecting, hence, instruction should support self-regulated learning (English & Kitsantas, 2013). Other clusters emphasized critical thinking, learning analytics, collaborative problem solving, and socially shared metacognition, suggesting learning is both a cognitive and social process. This is supported by Yildiz Durak and Kamali Arslantaş (2026), who found socially shared metacognitive scaffolds enhanced group metacognition and motivation. Viberg et al. (2020) also showed that learning analytics increasingly supports self-regulated learning individually and in groups, confirming metacognitive regulation is increasingly distributed across social and technological systems.

5.5 Research Gap: Limited Integration of Critical Literacy

The most significant result is the absence of critical literacy as a dominant keyword. Despite being included in the search query, it appeared in no major cluster. Critical thinking and information literacy featured more prominently. This is corroborated by Utomo et al. (2024), who found critical literacy research scarce. Similarly, Zamzam et al. (2024) reported that despite instructional models with potential for developing critical literacy, systematic curricular integration remains underdeveloped.

Sunggingwati and Trahutomo (2026) also observed that power relations, ideology, and social context remain underexplored. However, critical literacy is crucial for navigating digital society complexity, as students must identify embedded ideologies and biases, though practice still favors literal comprehension over critical awareness (Arvianti et al., 2026). Hardianti (2024) similarly found critical literacy integration in Indonesian higher education limited, though lecturers using the Critical Literacy Approach consider it effective despite implementation challenges (Ruing et al., 2025). Derince (2023) stated that critical literacy pedagogy encourages students to connect learning with broader social issues. However, it remains underintegrated in metacognition and PjBL research, pointing to a need for further investigations explicitly combining all three constructs.

5.6 Future Research Directions

First, researchers should investigate how metacognitive knowledge and skills develop across diverse educational contexts, especially where evidence remains limited (Rusyati et al., 2021; Zohar & Barzilai, 2013). Second, future research should expand advanced assessment methods, given persistent challenges measuring metacognitive processes through self-report (Sánchez-Munilla et al., 2025). Viberg et al. (2020), in a review of 54 articles, found that learning analytics research largely neglected the reflection phase of self-regulated learning and was used more frequently to measure self-regulation than to support it. Third, technological innovation is promising.

Clusters 2 and 8 show AI and adaptive learning platforms already supporting real-time metacognitive reflection (Larkin, 2023). Future research should examine how these technologies can also cultivate critical literacy within PjBL, for instance, AI-supported reflection tools requiring students to evaluate source credibility and ideological framing. Finally, future research should prioritize integrating critical literacy within PjBL, one of the least developed areas, contributing to graduates who are self-regulated, critical, and socially responsible citizens (Mota et al., 2025; Sunggingwati & Trahutomo, 2026).

5.7 Limitations

This research has several limitations, first, restricting to English-language publications may have excluded articles from Spanish-, Portuguese-, and Russian-speaking regions, thereby biasing the country distribution results (RQ2). Second, the restriction to Social Sciences, Psychology, and Arts & Humanities may have excluded interdisciplinary research under Computer Science or Engineering, particularly on metacognition and AI. Third, the use of only open-access articles may have excluded relevant subscription-based research, limiting the thematic mapping comprehensiveness. Future research may broaden these criteria or compare results across databases to validate these patterns.

6. Conclusion

In conclusion, this bibliometric research analyzed 154 Scopus-indexed publications on metacognition, critical literacy, and PjBL in higher education (2018–2026). The results show growing interest peaking in 2025, with Spain, the

United States, and the United Kingdom as leading contributors while Indonesia and China demonstrated increasing participation. Keyword co-occurrence analysis identified metacognition as the central theme (TLS = 393), strongly connected to learning, higher education, cognition, psychology, and self-regulated learning. Thematic mapping showed nine clusters covering artificial intelligence, active learning, assessment, critical thinking, student engagement, learning analytics, and collaborative problem solving. A significant result is the limited visibility of critical literacy within the keyword network and thematic clusters. Despite the inclusion in the search strategy, it remains underrepresented compared to metacognition and PjBL, indicating an important research gap.

This research has several limitations. First, reliance on a single database (Scopus) may have excluded relevant publications from other databases. Restriction to English-language and open-access articles may have introduced language and accessibility biases. In addition, the bibliometric approach captures thematic patterns without assessing methodological quality. Future research should focus on developing integrated frameworks connecting metacognition, critical literacy, and PjBL, particularly within non-Western contexts and new digital learning environments, to foster self-regulated, critical, and reflective learners in higher education.

Conflict of Interest

The authors declare that there are no competing interests associated with this work.

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