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Artificial Intelligence and active b-learning methodologies in higher education: a bibliometric analysis

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Inteligência artificial e metodologias ativas de b-learning no ensino superior: uma análise bibliométrica

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Inteligencia artificial y metodologías activas de b-learning en la educación superior: un análisis bibliométrico

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Abstract: *Artificial Intelligence (AI) emerged as a transformative technology in Higher Education, reshaping active and hybrid learning methodologies. This study conducts a bibliometric analysis of recent literature on the integration of AI into active b-learning methodologies in the university context. A six-stage bibliometric methodology was employed, using Scopus-indexed publications from 2015 to 2024. PRISMA criteria were applied for study selection, and VOSviewer, Bibliometrix, and Microsoft Excel were used to process and visualize the data. Results indicate exponential growth in scientific output related to AI and active methodologies, particularly from 2020 onwards. A total of 167 relevant documents were identified, with conference papers being the most frequent publication type. The dominant themes included personalized learning, intelligent gamification, automated flipped classrooms, and AI-supported project-based learning. The analysis also identified the most influential authors, journals, and documents, as well as key academic collaboration networks. Findings suggest that the convergence between AI and active learning represents a promising path for pedagogical innovation in Higher Education. However, several challenges remain, including ethical considerations, technical limitations, and teacher training. This study offers a comprehensive overview of the current state of research, highlighting the need for further investigation into pedagogical, ethical, and contextual impacts of digital transformation in education.*

Keywords: *Artificial intelligence. Blended learning. Flipped classroom. Gamification. Project-based learning.*

Resumo: Resumo: A Inteligência Artificial (IA) emergiu como uma tecnologia transformadora no Ensino Superior, remodelando as metodologias de aprendizagem ativa e híbrida. Este estudo realiza uma análise bibliométrica da literatura recente sobre a integração da IA em metodologias ativas de b-learning no contexto universitário. Foi aplicada uma metodologia bibliométrica em seis etapas, utilizando publicações indexadas na Scopus entre 2015 e 2024. Os critérios PRISMA foram usados para a seleção dos estudos, e os softwares VOSviewer, Bibliometrix e Microsoft Excel serviram para o processamento e visualização dos dados. Os resultados indicam um crescimento exponencial da produção científica relacionada à IA e às metodologias ativas, especialmente a partir de 2020. Foram identificados 167 documentos relevantes, sendo os artigos de

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conferência o tipo de publicação mais frequente. Os temas dominantes incluíram aprendizagem personalizada, gamificação inteligente, salas de aula invertidas automatizadas e aprendizagem baseada em projetos apoiada por IA. A análise também identificou os autores, revistas e documentos mais influentes, bem como as principais redes de colaboração académica. As conclusões sugerem que a convergência entre IA e aprendizagem ativa representa um caminho promissor para a inovação pedagógica no Ensino Superior. No entanto, permanecem diversos desafios, incluindo considerações éticas, limitações técnicas e formação docente. Este estudo oferece uma visão abrangente do estado atual da investigação, destacando a necessidade de aprofundar o estudo dos impactos pedagógicos, éticos e contextuais da transformação digital na educação.

Palavras-chave: Aprendizagem baseada em projetos. Aprendizagem híbrida. Gamificação. Inteligência artificial. Sala de aula invertida.

Resumen: *La Inteligencia Artificial (IA) ha emergido como una tecnología transformadora en la Educación Superior, reconfigurando las metodologías de aprendizaje activo e híbrido. Este estudio realiza un análisis bibliométrico de la literatura reciente sobre la integración de la IA en las metodologías activas de b-learning en el contexto universitario. Se empleó una metodología bibliométrica de seis etapas, utilizando publicaciones indexadas en Scopus entre 2015 y 2024. Los criterios PRISMA se aplicaron para la selección de los estudios, y los programas VOSviewer, Bibliometrix y Microsoft Excel se utilizaron para procesar y visualizar los datos. Los resultados indican un crecimiento exponencial de la producción científica relacionada con la IA y las metodologías activas, especialmente a partir de 2020. Se identificaron 167 documentos relevantes, siendo los artículos de conferencias el tipo de publicación más frecuente. Los temas dominantes incluyeron el aprendizaje personalizado, la gamificación inteligente, las aulas invertidas automatizadas y el aprendizaje basado en proyectos apoyado por IA. El análisis también identificó a los autores, revistas y documentos más influyentes, así como las principales redes de colaboración académica. Los hallazgos sugieren que la convergencia entre la IA y el aprendizaje activo representa una vía prometedora para la innovación pedagógica en la Educación Superior. No obstante, persisten varios desafíos, entre ellos las consideraciones éticas, las limitaciones técnicas y la formación del profesorado. Este estudio ofrece una visión completa del estado actual de la investigación, destacando la necesidad de profundizar en los impactos pedagógicos, éticos y contextuales de la transformación digital en la educación.*

Palabras-clave: *Aprendizaje basado en proyectos. Aprendizaje híbrido. Aula invertida. Gamificación. Inteligencia artificial.*

INTRODUCTION

Artificial intelligence (AI) is transforming higher education by reshaping teaching, learning, and technology interactions (Qian; Cao; Chen, 2025; Chen; Chen; Lin, 2020). Tools like intelligent tutoring systems, chatbots, adaptive platforms, and analytics enable personalized instruction and data-driven decisions, though ethical and training challenges persist (Alam, 2023; Almatrafi; Johri, 2025; Zahra; Rautela, 2024).

