Supplementary File S1 – Summary of Included Articles

This table provides a detailed summary of the 51 empirical studies included in the systematic review. Each entry documents key characteristics, including study reference, country, AI tool used, target population, AI function/application, reported outcomes, and the Sustainable Development Goals (SDGs) addressed.

S/N	References	Country	AI Tool	Target Group	Function/Application	Outcomes	SDG Focus
1	Conrad et al. (2024)	United States	EpiBot (Chatbot)	Undergraduate public health students at a Hispanic-Serving Institution	Course content assistance, admin support in online epidemiology	93.7% question accuracy; improved grades (72%); high usability and engagement	4, 10
2	Saleh A (2024)	Saudi Arabia	RANDOM FOREST, K-Nearest Neighbors (KNN), CNNs, and XAI	Undergraduates from various degree programs	Integration of AI to predict students' performance	99.97% accuracy	4, 10
3	Jaluza et al. (2023)	Brazil	Natural Language Processing (NLP).	The community	An AI tool was used to verify the alignment of HEI community outreach actions to SDGs.	AI was effective in identifying and monitoring data on community outreach actions in HEI towards SDGs, and sharing information with internal and external	4, 8, 12, 17

						stakeholders of the institution.	
4	Lin et al. (2024)	Canada	Grammarly and ChatGPT	Undergraduates from two different educational courses at Western Canada University	The utilization of AI tools to foster inclusive education in diverse learning environments was explored.	AI tools have the potential to promote inclusivity and accessibility in learning. by making learning more accessible to diverse students.	
5	Buenano-Fernandez et al. (2019)	Ecuador	Machine learning	Computer engineering degree students	Machine learning techniques to predict the students' performance	The tool enhanced the prediction of students' grades in a subject from their grades in previous academic years of the subject.	4
6	Bakry et al. (2024)	Egypt	ChatGPT	Faculty Members at 4 Private Higher Education Sector	Describes the relationship between academic performance, AI performance, Time management, enhance educational experience	AI has an effect on professors' overall performance, academic performance, time management, and	4

						enhanced educational experience at a 0.010 significant level.	
7	Katsamaka et al. (2024)	United States	ChatGPT	Higher Education student in	Develops a causal loop diagram (CLD) of the AI transformation in Higher Education.	HEI invests in AI to improve teaching, research, and administration.	4
8	Kalnina et al. (2024)	Latvia	ChatGPT	Pre-service teachers at the University of Latvia.	Investigated the benefits and challenges of AI.	Found a low adoption rate of AI among pre-service teachers. Emphasizes the need for HEIs to enhance AI literacy and readiness among future teachers.	10
9	Sendawula et al. (2024)	Uganda	ChatGPT, Quill Bot, SnapAI, Bard,	Students and facilitators from Makerere,	Exploring participants' Lived Experiences of AI Usage.	Chat-GPT was mostly used by students for information retrieval,	4

			and Questionnaire AI.			learning support and research projects. Awareness and adoption of AI was limited among facilitators.	
10	Al-dokhny et al. (2024)	Saudi Arabia	MLLMs, chatGPT	Saudi university undergraduate and postgraduate student	investigated the transformative potential of MLLMs in HEIs and the factors influencing their acceptance and effectiveness.	Task and technology characteristics enhance students' performance benefits via the willingness to accept the use of the technology.	4
11	Airaj 2022	Morocco	Machine learning	Undergraduate student	The study explored the impact of combining cloud computing technology with PBLon quality of e-learning in higher education.	The study found a strong impact of Cloud Computing, PBL and Student Learning Effort on qualitative education	4

