Region-Educational Research and Reviews, 2025,Volume 7, Issue 12
DOI:10.32629/rerr.v7i12.5002
ISSN Online:2661-4634
ISSN Print:2661-4626

A Bibliometric Study on the Self-Efficacy Foundation of Pre-service Teachers' AI Teaching Competence Development

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Abstract: The integration of AI necessitates re-evaluating pre-service teachers' readiness beyond mere technical skills, focusing on psychological capital like self-efficacy and resilience. This bibliometric study mapped the literature intersecting "pre-service teachers" AND "Artificial Intelligence" to chart the evolving knowledge structure regarding psychological preparedness, especially self-efficacy. Using ERIC data, the analysis tracked the paradigm shift post-2020 through clustering and burst detection. Findings reveal a shift from tool skills to deeper pedagogical and psychological alignment. Literature clustered into four domains: Proficiency, Pedagogy, Learner Factors, and Ethics, with recent surges in terms related to AI-induced stress and resilience training. This study pioneers mapping the Tech-Psychology lineage, confirming that mastery experiences are now mediated by AI feedback. The core insight is that effective AI teacher education must function as a Self-Efficacy and Well-being Support System. We mandate cultivating AI teaching self-efficacy and resilience through cognitive standards, personalized mastery scaffolding, and data-driven feedback to proactively mitigate psychological strain.

Keywords: pre-service teachers, artificial intelligence in education, bibliometrics

1. Introduction

AI integration profoundly challenges teacher roles. Existing literature often focuses narrowly on AI skills, systematically neglecting how scholarly discourse supports self-efficacy belief—the core psychological scaffolding for pre-service teachers' agency formation [1].

This study addresses this gap using advanced bibliometric analysis of ERIC literature on "pre-service teachers" and "AI." Employing CiteSpace and VOSviewer, we map intellectual evolution, identify knowledge clusters supporting self-efficacy formation, and interpret belief-support trends [2]. Ultimately, this analysis provides an evidence-based blueprint for AI teacher education theory centered on cultivating sustainable teacher agency anchored in psychological capital[3].

2. Materials and Methods

This bibliometric study leveraged the ERIC Core Database (2011–2026). A structured search targeting "pre-service teachers" AND "artificial intelligence" (Table 1) yielded 596 English records. After rigorous exclusion of duplicates, retracted papers, and non-core mentions (n=88), the final corpus of 508 articles was subjected to analysis. VOSviewer mapped the spatial structure and collaborations, while CiteSpace performed keyword clustering and burst detection (time slice: 1-year).

Table 1. Literature Search Strategy for Pre-service Teachers and AI

No.	Search String
1	SU=(pre-service teachers OR normal university students) AND (SU=artificial intelligence)
2	SU=(pre-service teachers OR normal university students) AND SU=(artificial intelligence OR AI)
3	TI=(pre-service teachers OR normal university students) AND TI=(artificial intelligence OR AI)
4	KY=(pre-service teachers OR normal university students) AND KY=(artificial intelligence OR AI)

3. Results

3.1 Annual Publication Volume

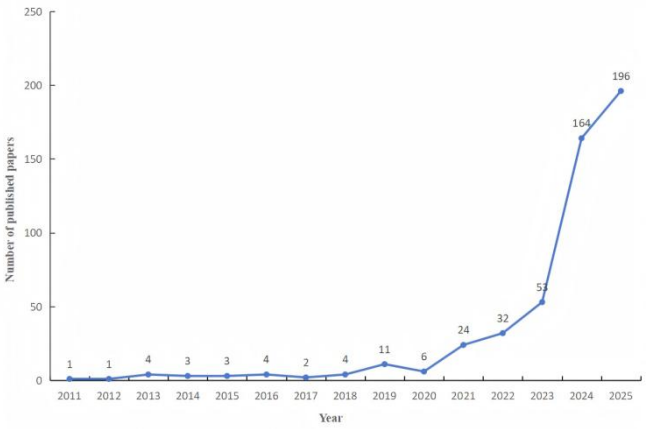

Figure 1. Annual Distribution Trend of Publication Volume

The output grew from 1 article initially to 196 in 2025, showing a strong 45.79% CAGR (Figure 1). The research trajectory features three key phases.Research output transitioned from slow accumulation through volatile warming to an explosive growth phase post-2023, sharply reflecting heightened global interest driven by AI integration.