Active hybrid methodologies—flipped classroom, PBL, gamification—promote student engagement and skills over traditional models, amplified by AI for adaptive feedback and inclusive practices (Sousa; Mangas, 2024; Sadradín; Céspedes-Carreño; Vera-Carreño, 2024; Martínez Casanovas; Ruíz-Munzón; Buil-Fabregá, 2022; Bell, 2010; Blumenfeld Et Al., 1991; Deterding Et Al., 2011; Dichev; Dicheva, 2017).

Despite growing research, integrated analyses of AI in these university-level approaches remain scarce, often focusing on isolated tools rather than trends, actors, and gaps (Chen; Chen; Lin, 2020; Wang Et Al., 2024; López-Chila Et Al., 2024; Huang; Lu; Yang, 2023; Lai; Cheung; Chan, 2023; Fang; Luo, 2025). This bibliometric study maps Scopus data (2015-2024), analyzing publication trends, influential authors/sources/documents, and themes (Elsevier, 2023; Aria; Cuccurullo, 2017; Ellegard; Wallin, 2015; Donthu et al., 2021).

To guide this analysis, the study addresses the following research questions: (RQ1) How has the volume and type of publications on AI and active blended learning in Higher Education evolved over the past decade? (RQ2) Who are the most influential authors in this field? (RQ3) Which academic sources—journals

and conferences—most frequently publish research on this topic? (RQ4) Which publications have had the greatest impact on studies of AI and active blended learning in Higher Education? and (RQ5) What are the prevailing themes and research topics within the literature on AI and active blended learning methodologies in Higher Education?

2 THEORETICAL FOUNDATION

2.1. ARTIFICIAL INTELLIGENCE IN HIGHER EDUCATION

AI adoption in higher education demands clear guidelines ensuring ethical, pedagogical, and responsible use, focusing on transparency, data protection, equity, and non-discrimination. UNESCO (2025) emphasize policies safeguarding rights while fostering innovation aligned with humanistic values. Guidelines must align with pedagogical goals, reinforce teachers' roles, verify data accuracy, and provide continuous training (Baig; Yadegaridehkordi, 2025).

2.2. ACTIVE HYBRID LEARNING METHODOLOGIES

Three key methodologies emerge: flipped classroom, problem-based learning (PBL), and gamification (Martínez Casanovas et al., 2022; EKICI, 2021). Flipped classroom combines pre-class preparation with in-class practice, enhanced by AI adaptive systems that boost performance and critical thinking (Bergmann et al., 2013; Almatrafi; Johri, 2025; Galindo-Domínguez, 2021; Dai; Kang, 2025; Lopes et al., 2024). PBL integrates hybrid activities with AI tools, developing creativity, problem-solving, and socio-emotional skills (Bailifard, 2023; Pellas, 2025; Sajja Et Al., 2023; Bernroitner, 2024). Gamification applies game design to boost engagement and performance (Deterding et al., 2011; Dichev; Dicheva, 2017; Manzano-León Et Al., 2021; Sailer; Homner, 2020).

2.3. INTEGRATION AND EMERGING METHODOLOGIES

AI serves as an intelligent tutor (Robert et al., 2025), particularly post-ChatGPT (García-PeñalvO, 2023), offering real-time analysis, feedback, adaptive interventions, and gamification—though training, privacy, and bias challenges persist. It excels in blended learning, supporting PBL (MAITY; DEROY, 2024), gamification (Yang et al., 2023), and flipped classrooms through automated content curation (Akavova et al., 2023). Adaptive frameworks and tools like Khanmigo, Google Gemini, MemorizAÍ, SocratiQ, and Iris enable scalable personalization (Joshi, 2023; Imran; Almusharraf, 2024; Bassner et al., 2024). AI augments educators, demanding digital and ethical competencies for inclusive, innovative education.