12	Chen et al. (2023)	China	ChatGPT, GAI	Undergraduate student of the university of China	Investigated the performance impact of ChatGPT on higher education students.	ChatGPT's performance impact depend on its overall quality.	4
13	Komatina et al.(2024))	Montenegro, Serbia	AI Not specified.	Final year architectural student of the university of Serbia	Explored how AI enhances students' understanding of sustainable practices in architecture and how sustainability challenges and concerns influence AI applications.	There is a significant relationship between students' understanding of sustainability and AI use,	4
14	Chiang (2021)	Taiwan	AI tool not specified	Undergraduate and graduates from eight university in Taiwan	Estimated AI learning efficiency for civil engineer education.	The study identified effective teaching practice as an important factor in the artificial intelligence courses for civil engineering students.	4
15	Naldi et al.(2024)	Indonesia	AI curriculum management	Several colleges	The use of AI in HEIs curriculum management to improve efficiency,	implementation of AI in HEIs curriculum management significantly improved process efficiency,	4

					adaptability and teaching quality.	accommodated dynamic changes in educational needs, and enhanced students' learning experience.	
16	Ibrahim And Ajilouni (2023)	Nigeria	ChatGPT	First second third year undergraduate student	Investigating the role of ChatGPT in achieving Council for Exceptional Children (CEC) standards among special education preservice teachers.	ChatGPT was an effective tool for special education preservice teachers in meeting the CEC standards.	4&10
17	Acousta-Enriquez et al. (2025)	Peru	AI tool not specified.	Professors from eight peruvian universities	Examined sustainability AI use among Peruvian university professors	Attitude toward AI influenced its sustainable use. No significant relationship between AI use and teaching concerns.	4
18	Ronalghi and Ronalghi (2025)	Turkey, Iran, Jordan, Iraq, Oman, Qatar,	AI tools not specified.	Administrative, educational, and research staff from 30	Explored the factors affecting AI adoption its effect on sustainable	technology performance,	4, 10

		Egypt, Saudi Arabia, UAE, and Lebanon		universities in Middle Eastern countries	performance in educational institutions and universities.	enjoyment, trust, social influence and organizational capabilities affect AI adoption in universities. AI fosters university sustainable performance improvement.	
19	Soobramoney et al. (2019)	South Africa	MLA’s	Undergraduate and post graduate university student of South Africa	Exploring how MLAs can be used to identify students at risk better than the manual methods.	Student at risk can be predicted effectively using an ensemble of MLAs by including several factors that may often not even be practical with manual methods.	4, 10
20	Villeges-cv et al (2023)	Ecuador	Artificial Neural Network	Higher education students	Apply ML to identify at-risk students and deliver personalized instruction strategies.	Retention rate improved from 75% to 81%: AI model achieved 85% precision, 80% recall, 82% F1-score; promoted sustainability	4

						education and early interventions.	
21	Jokhan et al. (2022)	Fiji	Random Forest (AI analytics)	First-year university IT students	Developed an early warning system using logins, completion rate, and coursework scores to predict student performance.	AI model achieved 97.03% accuracy, enabling early detection of at-risk students and allowing timely interventions; improved decision-making for equitable quality education through predictive insights.	4
22	Lengyel et al. (2025)	Hungary	Generative AI	Agricultural students & educators	Explored AI in curricula, student engagement, skill development, interdisciplinary collaboration, and industry preparation	AI-enhanced learning, through predictive modeling, decision-making, interdisciplinary projects, and real-world applications such as precision agriculture, fosters innovation, engagement, and industry readiness.	2, 4, 9, 12
23	Jiang (2025)	China	Kimi.AI	University students in Tibet, China	Used the ICAP framework to evaluate writing performance under 4 feedback modes: teacher-	Hybrid AI and teacher feedback led to the highest writing gains. The study confirmed	4, 10

					only, AI-only, AI-interactive, and hybrid.	that AI-human synergy promotes educational equity in under-resourced areas like Tibet.	
24	Agostini and Picasso (2023)	Italy	Large Language Models (LLMs)	Higher education instructors and students.	Designed a pedagogical-technological model (AI-MAAS) using LLMs like ChatGPT for formative and summative assessment support.	LLMs automate feedback, enhance the authenticity and sustainability of assessments, and support student reflection; the model includes both formative and summative levels, validated using the Delphi methodology.	4, 9, 17
25	Mahade et al (2025)	UAE	AI-driven HR insights	215 HR professionals, AI experts, and university leaders	Explored mediating roles of HRM practices and decision-making; and moderating roles of ethical considerations, culture, and AI readiness.	AI insights positively influenced sustainable HRM performance ($\beta = 0.230$); HRM practices ($\beta = 0.208$) and decision-making ($\beta = 0.361$) were strong mediators; ethical and cultural factors had direct but not moderating effects	4, 8, 9, 16