3.2 Author Collaboration Network Map

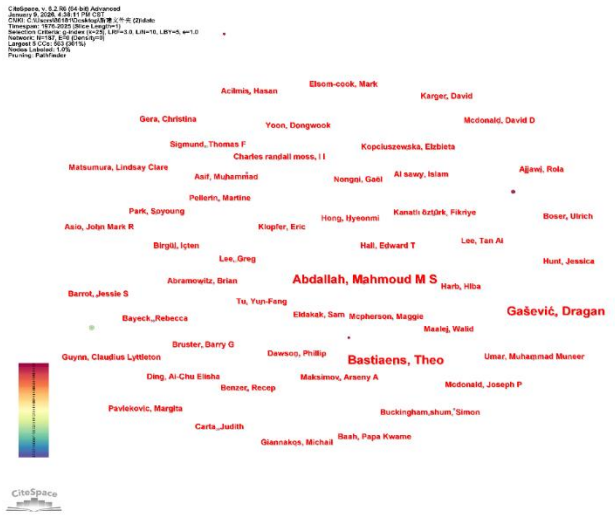

Figure 2. Author Collaboration Network

Author co-citation analysis reveals the field's nascent structure. The resulting network (Figure 2) of 187 authors and 563 links exhibits a very low density of 0.01. Core authors are isolated, forming fragmented, sparse collaboration sub-networks. This loose topology signifies that a tight, stable academic cooperation ecosystem has not yet formed, likely due to the field's early stage or topic diversity. Future work must focus on building a denser network through interdisciplinary projects and forums to accelerate field maturity.

3.3 Keyword Knowledge Map

3.3.1 High-Frequency Keywords

Table 2. Top 10 most common keywords appearing in Pre-service Teachers and AI

Rank (r)	Keyword	Occurrences of Freq. (f)	Centrality
1	Artificical intelligence	455	0.28
2	Foreign countries	237	0.03
3	Preservice teachers	185	0.07
4	Students sttitudes	158	0.05
5	Technology integration	128	0.04
6	Teaching methods	118	0.09
7	Educational technology	101	0.08
8	Teacher attitudes	90	0.02
9	Teacher student relationship	89	0.07
10	Preserive teacher education	86	0.07

Keyword frequency analysis reveals the field's core and evolutionary trends. As shown in Table 2, "Artificial intelligence" dominates with the highest Occurrence (455) and Centrality (0.28), positioning it as the central knowledge hub. "Foreign countries" (237) highlights a significant international research focus. "Preservice teachers" (185) forms the essential pairing, while other terms like "Students attitudes" (158) and "Technology integration" (128) signal a mature research focus on pedagogical impact beyond mere technology adoption.

3.3.2 Keyword Cluster Analysis

Figure 3 displays the co-occurrence network topology, distinctly revealing four thematic research domains in AI-empowered education. The Red Cluster identifies Technological Tool Applications, featuring concepts like computer simulation. The Yellow Cluster centers on Instructional Methods and Assessment, with core nodes such as writing instruction and student evaluation. The Green Cluster highlights Learning Sciences and Student Factors, prominently including artificial intelligence and student needs. Finally, the Blue Cluster addresses Teacher Professional Development and Ethical Boundaries, encompassing educational policy and man-machine systems. This topology organizes research around four pillars: Tools, Practices, Learners, and Policy. The prominence of student needs and teacher attitudes signals a clear shift toward the psychological determinants governing technology adoption.