3 METHODOLOGY

Scopus was selected for its comprehensive coverage (ELSEVIER, 2023; MING, 2024). The search combined "artificial intelligence" AND ("higher education" OR equivalents) AND ("active learning" OR "flipped classroom" OR "project-based learning" OR "gamification"), spanning 2015–2024 and limited to titles/abstracts (Chen; Chen; Lin, 2020; López-Chila et al., 2024). Inclusion focused on English-language journals, conference papers, and book chapters in relevant fields; exclusions removed non-DOI documents, reviews, and irrelevant studies to minimize bias (Crossref, 2023; Donthu et al., 2021). PRISMA-guided screening reduced 195 initial records to 167 for analysis (KIRSCH et al., 2020). Data were processed via Bibliometrix (R package), VOSviewer, and Excel to assess production trends, authorship, sources, citations, and keyword networks (Aria; Cuccurullo, 2017; Van Eck; Waltman, 2010; Microsoft Corporation, 2023), revealing collaboration patterns, thematic clusters, and influential works at the AI-active learning intersection (Dias Lousã; Teixeira; Pereira De Morais, 2025; Sari; Aypay, 2024).

Figure 1- Methodology

1st Step - Database selection ScopuS
2nd Step Definition of search terms selection of terms and boolean operators: “artificial intelligence” AND (“higher education” OR “university” OR “college” OR “tertiary education”) AND (“active learning” OR “flipped classroom” OR “project-based learning” OR “gamification”)

Figure 1 (cont.)
Methodology.

PRISMA stages

3rd Step Definition of search criteria and application of the PRISMA protocol Period: January 2015- March 2025 Search: Title and Abstract. Publication type: Book Chapters, Journal Articles, Conference paper. Fields of study: Computer Science, Computer Sciences, Social Sciences.	Identification	Records identified from the database searching “Scopus” (n=773)	Records removed before screening (n=126) Reason 1: publication type (n=73) Limited to Conference paper (n=455) Limited to Article (n=171) Limited to Book chapter (n=21). Reason 2: outside field of study (n=52) Limited to Computer Sciences; Social Sciences; Engineering. Reason 3: Language (n=1) Limited to English (n=647)
4th Step Selection of analysis software Scopus, VOSviewer, Bibliometrix, Microsoft Excel	Screening and Eligibility	Records screened (n=647)	Records excluded (n=449) Reason 1: items without DOI identifier (n=131) Reason 2: literature review articles (n=17) Reason 3: exclusion of studies that do not focus on artificial Intelligence and active learning methodologies in Higher Education (n=304)
5th Step Analysis and discussion of results Analysis of Annual Scientific Production, Contributions from Journals, and Authors, along with the Number of Articles, Citations, and co-occurrence analysis of keywords from titles and abstracts.		Records assessed for eligibility (n=195)	Reports excluded (n=28)
6th Step Synthesis of results Summary of the study’s contributions and limitations, along with recommendations for future research.	Included	Records included in the final quantitative and qualitative analysis (n=167)	

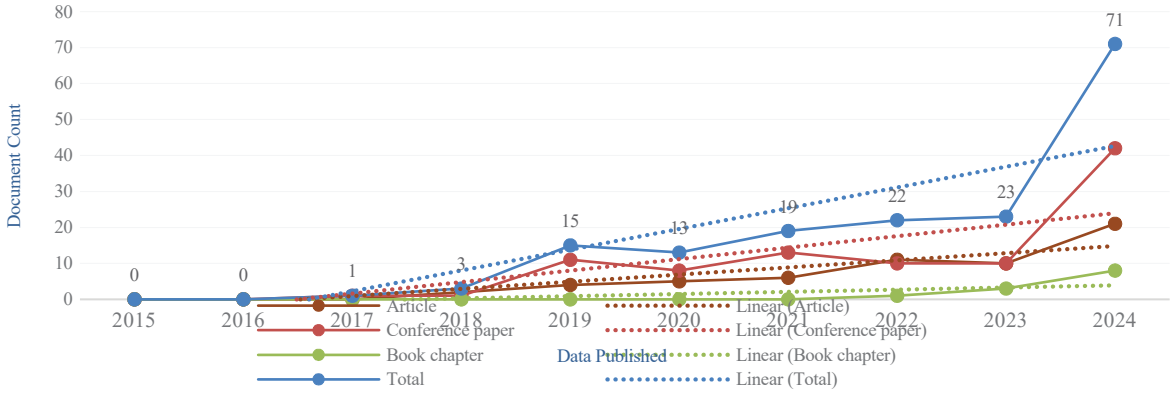
Source: Own elaboration (2025)

4 ANALYSIS AND DISCUSSION OF RESULTS

4.1 EVOLUTION OF SCIENTIFIC PRODUCTION

Between 2015–2024, research on AI and active blended learning in higher education shows steady growth, starting from 2017, accelerating post-2021, and peaking at 71 publications in 2024—mainly journal articles and initial book chapters—mirroring broader AI educational trends (CHEN; CHEN; LIN, 2020; LÓPEZ-CHILA et al., 2024; WANG et al., 2024).

Figure 2- Evolution of the number of publications by document type



Source: Own elaboration (2025)

This expansion reflects AI technological advances and pandemic-driven digital transformation in universities (Purwanto; Wibowo; Rahayu, 2023; López-Chila et al., 2024). Citation patterns show high-impact early works (2018, 2020, 2023) versus lower 2024 averages due to shorter citation windows, not reduced relevance (Donthu et al., 2021; Huang; Lu; Yang, 2023).