						on AI-HRM outcomes.	
26	Latrellis et al. (2024)	Greece, Cyprus	ChatGpt	Academic advisors & students	Compared ChatGPT vs. human-generated academic advising using 7 realistic advising scenarios.	ChatGPT was rated high in relevance and clarity but scored lower in practicality and acceptance; it was suggested that hybrid human-AI models could improve the scalability and sustainability of advising systems.	4, 9, 17
27	Boustani et al., (2024)	Lebanon	ChatGPT (Generative AI)	157 university lecturers at a private Lebanese university	Examined how ICT and generative AI (esp. ChatGPT) enhance sustainability in higher education through personalized learning, content automation, and efficient administration.	AI tools contributed to improved personalized learning, professional development, green practices, and efficient education systems; the highest impact was seen in internet access and infrastructure; strong synergy between AI and higher education for sustainability.	4, 9, 12
28	Prior et al., (2024)	Australia	Semantic matching (AI-based)	University-wide course data	Developed a semantic algorithm to assess SDG alignment in 5,461 course	Found 75% algorithmic accuracy; most aligned courses	4, 9, 17

					descriptions and learning outcomes	with SDG 4 (Quality Education) and SDG 17 (Partnerships); highlighted efficiency in tracking SDG content across curricula.	
29	Espinoza Vidaurre et al., (2024)	Peru and Chile	Adaptive learning & intelligent systems	University students from 13 institutions	Structural equation modeling (SEM) was used to assess how students' AI perceptions affect academic integrity across two countries.	AI perceptions significantly predicted academic integrity ($\beta = 0.44$); in Peru, attitudes toward AI mattered more; in Chile, trust and responsibility had stronger influence.	4 & 16
30	Shilbayeh & Abonamah (2021)	UAE	Machine learning (boosted regression trees, Apriori algorithm)	Higher education students	Developed models to predict enrolment trends and identify students at risk of attrition using machine learning; also designed personalized intervention strategies for student retention.	Achieved high accuracy (up to 89%) in enrolment prediction and 100% confidence for some attrition rules; models help identify at-risk students and inform targeted interventions to boost retention and enrollment planning	4, 9, 10
31	Villegas-Ch et al., (2020)	Ecuador	AI-powered chatbot	University students	Developed an AI-Chatbot model integrated into	Improved participation, task	4, 9

					LMS for activity recommendation, monitoring, and student support	completion, and quality of submissions; chatbot identified learning barriers and personalized interventions to enhance student outcomes.	
32	Chomiak-Orsa & Smolag (2024)	Poland	AI-supported Remote Learning Platforms	Part-time university students (2020–2022 cohort)	Assessed the role of AI-powered distance learning tools in expanding access and promoting lifelong learning during COVID-19	Found increased preference for and availability of remote learning; students showed growing interest in AI-based, flexible education formats.	4
33	Tarisayi & Manhibi (2025)	Zimbabwe	Intelligent tutoring systems, predictive analytics, and automated grading	University stakeholders (educators)	Explored stakeholder views on strategic AI adoption for learning, personalization, retention, and institutional efficiency	Strong readiness to adopt AI, but faced with resource constraints; emphasized the need for collaboration, policy frameworks, and equitable implementation	4, 10, 16
34	Shahid et al. (2024)	Cyprus	Adaptive learning,	Humanities students and educators	Explores AI's potential in personalizing learning, enhancing creativity,	Improved personalized learning, deeper engagement, stronger	4, 9, 10, 16