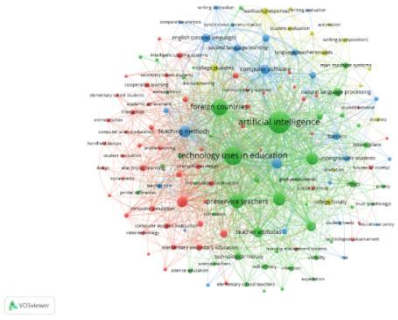

Figure 3. Co-occurrence Knowledge Map of High-Frequency Keywords in Pre-service Teachers and AI Research

Keyword clustering (Figure 4, $Q=0.575, S=0.817$) revealed three core agendas mapping the domain's evolution. The streams focus on: (1) Pedagogical prerequisites linking CAI to student attitudes; (2) Instructional outcomes, covering quality and collaboration impact on efficacy; and (3) Specific applications in Cooperative learning, Math, and English. Evolution shows a shift from technology-centric origins to deeper integration in quality and interpersonal dynamics.

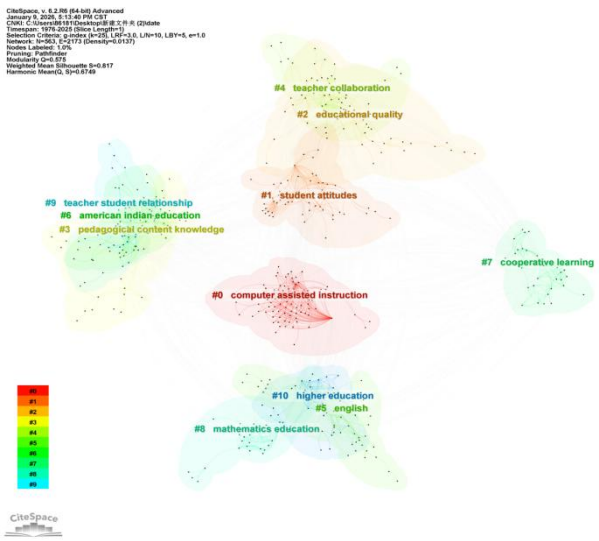

Figure 4. Keyword Co-occurrence Network Cluster Map

3.3.3 Keyword Burst Analysis

Keyword burst analysis (Figure 5) sketches dynamic hotspot evolution. The strongest 22 terms show a strategic transition. Early technology terms like intelligent tutoring systems peaked around 2014. Momentum has shifted to refined practice: learning analytics and teaching methods now dominate, signaling a move from tool usability to optimizing instructional quality via hybrid models, reflecting a focus on procedural efficacy in digital transformation.

Top 22 Keywords with the Strongest Citation Bursts

Keywords	Year	Strength	Begin	End	2011 - 2025
learning processes	2011	2.6	2011	2022	
computer mediated communication	2011	2.33	2011	2017	
computer simulation	2012	4.76	2012	2023	
online courses	2013	2.54	2013	2023	
interaction	2013	2.52	2013	2022	
case studies	2013	2.25	2013	2019	
intelligent tutoring systems	2014	4.62	2014	2022	
educational technology	2011	4.31	2014	2023	
handheld devices	2014	3.03	2014	2022	
blended learning	2014	2.94	2014	2022	
cooperative learning	2014	2.9	2014	2022	
computer science education	2014	2.64	2014	2022	
data analysis	2015	3.23	2015	2023	
high school students	2015	3	2015	2023	
automation	2015	2.54	2015	2023	
academic achievement	2015	2.31	2015	2023	
teaching methods	2013	4.74	2017	2021	
elementary secondary education	2018	3.54	2018	2023	
learning analytics	2019	3.88	2019	2023	
instructional design	2011	2.99	2019	2022	
covid-19	2020	4.4	2020	2023	
educational improvement	2022	2.13	2022	2025	

Figure 5. Top Keywords with the Strongest Citation Bursts.

4. Discussion and Conclusion

Post-2020 AI teacher research critically shifted focus to psychological drivers, mainly self-efficacy. The analysis integrates technology clusters with three Self-Efficacy pillars Cognitive Anchors Mastery Experiences and Social Skills into a Technology-Psychology dual-mode framework. Practically teacher education must operate as psychological support engineering embedding mastery scenarios and optimized learning environments to enhance efficacy beliefs ensuring future AI adoption.

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Acknowledgements:

This work was supported by the Tianshui Normal University Graduate Quality Enhancement Project 2025 (Grant No. TSXM2501) and the Tianshui Normal University 2025 Institutional Project for Educational Teaching Reform Research.