Figure 3- Mean total citations per year in publications

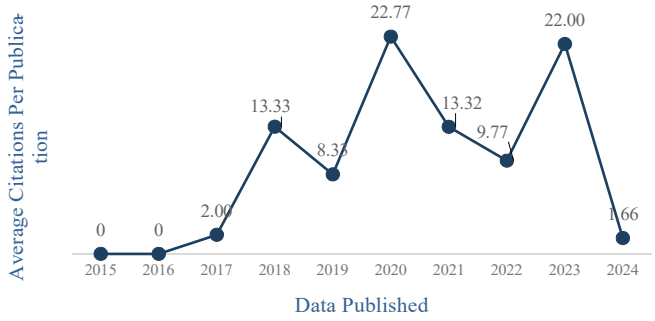


Table 1- Mean total citations per publication (meantcperpub)

Year	MeanTCperPub	N
2015	0.00	0
2016	0.00	0
2017	2.00	1
2018	13.33	3
2019	8.33	15
2020	22.77	13
2021	13.32	19
2022	9.77	22
2023	22.00	23
2024	1.66	71

Source: Own elaboration (2025)

4.2 MOST RELEVANT AUTHORS

Bucea-Manea-Ţoniş, Kumar, Molina, Palacios-Pacheco, and Villegas-Ch lead in productivity with three publications each, while Draskovic, Ilić, Kuleto, and Lianu show strong local impact despite fewer works (Table 2) (Bucea-Manea-Ţoniş et al., 2021, 2022; Draskovic, 2019; Draskovic; Cvetanovic; Nikolic, 2018).

Table 2- Most relevant authors considering the number of publications and the value of articles fractionalized

Authors	Publications	Articles Fractionalized
Bucea-Manea-Toniş R.	3	0.43
Kumar A.	3	0.35
Molina A.	3	0.64
Palacios-Pacheco X.	3	1.17
Villegas-Ch W.	3	1.17
Draskovic D.	2	1.33
Gholson J.	2	0.20
Hainey B.	2	0.33
Ilić M.P.	2	0.29
Kuleto V.	2	0.29
Lianu C.	2	0.29

Source: Own elaboration (2025)

Citation analysis reveals Bucea-Manea-Ţoniş topping with 203 citations and m-index 0.600 (since 2021), Kumar with the highest m-index (0.667), and Ilić, Kuleto, and Lianu each exceeding 130 citations despite recent entry (Table 3).

Table 3- Main authors' local impact

Author	h_index	g_index	m_index	TC	NP	PY_start
Bucea-Manea-Toniş R.	3	3	0.600	203	3	2021
Molina A.	3	3	0.500	23	3	2020
Draskovic D.	2	2	0.250	12	2	2018
Gholson J.	2	2	0.222	4	2	2017
Ilić M.P.	2	2	0.400	135	2	2021
Kuleto V.	2	2	0.400	135	2	2021
Kumar A.	2	3	0.667	28	3	2023
Lianu C.	2	2	0.500	134	2	2022
Palacios-Pacheco X.	2	3	0.286	93	3	2019
Villegas-Ch W.	2	3	0.286	93	3	2019

TC: Total Citation; NP: Number of Publications; PY_start: Publication Year Start
Source: Own elaboration (2025)

Their research converges on AI innovations like blockchain smart learning, Education 4.0 engineering education, AI chatbots, smart campuses, and adaptive intelligent assistants (Cortés; Molina; Ramírez, 2020; Villegas-Ch; Arias-Navarrete; Palacios-Pacheco, 2020; Sajja Et Al., 2023; Bassner; Frankford; Krusche, 2024). This diversity illustrates how AI is being embedded across different active learning scenarios and disciplinary contexts.

4.3 MOST RELEVANT SOURCES

Conference proceedings and book series like *Lecture Notes in Networks and Systems*, *Communications in Computer and Information Science*, *Advances in Intelligent Systems and Computing*, and *Lecture Notes on Data Engineering and Communications Technologies* dominate, focusing on AI-enhanced pedagogical innovation in engineering

contexts. Conferences such as EDUCON, FIE, and the International Symposium on Project Approaches in Engineering Education lead discussions on AI integration (Pedersen et al., 2024; Robledo-Rella; TOH, 2024). Journals including *Education Sciences*, *Sustainability*, and *Computers and Education: Artificial Intelligence* show growing interest in pedagogical and societal implications (Bucea-Manea-Ţoniş et al., 2021; Pellas, 2025; Sari; Aypay, 2024). This distribution reflects the field's roots in computer science/engineering while expanding into education and social sciences (Table 4).