			Tutoring systems		critical thinking, student engagement, and interdisciplinary collaboration in the humanities.	critical and creative thinking; recognized challenges around equity, ethics, and the digital divide	
35	Perkins et al. (2024)	Vietnam, Singapore	GenAI Text Detectors	Multiple institutions worldwide (cases not individually named)	Evaluated AI detector bias and accuracy for academic integrity	Detectors unreliable; risks of bias against 'Non-Native English Speaker'; ethical concerns raised	4 & 10
36	Clark et al. (2024)	United States	ChatGPT	Non-science majors in chemistry	Final exam activity comparing student vs. ChatGPT essay	Students demonstrated improved metacognition, deeper reflections on science writing, and sustainability.	4 & 12
37	Asad et al. (2025)	Mexico	AI in teaching (simulations)	Higher educational institutions in Pakistan.	AI as a moderator in shaping sustainable entrepreneurial intentions	AI and fear significantly moderate the effects of personal attitude, perceived control, and feasibility on SEI.	4 & 8
38	Daniela et al. (2018)	Latvia	learning analytics dashboards	Professors and students	Explored TEL's impact on sustainable teaching practices	TEL is perceived as a catalyst for quality education and sustainable socio-economic growth; however, real-world adoption is hindered	4, 9, 17

						by ICT literacy gaps, inadequate infrastructure, and insufficient alignment with SDG frameworks.	
39	Vázquez-Verdera et al., (2021)	Spain	AI-enabled Learning Experience Design	University of Valencia students and faculty	Designed and implemented an interdisciplinary, AI-supported “Learning Experience” in collaboration with the UN Service for Geospatial, Information, and Telecommunications Technologies	AI chatbots increased student access to SDG resources by 43 %	4, 13 & 17
40	Man et al. (2023)	Romania	Intelligent Chatbot (UniBot)	International applicants to UMF	The chatbot’s knowledge base (“ontology”) was built, tested, and continuously maintained through six lifecycle stages (conceptualization through maintenance), utilizing FAQs and structured admission rules as sources.	Resolved candidate requests automatically	3, 4, & 9
41	Zhang & Xu (2024)	China	ChatGPT)	Undergraduate students at a first-tier Chinese university	Investigated how the frequency of generative AI use affects students’	The frequency of AI usage positively influenced confidence	4 & 10

					self-efficacy and their dependence on AI.	perception (β = 0.217, p < .01) and efficiency perception (β = 0.230, p < .01).	
42	Savec & Jedrinović (2025)	Slovenia	ChatGPT, Midjourney, DALL-E, Virtual Caliper, Blender, TensorFlow, Keras, dairy-breeding simulator)	University of Ljubljana faculty and their students	Conducted an exploratory case study of AI integration across 26 courses using content analysis to identify how AI tools enabled or inhibited progress on specific SDG targets in teaching and learning. Mapped each practice to SDG targets using a rubric and quantified positive/negative impact.	AI in healthcare courses (e.g., CNN/TensorFlow for ultrasound assessment) improved diagnostic accuracy	3,4, 8, 9, 11, 13, and 15
43	Niu et al., 2024	China	AI educator autonomy (sensing, thought, action)	Chinese college students	Examined how three dimensions of "AI educator" autonomy influence students' intention to use AI educators,	Sensing autonomy positively influenced social interaction gratification (β = 0.315, p < .001) and entertainment gratification (β = 0.383, p < .001), which in turn increased usage intention.	4

44	Ballesteros et al., (2024)	Peru	ChatGPT	Undergraduate students	Investigated factors influencing Peruvian undergraduates' acceptance and actual use of ChatGPT for academic tasks.	Effort expectancy, performance expectancy, and knowledge sharing each had significant, positive direct effects on actual ChatGPT use.	4
45	Chadha (2024)	India	Intelligent Tutoring System (ITS)	Fifth graders (studying multiplication and division)	To tailor instruction and feedback, adapting educational material to meet individual student needs.	Academic: 30% improvement in math scores, bolstering comprehension. Emotional: Reduced student anxiety by 20%. Offered more supportive, engaging, and effective learning experiences.	4
46	Adžić et al. (2024)	Serbia & Austria	ChatGPT, Bard, local EU-developed LLMs	Undergraduate students	Examined the influence of demographic factors and developed "Attitude toward AI" scale.	Students' attitudes toward AI differed significantly by field of study and gender	4, 10
47	Black & Tomlinson (2025)	United States	ChatGPT, Claude AI, Grammarly, and QuillBot	Undergraduate students	Brainstorming & understanding complex topics, paraphrasing, revising, and proofreading.	Greater writing efficiency & confidence, improved clarity/flow of prose.	4