Table 4 - Most relevant sources by number of publications

Publications	Type	Publisher	Main Fields	NP
Lecture Notes in Networks and Systems	Proceedings	Springer Science and Business Media Deutschland GmbH	Computer Science; Engineering.	6
ACM International Conference Proceeding Series	Proceedings	IEEE Computer Society	Computer Science.	5
Communications in Computer and Information Science	Proceedings	Springer Verlag	Computer Science; Mathematics.	5
Advances in Intelligent Systems and Computing	Proceedings	Springer Science and Business Media Deutschland GmbH	Computer Science; Engineering.	4
Education Sciences	Journal	Multidisciplinary Digital Publishing Institute (MDPI)	Computer Science; Health Professions; Psychology; Social Sciences.	3
IEEE Global Engineering Education Conference, EDUCON	Proceedings	IEEE Computer Society	Decision Sciences; Engineering; Social Sciences.	3
International Symposium on Project Approaches in Engineering Education	Proceedings	University of Minho	Engineering; Social Sciences; Environmental Science.	3
Lecture Notes on Data Engineering and Communications Technologies	Book Series	Springer International Publishing AG	Computer Science; Engineering.	3
Proceedings - Frontiers in Education Conference, FIE	Proceedings	IEEE Inc.	Computer Science; Social Sciences.	3
Sustainability (Switzerland)	Journal	Multidisciplinary Digital Publishing Institute (MDPI)	Computer Science; Energy; Environmental Science; Social Sciences.	3

NP: Number of Publications

Source: Own elaboration (2025)

Analysis of local impact publications (Table 7) reveals varied relevance across journals, book series, and conference proceedings in AI and active learning in higher education. *Sustainability (Switzerland)* leads with 217 citations, h-index 3, and m-index 0.500 since 2020, followed by *Education Sciences* and *Lecture Notes on Data Engineering and Communications Technologies* with h-index 2–3, m-index 0.500, and 50+ citations since 2022, signaling rapid growth. Other sources like *IEEE Transactions on Education*, *Higher Education, Skills and Work-based Learning*, and *Mathematical Problems in Engineering* show consistent metrics, while EDUCON and FIE conferences

excel in applied research dissemination. The diversity across MDPI, IEEE, Springer, Wiley, and Emerald publishers—and disciplines spanning Computer Science, Engineering, Social Sciences, and Education—highlights the field's multidisciplinary nature.

Table 5- Top publications local impact

Publications	Type	Publisher	Main Fields	h-index	g-index	m-index	TC	NP	PY_start
Sustainability (Switzerland)	Journal	Multidisciplinary Digital Publishing Institute (MDPI)	Computer Science; Energy; Environmental Science; Social Sciences.	3	3	0.500	217	3	2020
Computer Applications in Engineering Education	Journal	John Wiley & Sons Inc.	Computer Science; Engineering; Social Sciences.	2	2	0.250	23	2	2018
Education Sciences	Journal	Multidisciplinary Digital Publishing Institute (MDPI)	Computer Science; Health Professions; Psychology; Social Sciences.	2	3	0.500	61	3	2022
Higher Education, Skills and Work-based Learning	Journal	Emerald Publishing	Social Sciences.	2	2	0.333	64	2	2020
IEEE Global Engineering Education Conference, EDUCON	Conference	IEEE Computer Society	Decision Sciences; Engineering; Social Sciences.	2	2	0.286	5	3	2019
IEEE Transactions on Education	Journal	Institute of Electrical and Electronics Engineers Inc.	Engineering; Social Sciences.	2	2	0.286	75	2	2019
Lecture Notes on Data Engineering and Communications Technologies	Book Series	Springer International Publishing AG	Computer Science; Engineering.	2	3	0.500	58	3	2022
Mathematical Problems in Engineering	Journal	John Wiley and Sons Ltd	Engineering; Mathematics.	2	2	0.400	58	2	2021
Proceedings - Frontiers in Education Conference, FIE	Conference	IEEE Inc.	Computer Science; Social Sciences.	2	3	0.500	9	3	2022
Advances in Intelligent Systems and Computing	Book Series	Springer Science and Business Media Deutschland GmbH	Computer Science; Engineering.	1	4	0.143	20	4	2019

TC: Total Citations; NP: Number of Publications; PY_start: Publication Year Start
Source: Own elaboration (2025)

Most cited works on AI and active blended learning in higher education show dynamic impact beyond publication age. Huang et al. (2023) lead with 208 citations (69.33 annual), demonstrating AI-driven video recommendations that boost engagement and performance in flipped classrooms, especially for moderately motivated students. Salinas-Navarro et al. (2024) achieve the highest normalized score (31.89), analyzing generative AI for authentic assessment and experiential learning while stressing ethical use (Table 6).

Villegas-Ch et al. (2020) highlight chatbots, Lai et al. (2023) examine large language models, and Bucea-Manea-Ţoniş et al. (2021, 2022) explore blockchain—all showcasing intelligent systems for personalization and motivation. Ahmad (2019) advocates adapting higher education to AI/5G via "fusion skills," RRI, digital literacy, and active learning; Gren (2020) confirms flipped classrooms improve performance contingent on faculty skill; Ilieva et al. (2023) propose GenAI chatbot frameworks for blended learning; and Alam (2023) emphasizes intelligent tutoring systems that support teachers, enhance engagement, and reduce gaps through equitable implementation.

TABLE 6- MOST CITED DOCUMENTS

Document	Author(s)	TC	TC per Year	Normalized TC
Effects of artificial Intelligence–Enabled personalized recommendations on learners'…	Huang et al. (2023)	208	69.33	9.45
Proposal of an architecture for the integration…	Villegas-Ch et al. (2020)	82	13.67	3.60
Exploring the role of intrinsic motivation in ChatGPT...	Lai et al. (2023)	80	26.67	3.64
Blockchain technology enhances sustainable higher education.	Bucea-Manea-Ţoniş et al. (2021)	68	13.60	5.11
Artificial intelligence potential in higher education institutions...	Bucea-Manea-Ţoniş et al. (2022)	67	16.75	6.86
Scenario based approach to re-imagining future of higher education…	Ahmad, T. (2019)	62	10.33	2.72
A flipped classroom approach to teaching empirical software engineering.	Gren (2020)	55	9.17	2.42
Using generative artificial intelligence tools…	Salinas-Navarro et al. (2024)	53	26.50	31.89
Effects of generative chatbots in higher education.	Ilieva et al. (2023)	52	17.33	2.36
Harnessing the power of AI...	Alam (2023)	47	15.67	2.14

TC: Total Citations; Pub(s): Publications

Source: Own elaboration (2025)

Local citation analysis (LC) reveals only Draskovic (2018) received intra-corpus citations, while other high global citation works show zero LC due to recent publication dates—a common bibliometric lag (DONTHU et al., 2021; ARIA; CUCCURULLO, 2017). Recent 2024 papers like Wang (2024) (5 citations) and Gouia-Zarrad (2024) (4 citations) demonstrate early global recognition but 0% LC/GC ratios, highlighting a maturity gap between foundational and emerging studies in the field (Table 7).

Table 7- Most cited articles according to the LCS and GCS

Articles	Author(s)	LCS	GCS	LC/GC Ratio
SAIL-Software system for learning AI algorithms	Draskovic et al. (2018)	1	9	11.11
Artificial intelligence in physics courses…	Robledo-Rella & Toh (2024)	0	0	--
Empowering critical thinking through AI…	Maya & Valdes (2024)	0	0	--
Comparative investigation of BOPPPS–AI integrated flipped classroom method…	Hatwalne et al. (2014)	0	0	--
Evaluating the connectional benefits of artificial intelligence…	Pivneva et al. (2014)	0	0	--
Preliminary insights into Ai and engineering education…	Vinod & Guile (2024)	0	0	--
Enhancing Students' Learning Experience in Mathematics Class…	Gouia-Zarrad & Gunn (2024)	0	4	0.00
The impact of AI usage on university students'…	Wang & Li (2024)	0	5	0.00
Active learning and new technologies…	Pedersen et al. (2014)	0	0	--
Thinking critically about scientific information generated by ChatGPT	Archila et al. (2014)	0	0	--

GCS: Global Citation Score; LCS: Local Citation Score; Pub(s): Publications.

Source: Own elaboration (2025)

Table 8 - The most local cited references

Document	Author(s)	Cit.
Experiential learning: Experience as the source of learning and development	Kolb (2014)	4
Project-based learning for the 21st century: Skills for the future	Bell (2010)	3
Motivating project-based learning: Sustaining the doing, supporting the learning	Blumenfeld et al. (1991)	3
Artificial intelligence in education: A review	Chen et al. (2020)	3
Statistical power analysis for the behavioral sciences	Cohen (2013)	3
Project-based learning: A review of the literature	Kokotsaki et al. (2016)	3
Gamified learning in higher education: A systematic review of the literature	Subhash & Cudney (2018)	3

Source: Own elaboration (2025)

- Predominant themes and topics within AI and active b-learning methodologies in Higher Education

The thematic map (Figure 7) organizes key terms into four quadrants, revealing focus areas, trends, and gaps in AI and active blended learning research.

Motor themes in the upper-right quadrant—"Students," "Artificial Intelligence," and "Teaching"—form the core, highlighting AI's pedagogical innovation role (WANG; LI, 2024; CHEN et al., 2020; ALAM, 2023), alongside tool development terms like "Application Programs," "Intelligent Systems," and "Software Design" (DRASKOVIC, 2018, 2019).