48	Xiao et al. (2025)	China	Doubao, ERNIE Bot	American University (not named, general education course)	Exploring GenAI usage and challenges for sustainability	High usage rates but limited proficiency; need for curriculum integration and support	4, 9, 10
49	Zipf et al. (2025)	USA	GenAI (unspecified)	Chinese Universities (Doubao & ERNIE Bot usage studied)	Analyzing GenAI equity via the information inequity framework	Faculty/staff emphasized access; students focused on ethics; called for broader AI literacy efforts	4, 10
50	Okulich-Kazarin et al, 2024	Poland	Various AI tools	U.S. higher education institutions	Exploring AI-supported peace-focused learning environments	Promoted personalized, inclusive education aligned with SDG 4.3 through GenAI and ethical learning design	4, 16
51	Santiago-Ruiz (2023)	Mexico	ChatGPT	Spanish universities (unspecified, focused on SDG 4.3)	Understanding AI use in low-resource settings with the digital divide	Students primarily used ChatGPT for basic tasks, exhibiting limited prompt literacy and critical evaluation; teacher unfamiliarity further exacerbates the gap.	4, 10

Source: Authors’ own work

Supplementary File S2 – Codebook and Audit Note

This codebook defines all extraction variables and analytic codes used in our thematic synthesis. It also records the audit trail of coding decisions for transparency.

1 Extraction Variables

Variable	Definition	Format / Rule
S/N	Serial number of the study	Integer 1–51
Reference	Full APA 7 reference	Free text
Country	Country/region of study	Free text: semicolons to separate multiple
AI Tool	AI technology investigated	Free text; commas for multiple; "Not specified" if absent
Target Group	Population under study	Free text
Function/Application	How AI was applied	Concise sentence
Outcomes	Reported results	Metrics or qualitative outcomes
SDG Focus	SDG numbers are explicitly referenced	e.g., "4 & 10" or "4; 9; 12"; "Not specified" if absent

2 Contribution Codes

Code	Definition	Illustrative Example
Prediction & Analytics	Machine learning or analytics predicting outcomes or risks	"Random Forest predicted at-risk students with 97% accuracy."
Adaptive Learning / ITS	Systems that adapt content/feedback	"ITS personalised quizzes based on prior performance."
Chatbot / Conversational AI	Chatbots supporting learning or admin tasks	"EpiBot answered epidemiology queries (93.7% accuracy)."
Automated Assessment / Feedback	Automated grading or feedback generators	"ChatGPT graded essays and provided instant comments."
Accessibility & Inclusion	AI features improving access for diverse learners	"Speech-to-text improved accessibility for non-native speakers."
Equity-Focused Applications	Designed explicitly for marginalized groups	"ChatGPT scaffolded assignments for special-education teachers."

3 Governance Codes

Code	Definition	Illustrative Example

Ethical Concerns	Mentions of bias, plagiarism, or misuse	"Detector bias undermined integrity."
Data Privacy & Security	References to data protection issues	"Privacy concerns limited AI deployment."
Skill & Training Gaps	Lack of AI literacy or training	"Facilitators lacked AI awareness."
Opportunity – Innovation	AI enabling new pedagogical models	"AI revolutionized curriculum design."

4 Outcome Codes

Code	Definition	Illustrative Example
Sustainability Literacy & Awareness	Gains in SDG knowledge	"Awareness of SDG 13 increased by 43%."
Critical Thinking & Reflection	Improved analytical or reflective skills	"Students engaged in deeper reflection."
Institutional Sustainability Outcomes	Efficiency or resource savings	"Smart analytics cut energy use by 20%."

Source: Authors' own work

5 Audit Note

Four independent reviewers manually coded all 51 studies using the definitions above. Each article could receive multiple codes per theme (Contribution, Governance, Outcome). After initial independent coding, the four reviewers met to compare results and resolve any discrepancies through discussion until consensus was achieved.