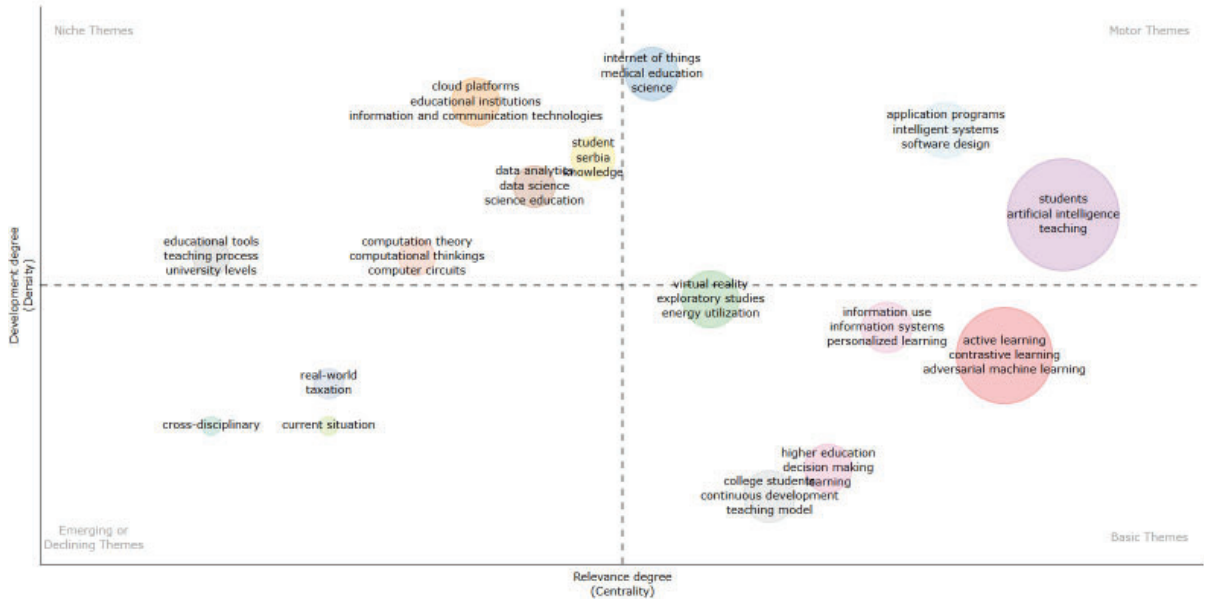
Niche themes (upper-left) with high development but lower centrality include "Internet of Things," "Medical Education," and infrastructural aspects like "Cloud Platforms" and "Information and Communication Technologies" (BUCEA-MANEA-ȚONIȘ et al., 2022; BUCEA-MANEA-ȚONIȘ et al., 2021; VILLEGAS-CH et al., 2020).

Basic themes (lower-right) with growth potential feature "Virtual Reality" for active blended learning (KUMAR et al., 2023) and personalization via "Personalized Learning,"

"Active Learning," "Contrastive Learning," and "Adversarial Machine Learning" (CHUANG et al., 2020; HUANG et al., 2023; LAI et al., 2023).

Emerging/declining themes (lower-left) like "Educational Tools," "Teaching Process," and discipline-specific "Cross-disciplinary" remain peripheral (SALINAS-NAVARRO et al., 2024). The map signals a trend toward AI-driven personalization enhancing higher education practices.

Figure 7 Thematic map



Source: Own elaboration (2025)

Zipf's Law (ZIPF, 1932) was applied to keyword frequency analysis via VOSviewer, with "Project" appearing most frequently (39 times; √39 ≈ 6), consistent with Zipf's distribution and co-occurrence patterns from titles/abstracts. Twenty-six keywords (≥6 occurrences) formed four clusters (Table 11): red (9 terms, led by "course," 33 occurrences); green (9 terms, dominated by "higher education," 30 occurrences); blue (6 terms, headed by "assessment," 16 occurrences); and yellow (2 terms, highlighting "project," 39 occurrences) (Table 9).

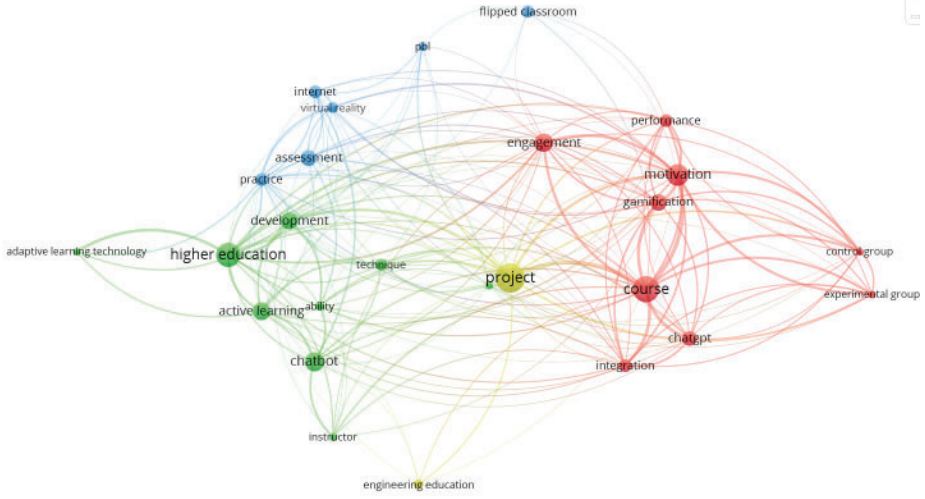
Table 9- Cluster of co-occurrences of keywords

Cluster	Items	Number of occurrences	Relevance
Cluster 1 - Red	Chatgpt	14	0.53
	control group	6	0.86
	Course	33	0.47
	Engagement	20	0.61
	experimental group	6	0.90
	Gamification	17	0.45
	Integration	12	0.42
	Motivation	25	0.36
	Performance	12	0.43

Cluster	Items	Number of occurrences	Relevance
Cluster 2 - Green	Ability	7	0.95
	active learning	19	1.30
	adaptive learning technology	6	3.02
	Chatbot	21	1.85
	Development	18	1.03
	generative ai	6	0.53
	higher education	30	0.86
	Instructor	6	1.16
	Technique	10	0.55
Cluster 3 - Blue	Assessment	16	0.89
	flipped classroom	11	1.27
	Internet	12	1.67
	Pbl	7	0.89
	Practice	12	0.80
	virtual reality	9	1.28
Cluster 4 - Yellow	engineering education	8	0.47
	Project	39	0.46

Source: Own elaboration (2025)

Figure 8- Keyword co-occurrence network



Source: Own elaboration (2025)

The thematic clustering identifies four main research areas linking AI with active blended learning in higher education (Figure 8).

Cluster 1 – Red focuses on AI integration into teaching, learning, and assessment, with core terms like *course*, *motivation*, and *engagement* showing AI›s role in personalized instruction (Alam, 2023; Draskovic, 2019; Subhash; Cudney, 2018). Growing interest in *ChatGPT* and *chatbots* highlights generative AI for feedback and support (ARCHILA et al., 2024; GOUÍA-ZARRAD; GUNN, 2024; ILIEVA et al., 2023).

Cluster 2 – Green examines AI's support for *active learning* via *chatbots*, *adaptive technologies*, and *generative AI* (Alam, 2023; Huang et al., 2023; Salinas-Navarro et al., 2024). It connects to *instructor training* (Maya; Valdes, 2024), *skill development* (AHMAD, 2019), and AI pedagogy evolution (Pedersen et al., 2024; Robledo-Rella; Toh, 2024).

Cluster 3 – Blue emphasizes digital tools and active methods like *virtual reality*, *Flipped Classroom*, And *PBL* (Villegas-Ch; Palacios-Pacheco, 2021; Kumar Et Al., 2023; PÉREZ-RODRÍGUEZ et al., 2022), enhancing engagement through adaptive feedback (Alam, 2023).

Cluster 4 – Yellow links *PBL* strongly to *engineering education*, where AI aids project design, feedback, and collaboration to build creativity and adaptability (PÉREZ-RODRÍGUEZ et al., 2022; AHMAD, 2019).

5 CONCLUSIONS

This bibliometric study mapped recent scientific production on artificial intelligence and active blended learning methodologies in Higher Education, based on 167 Scopusindexed documents published between 2015 and 2024. The findings point to sustained growth in publications, with a sharp increase after 2020, reflecting both technological advances in AI and the acceleration of digital transformation in universities (Chen; Chen; Lin, 2020; LópezChila Et Al., 2024; Wang et al., 2024). Conference proceedings and computerscienceoriented series remain central outlets, but journals in education and sustainability are gaining prominence, indicating the progressive pedagogical and societal framing of the topic (BuceaManeaȚoniş et al., 2021; Sari; Aypay, 2024; Pellas, 2025).

The analysis identified a group of influential authors, sources and documents that shape the field, as well as four main thematic clusters related to personalized learning, gamification, flipped classrooms and AIsupported projectbased and collaborative learning. Together, these clusters show that AI is not a single technology but a multifaceted ecosystem that can augment different active learning models when aligned with clear pedagogical goals (Ruiza et al., 2025; Huang; Lu; Yang, 2023; Sajja et al., 2023). At the same time, the literature highlights persistent challenges linked to ethics, data protection, algorithmic transparency and teacher training, suggesting that institutional strategies must balance innovation with responsibility (GarcíaPeñalvo, 2023; Unesco, 2025; An; Yu; James, 2025).

Future research could deepen understanding of contextual factors that mediate the effectiveness of AI in active blended learning, including disciplinary differences, institutional cultures and student diversity. Longitudinal and mixedmethods studies may help connect bibliometric patterns with concrete learning outcomes and with changes in teaching practice (Dias Lousã; Teixeira; Pereira De Morais, 2025; Purwanto; Wibowo; Rahayu, 2023). There is also room for more work that integrates critical perspectives on power, equity and inclusion in AImediated Higher Education, ensuring that technological innovation contributes to more just and humancentered learning environments (Unesco, 2025; Wang; Li, 2024).

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